FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT / SUPPLEMENTAL OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL OPERATIONS

JUNE 2012

Prepared for
Department of the Navy

In accordance with
Chief of Naval Operations Instruction 5090.1C CH-1

Pursuant to
National Environmental Policy Act
Section 102(2)(C)
and
Executive Order 12114

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/SUPPLEMENTAL OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

June 2012

Abstract

This Final Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (FSEIS/SOEIS) evaluates the potential environmental impacts of employing the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar. It has been prepared by the Department of the Navy in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA) and Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions). The Navy currently plans to operate up to four SURTASS LFA sonar systems for routine training, testing and military operations. Based on current U.S. Navy national security and operational requirements, routine training, testing and military operations using these sonar systems could occur in the Pacific, Atlantic and Indian Oceans, and the Mediterranean Sea. Vessels equipped with, or to be equipped with, SURTASS LFA sonar systems are the USNS IMPECCABLE (T-AGOS 23) and USNS VICTORIOUS (T-AGOS 19) class ocean surveillance vessels. In addition to the No Action Alternative, the FSEIS/SOEIS analyzed two additional alternatives. The analysis of these three alternatives is intended to address concerns of the U.S. District Court for the Northern District of California in its 6 February 2008 opinion and order in relation to compliance with NEPA and the Marine Mammal Protection Act (MMPA); as well as to fulfill the Navy's responsibilities under NEPA with regard to providing additional information related to the proposed action. The FSEIS/SOEIS considers mitigation measures, including the practicability of greater coastal standoff range where the continental shelf extends further than the current coastal standoff range of 22 kilometers (12 nautical miles), the designation of additional offshore biologically important areas, and further analysis of potential cumulative impacts with concurrent use of SURTASS LFA sonar with other active sonar sources

---

Please contact the following person with comments and questions:
CDR R.A. Dempsey, USN
Attn: SURTASS LFA Sonar SEIS/SOEIS Program Manager
4100 Fairfax Drive, Suite 730
Arlington, VA 22203
E-Mail: eisteam@mindspring.com

PREFACE

This Final Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (FSEIS/SOEIS) for Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems[1] provides supplemental analyses to the Final Overseas Environmental Impact Statement/Environmental Impact Statement (FOEIS/EIS) for SURTASS LFA Sonar (DoN, 2001) and the Final Supplemental Environmental Impact Statement (FSEIS) for SURTASS LFA Sonar (DoN, 2007a), which were filed with the United States (U.S.) Environmental Protection Agency in January 2001 and April 2007, respectively. This second supplemental analysis has been prepared in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [USC] §4321 et seq.)[2]; the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [CFR] §§1500-1508); Navy Procedures for Implementing NEPA (32 CFR §775); and Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions[3]. The proposed action herein is the employment by the U.S. Navy of up to four SURTASS LFA sonar systems for routine training, testing, and military operations[4]. Based on current operational requirements, exercises using these sonar systems would occur in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea. To reduce adverse effects on the marine environment, areas would be excluded as necessary to prevent 180-decibel (dB) sound pressure level (SPL) or greater within specific geographic range of land, in offshore biologically important areas (OBIA) during biologically important seasons, and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites.

REFERENCES TO UNDERWATER SOUND LEVELS
• **References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dB), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa @ 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).** • **In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).** • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS/SOEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for the energy of all the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for details. As discussed in Appendix C, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001 and 2007a).**

The purpose of the SURTASS LFA sonar SEIS/SOEIS is to:

---

1 In this SEIS/SOEIS, "SURTASS LFA sonar systems" refers to both the LFA and compact LFA (CLFA) systems, each having similar acoustic operating characteristics.

2 The provisions of NEPA apply to major federal actions that occur or have effects in the U.S., its territories, or possessions.

3 The provisions of EO 12114 apply to major federal actions that occur or have effects outside of U.S. territories (the U.S., its territories, and possessions).

4 The phrase "military operations" does not include use of SURTASS LFA sonar in armed conflict, or direct combat support operations, or use of SURTASS LFA sonar during periods of heightened threat conditions, as determined by the National Command Authorities.

- Address concerns of the U.S. District Court for the Northern District of California (herein referred to as the Court) in its 6 February 2008 Opinion and Order in relation to compliance with NEPA and the Marine Mammal Protection Act (MMPA);
- Provide information to support the proposed issuance of MMPA incidental take regulations, the 2012 Letters of Authorization (LOAs), and future LOAs as appropriate; and
- Provide additional information and analyses pertinent to the proposed action.

Due to concerns raised during litigation over employment of the SURTASS LFA sonar system and to support issuance of a follow-on five-year Rule under the MMPA for employment of SURTASS LFA sonar systems, the Deputy Assistant Secretary of the Navy for Environment (DASN(E)) determined on 14 November 2008 that the purposes of NEPA and EO 12114 would be furthered by the preparation of an additional supplemental analysis related to the employment of the system. This analysis takes the form of this new SEIS/SOEIS.

Accordingly, DASN(E) directed that the new SEIS/SOEIS provide:

- Further analysis of potential additional offshore (greater than 22.2 kilometers [km] [12 nautical miles {nmi}]) biologically important areas (OBIA) in regions of the world where the Navy intends to use the SURTASS LFA sonar systems for routine training, testing, and military operations;
- Further analysis of whether using a greater coastal standoff distance where the continental shelf extends further than current standoff distance is practicable for SURTASS LFA sonar, at least in some locations; and
- Further analysis of potential cumulative impacts with concurrent use of SURTASS LFA with other active sonar sources.

In addition to the DASN(E) direction, the FSEIS/SOEIS analyses include:

- Updating purpose and needs statement for the proposed action.
- Updating literature reviews and determining data gaps, especially for fish, sea turtles, marine mammals, and other marine species.
- Updating acoustic modeling of potential effects of the proposed action for current LOA sites and additional sites in areas of potential strategic importance and/or areas of possible Fleet exercises. Modeling updates will include up-to-date marine mammal abundance, density, and behavioral scientific information.

Information from these analyses is used to assist the Navy in determining how to employ SURTASS LFA sonar, including the selection of operating areas that the Navy requires for routine training, testing, and military operations in requests for MMPA LOAs submitted to NMFS. These analyses, or risk assessments, will also support NMFS consideration of whether:

- Under the MMPA, the total taking will have a negligible impact on the marine mammal species or stock(s), and will not have an unmitigable adverse impact on the availability of species or stock(s) for subsistence uses (as well as inform the permissible methods of taking and requirements pertaining to the mitigation, monitoring), and
- Under the ESA, potential impacts from the proposed employment of SURTASS LFA sonar are not likely to jeopardize the continued existence of any endangered or threatened marine/anadromous species or result in the destruction or adverse modification of critical habitats.

Table P-1 provides a comparison of the original FOEIS/EIS and the first supplement (FSEIS) with this second final supplement (FSEIS/SOEIS).

Table P-1. SURTASS LFA Sonar FOEIS/EIS, FSEIS, and FSEIS/SOEIS comparison.

FOEIS/EIS		FSEIS		FSEIS/SOEIS		Comparison (FSEIS/SOEIS updates/changes)
Chapter	Subchapter	Chapter	Subchapter	Chapter	Subchapter	
1		1		1		• Updated Purpose and Need with addition of NMFS' purpose and need • Updated background and chronology of key events • Updated environmental impact analysis process description • Updated analytical context
2		2		2		• Updated general SURTASS LFA sonar system description to include compact LFA (CLFA) • Updated operating profile and potential OPAREAs • Review of NMFS interim operational restrictions and modifications to mitigation • Additional alternatives to include updated (additional) offshore biologically important areas
3	3.1	3	3.1	3	3.1	Updated marine environment
	3.2.1		3.2.1		3.2.1	Species Screening—Updated literature review
	3.2.2		3.2.2		3.2.2	Fish—Updated literature
	3.2.3		3.2.3		3.2.3	Sea Turtles—Updated literature review
	3.2.4		3.2.4.1		3.2.4.1	Mysticete Species—Updated literature review
	3.2.5		3.2.4.2		3.2.4.2	Odontocete Species—Updated literature review
	3.2.6		3.2.5		3.2.5	Pinnipeds—Updated literature
					3.2.6.1 through 3.2.6.3	Protected Habitats—ESA Critical Habitat, Essential Fish Habitat, and Marine Protected Areas—<u>New</u>
	3.3.1		3.3.1		3.3.1.1 and 3.3.1.2	Commercial Fisheries, Marine Fisheries Production and Fisheries Trade—Updated literature review
	3.3.1.4		3.3.1.3		3.3.1.3	Commercial Fisheries, Marine Mammals, Subsistence Whaling—Updated literature

Table P-1. SURTASS LFA Sonar FOEIS/EIS, FSEIS, and FSEIS/SOEIS comparison.

FOEIS/EIS		FSEIS		FSEIS/SOEIS		Comparison (FSEIS/SOEIS updates/changes)
Chapter	Subchapter	Chapter	Subchapter	Chapter	Subchapter	
						review
	3.3.2		3.3.2		3.3.2	Other Recreational Activities—Updated literature review
	3.3.3		3.3.3		3.3.3	Research and Exploration Activities—Updated literature review
	3.3.4		3.3.4		3.3.4	Coastal Zone Management—No changes; FOEIS/EIS incorporated by reference
4	4.1.1	4	4.1	4	4.1	• Potential Impacts on Fish Stocks—Analysis and literature updated • Presented additional results of Fish Controlled Exposure Experiments
	4.1.2		4.2		4.2	Potential Impacts on Sea Turtle Stocks—Updated literature review
	4.2		4.3		4.3	Potential Impacts on Marine Mammals—Updated literature reviews include non-auditory injury and auditory effects of sound on marine mammals
			4.4.3		4.3.3	Marine Mammal Strandings—Updated literature review and analysis
	4.2.6		4.4		4.4	FSEIS/SOEIS updated the Risk Assessment of Potential Impacts on Marine Mammals from SURTASS LFA Sonar Operations
					4.5	Comprehensive update of Offshore Biologically Important Areas for SURTASS LFA Sonar Operations—New
	4.3		4.5		4.6	Socioeconomic—Updated literature review
	4.4		4.6		4.7	Cumulative Effects—Analysis updated

Table P-1. SURTASS LFA Sonar FOEIS/EIS, FSEIS, and FSEIS/SOEIS comparison.

FOEIS/EIS		FSEIS		FSEIS/SOEIS		Comparison (FSEIS/SOEIS updates/changes)
Chapter	Subchapter	Chapter	Subchapter	Chapter	Subchapter	
	4.4.1 4.4.2		4.6.1		4.7.1 4.7.1.1	Cumulative Effects from Anthropogenic Oceanic Noise—New data on recent changes in oceanic noise levels, commercial shipping, vessel noise sources, oil and gas industry, and military and commercial sonar
	4.4.3		4.6.1.2		4.7.1.2	Comparison of SURTASS LFA sonar with other human-generated sources of oceanic noise—Analysis updated
			4.6.2		4.7.2	Cumulative effects due to injury and lethal takes—Updated literature review
			4.6.3		4.7.3	Cumulative effects on socioeconomic resources—Analysis updated
					4.7.4	Cumulative effects from concurrent LFA and MFA sonar operations—New analyses
	4.4.4		4.6.4		4.7.5	Summary of Cumulative Effects—Conclusion updated
			4.7		4.8	Evaluation of Alternatives—Revised
					4.9	Conclusions of analyses of potential impacts and effects of SURTASS LFA sonar on marine species
5		5		5		Mitigation Measures—Changes include increased number of offshore biologically import areas (OBIA)
6		6		6	6.2	Federal, State, Local Plans, Policies, and Controls—Updated
7		7			6.1	Unavoidable Adverse Impacts—No change/Incorporated by reference
8		8			6.3	Relationship Between Short-term Use of Man's Environment and Maintenance and Enhancement of Long-

Table P-1. SURTASS LFA Sonar FOEIS/EIS, FSEIS, and FSEIS/SOEIS comparison.

FOEIS/EIS		FSEIS		FSEIS/SOEIS		COMPARISON (FSEIS/SOEIS UPDATES/CHANGES)
CHAPTER	SUBCHAPTER	CHAPTER	SUBCHAPTER	CHAPTER	SUBCHAPTER	
						term Productivity—No change/Incorporated by reference
9		9			6.4	Irreversible/Irretrievable Commitments of Resources—No change/Incorporated by reference
10		10		7		Public Review Process—Updated
11		11		8		Distribution—Updated
12						Glossary—No changes/incorporated by reference (not included in this document)
13		12		9		Literature Cited—Updated
14		13		10		List of Preparers and Reviewers—Updated

EXECUTIVE SUMMARY

This Final Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (FSEIS/SOEIS) for Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems[1] provides supplemental analyses to the Final Overseas Environmental Impact Statement/Environmental Impact Statement (FOEIS/EIS) for SURTASS LFA Sonar (DoN, 2001) and the Final Supplemental Environmental Impact Statement (FSEIS) for SURTASS LFA Sonar (DoN, 2007a), which were filed with the United States (U.S.) Environmental Protection Agency in January 2001 and April 2007, respectively. This second supplemental analysis has been prepared in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [USC] §4321 et seq.)[2]; the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [CFR] §§1500-1508); Navy Procedures for Implementing NEPA (32 CFR §775); and Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions[3].

REFERENCES TO UNDERWATER SOUND LEVELS
• **References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dB), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa @ 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).** • **In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).** • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS/SOEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for the energy of all the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for details. As discussed in Appendix C, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001; 2007a).**

To meet long-range submarine detection capabilities necessary to provide U.S. forces with the time to react to and defend against potential undersea threats, the Navy developed the SURTASS LFA sonar system.

1 In this FSEIS/SOEIS, "SURTASS LFA sonar systems" refers to both the LFA and compact LFA (CLFA) systems, each having similar acoustic operating characteristics.

2 The provisions of NEPA apply to major federal actions that occur or have effects in the U.S., its territories, or possessions.

3 The provisions of EO 12114 apply to major federal actions that occur or have effects outside of U.S. territories (the U.S., its territories, and possessions).

The Federal actions considered are:

- The employment by the U.S. Navy of up to four SURTASS LFA sonar systems for routine training, testing, and military operations[4] in the oceanic areas (Figure ES-1) occurring in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea.
- The interrelated actions of NMFS' issuance of five-year regulations and subsequent letters of authorization (LOAs) under Section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA) for the incidental, but not intentional, taking of marine mammals during routine training, testing, and military opertations using SURTASS LFA sonar, following NMFS' regulatory process for issuing such regulations and LOAs.

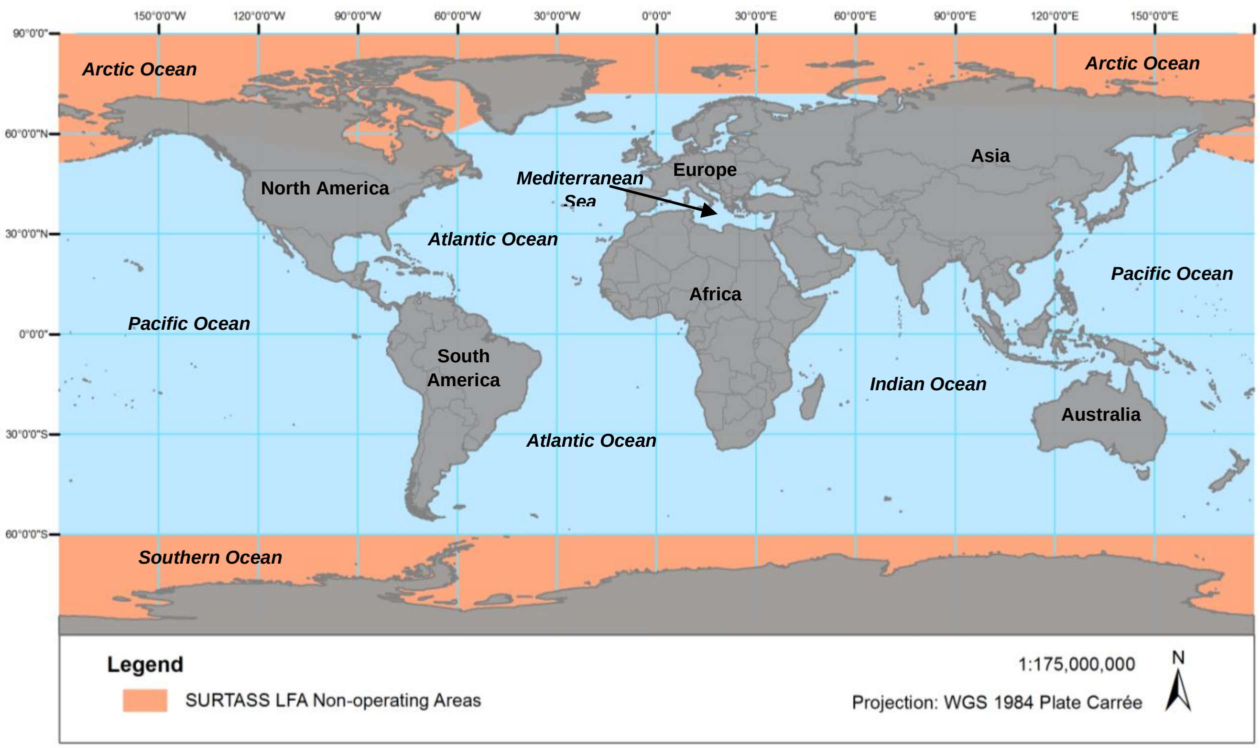


Figure ES-1. Potential areas of operation for SURTASS LFA sonar.

To reduce potential adverse effects on the marine environment, the Navy will use a suite of mitigation measures including: 1) visual, passive acoustic, and active acoustic monitoring; 2) delay/shutdown protocols for LFA transmissions; 3) geographic restrictions to prevent 180-decibel (dB) sound pressure level (SPL) or greater within 22 kilometers (km) (12 nautical miles [nmi]) of land, and in offshore biologically important areas (OBIA) during biologically important seasons: and 4) geographic restrictions to prevent greater than 145-dB SPL at known recreational and commercial dive sites. Mission planning for annual LOA applications will include the identification of marine areas based on updated scientific data and information for SURTASS LFA sonar routine testing, training, and military operations that contribute

4 The phrase "military operations" does not include use of SURTASS LFA sonar in armed conflict, or direct combat support operations or use of SURTASS LFA sonar during periods of heightened threat conditions, as determined by the National Command Authorities.

to the least practicable adverse impacts on marine mammals while meeting National Security requirements.

The purpose of the SURTASS LFA sonar FSEIS/SOEIS is to:

- Address concerns of the U.S. District Court for the Northern District of California (herein referred to as the Court) in its 6 February 2008 Opinion and Order in relation to compliance with NEPA and the Marine Mammal Protection Act (MMPA);
- Analyze a range of management alternatives to assist NMFS in carrying out its statutory responsibilities to authorize the incidental take of marine mammals associated with SURTASS LFA sonar operations for the five-year period of 2012 through 2017, if the required statutory determinations can be made; and
- Provide additional information and analyses pertinent to the proposed action.

The Navy is the lead agency, with the National Marine Fisheries Service (NMFS) as the cooperating agency, in accordance with NEPA regulations (40 CFR §1501.6).

In response to the Court ruling on the motion for preliminary injunction, the Deputy Assistant Secretary of the Navy for Environment (DASN(E)), on 14 November 2008, determined that the purposes of NEPA and Executive Order 12114 would be furthered by the preparation of additional supplemental analyses in the form of a new SEIS/SOEIS. On 21 January 2009, the Navy published a Notice of Intent (NOI) to prepare a SEIS/SOEIS for the employment of SURTASS LFA sonar, with NMFS as a cooperating agency (*Federal Register* (FR) (74 (12):3574) (DoN, 2009a). In the NOI, the Navy and NMFS solicited scoping comments on the above topics, to include OBIAs, greater coastal standoff, and cumulative effects. At the end of the 45-day public scoping period, no comments were received.

The initial FOEIS/EIS for SURTASS LFA sonar was completed in January 2001 by the Department of the Navy (DON) with NMFS as a cooperating agency in accordance with the requirements of NEPA and EO 12114. DASN(E) signed the Record of Decision (ROD) on 16 July 2002 (FR 67(141):48145), authorizing the operational employment of SURTASS LFA sonar systems contingent upon issuance by NMFS of LOAs under the MMPA and incidental take statements (ITS) under the ESA for each vessel.

To improve military readiness, the Department of Defense (DoD) asked Congress to amend several provisions of environmental laws as they applied to military training and testing activities. These legislative amendments were provided by Congress as parts of the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2003 (Public Law 107-314) and the NDAA for FY 2004 (Public Law 108-136).

The term “military readiness activity” is defined in NDAA for FY 2003 (16 U.S.C. § 703 note) to include all training and operations of the Armed Forces that relate to combat; and the adequate and realistic testing of military equipment, vehicles, weapons and sensors for proper operation and suitability for combat use. NMFS and the Navy have determined that the Navy’s SURTASS LFA sonar testing, training, and military operations that are the subject of NMFS’ Final Rules constitute military readiness activities because those activities comprise “training and operations of the Armed Forces that relate to combat” and constitute “adequate and realistic testing of military equipment, vehicles, weapons and sensors for proper operation and suitability for combat use.”

The provisions of the NDAA that specifically relate to SURTASS LFA sonar concern revisions to the MMPA, as summarized below:

- Overall—Changed the MMPA definition of “harassment,” adjusted the permitting system to better accommodate military readiness activities, and added a national defense exemption[5].

5 SURTASS LFA sonar has never been employed under this national defense exemption.

- Amended definition of "harassment" as it applies to military readiness activities and certain scientific activities conducted on behalf of the Federal government.
- Level A "harassment" defined as any act that injures or has the *significant* potential to injure a marine mammal or marine mammal stock in the wild.
- Level B "harassment" defined as any act that disturbs or is *likely to disturb* a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering *to a point where the patterns are abandoned or significantly altered*.
- Secretary of Defense may invoke a national defense exemption not to exceed two years for DoD activities after conferring with the Secretary of Commerce and the Secretary of Interior, as appropriate.
- NMFS' determination of "least practicable adverse impact on species or stock" must include consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.
- Eliminated the "small numbers" and "specified geographic region" requirements from the incidental take permitting process for military readiness activities.

The FSEIS/SOEIS focuses on DASN(E) direction for supplemental analyses, to include:

- Further analysis of potential additional OBIAs in regions of the world where the Navy intends to use SURTASS LFA sonar systems for routine training, testing and military operations;
- Further analysis of whether using a greater coastal standoff range where the continental shelf extends further than the current coastal standoff range (22 km [12 nmi]) is practicable for SURTASS LFA sonar; at least in some locations; and
- Further analysis of potential cumulative impacts with concurrent use of SURTASS LFA sonar with other active sonar sources.

Additional FSEIS/SOEIS analyses include:

- Updating literature reviews, especially for fish, sea turtles, and marine mammals;
- New subchapter on protected habitats, including ESA Critical Habitat, Essential Fish Habitat, and Marine Protected Areas;
- Updated literature review on commercial fisheries, marine mammal strandings, cumulative effects from anthropogenic oceanic noise, cumulative effects on socioeconomic resources; and
- Mitigation measures: changes due to increased number of OBIAs.

Information from these analyses is used to assist the Navy in determining how to employ SURTASS LFA sonar, including the selection of operating areas that the Navy requires for routine training, testing, and military operations in requests for MMPA LOAs submitted to NMFS.

ES.1 PURPOSE AND NEED

The Navy's primary mission is to maintain, train, equip, and operate combat-ready naval forces capable of accomplishing American strategic objectives, deterring maritime aggression, and assuring freedom of navigation in ocean areas. The Secretary of the Navy and Chief of Naval Operations (CNO) have continually validated that Anti-Submarine Warfare (ASW) is a critical part of that mission—a mission that requires unfettered access to both the high seas and littorals[6]. In order to be prepared for all potential threats, the Navy must maintain ASW core competency through continual training and operations in open-ocean and littoral environments.

The challenges faced by the U.S. Navy today are very different from those faced at the end of the Cold War nearly two decades ago. Since the early 1990s, U.S. Navy ASW strategy has had to shift from a known Soviet adversary to "uncertain potential adversaries" with less well-understood and defined strategies and goals (Benedict, 2005). The wide proliferation of diesel-electric submarines, a Chinese undersea force that is growing in size and tactical capability, and a resurgent Russian submarine service mean that U.S. ASW capability must meet more technologically-capable threats in a wider range of ocean environments (Benedict, 2005; ONI, 2009a and 2009b). Due to the advancement and use of quieting technologies in diesel-electric and nuclear submarines, undersea threats are becoming increasingly difficult to locate using the passive acoustic technologies that were effective during the Cold War. The range at which U.S. ASW assets are able to identify submarine threats is decreasing, and at the same time, improvements in torpedo design are extending the effective weapons range of those same threats (Benedict, 2005).

To meet this long-range submarine detection need, the U.S. Navy has investigated the use of a broad spectrum of acoustic and non-acoustic technologies. These are discussed in Subchapter 1.1.4. Of the technologies evaluated, LFA sonar is the only system capable of meeting the U.S. Navy's long-range ASW detection needs in a variety of weather conditions during the day and night. SURTASS LFA sonar is providing a quantifiable improvement in the Navy's undersea detection capabilities and therefore markedly improving the survivability of U.S. Naval forces in hostile ASW scenarios.

The proposed action meets the need of the U.S. Navy for improved long-range submarine detection capability, which is essential to providing U.S. forces the time necessary to react to and defend against potential undersea threats. It is critical that U.S. forces be able to identify threats while remaining at a safe distance beyond a submarine's effective weapon's range (Davies, 2007).

Sections 101(a)(5)(A) and (D) of the MMPA direct NMFS to allow, upon request, the incidental, but not intentional, taking of marine mammals of a species or population stock by U.S. citizens who engage in a specified military readiness activity if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of proposed authorization is provided to the public for review. Authorization for incidental taking shall be granted if NMFS finds that the taking will have a negligible impact on the affected species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses. NMFS must also prescribe: the permissible methods of taking pursuant to the activity; other means of effecting the "least practicable adverse impact" on the affected species or stock and its habitat and on the availability of such species or stock for subsistence uses; and requirements pertaining to the monitoring and reporting of such take.

NMFS anticipates receipt of applications to take marine mammals incidental to routine training, testing, and military operations using SURTASS LFA sonar pursuant to Section 101(a)(5)(A) of the MMPA. This FSEIS/SOEIS will assist NMFS in its MMPA decision-making process related to projected requests for LOAs in the Atlantic, Pacific, and Indian Oceans, and the Mediterranean Sea for future years. NMFS intends to use this FSEIS/SOEIS as the required NEPA documentation for the issuance of regulations and LOAs for the incidental taking of marine mammals during routine training, testing, and military operations using SURTASS LFA sonar. If necessary, NMFS may tier from this FSEIS/SOEIS to support future SURTASS LFA authorization decisions if such activities fall outside the scope of this FSEIS/SOEIS.

---

6 See Subchapter 1.1.3 for the definition of "littoral."

ES.2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

SURTASS LFA sonars are long-range systems operating in the LF band (below 1,000 Hz). These systems are composed of both active and passive components (Figure ES-2). SONAR is an acronym for SOund NAvigation and Ranging, and its definition includes any system that uses underwater sound, or acoustics, for observations and communications. Sonar systems are used for many purposes, ranging from commercial off-the-shelf (COTS) “fish finders” to military ASW systems for detection and classification of submarines. There are two basic types of sonar:

- Passive sonar detects the sound created by an object (source) in the water. This is a one-way transmission of sound waves traveling through the water from the source to the receiver and is the same as people hearing sounds that are created by another source and transmitted through the air to the ear.
- Active sonar detects objects by creating a sound pulse, or “ping,” that is transmitted through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver). Some marine mammals locate prey and navigate utilizing this form of echolocation.

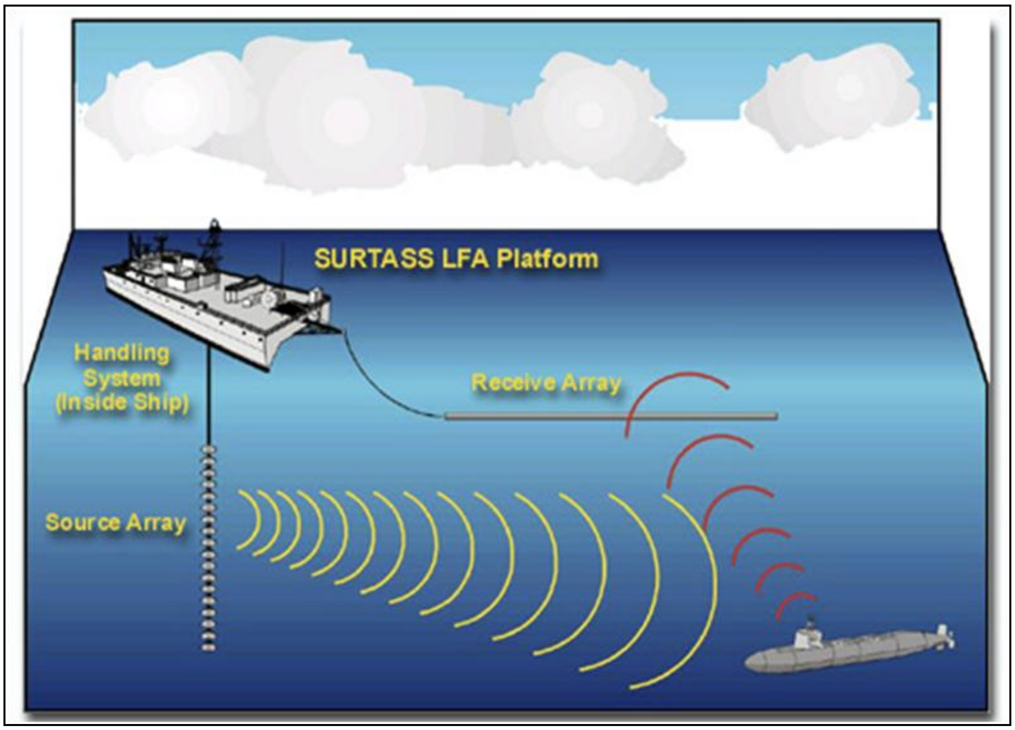


Figure ES-2. SURTASS LFA sonar systems.

ES.2.1 PROPOSED ACTION

The proposed action herein is the U.S. Navy employment of up to four SURTASS LFA sonar systems in the oceanic areas presented in Figure ES-1. Based on current operational requirements, routine training, testing and military operations using these sonar systems could occur in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea.

LFA systems were initially installed on two SURTASS vessels: R/V *Cory Chouest*, which was retired in fiscal year (FY) 2008, and USNS IMPECCABLE (T-AGOS 23). As future undersea warfare requirements continue to transition to littoral ocean regions, the introduction of a compact active system deployable on SURTASS ships was needed. This system upgrade is known as Compact LFA, or CLFA. CLFA consists of smaller, lighter-weight source elements than the current LFA system, and is compact enough to be installed on the VICTORIOUS class platforms (T-AGOS 19). The initial CLFA installation was completed on the USNS ABLE (T-AGOS 20) in 2008 and at-sea-testing commenced in August 2008. CLFA improvements include:

- Operational frequency, within the 100 to 500 Hz range, matched to shallow water environments with little loss of detection performance in deep water environments.
- Improved reliability and ease of deployment.
- Lighter-weight design with mission weight of 64,410 kilograms (kg) (142,000 pounds [lb]) vice 155,129 kg (324,000 lb) mission weight of LFA).

With the R/V *Cory Chouest's* retirement in FY 2008, two systems are currently operational. At present, there is one SURTASS LFA sonar system onboard USNS IMPECCABLE (T-AGOS 23) and one SURTASS CLFA sonar system onboard USNS ABLE (T-AGOS 20). Two additional CLFA systems are planned for the T-AGOS 19 Class. Late in FY 2011, the CLFA system onboard USNS EFFECTIVE (T-AGOS 21) commenced at-sea testing and training. The CLFA system to be installed onboard USNS VICTORIOUS (T-AGOS 19) is scheduled for at-sea testing and training in FY 2012. Therefore, no more than four systems are expected to be in use through FY 2017, and thus this FSEIS/SOEIS considers the employment of up to four systems.

The operational characteristics of CLFA are comparable to the existing LFA system as presented in Subchapter 2.1 of the FOEIS/EIS, FSEIS and this document. Therefore, the potential impacts from CLFA are expected to be similar to, and not greater than, those from the existing SURTASS LFA sonar system. Hence, for this analysis, the term LFA will be used to refer to both the existing LFA system and/or the compact (CLFA) system, unless otherwise specified.

The active component of the existing SURTASS LFA sonar system, LFA, is an active adjunct to the SURTASS passive capability and is planned for use when passive system performance is inadequate. LFA complements SURTASS passive operations by actively acquiring and tracking submarines when they are in quiet operating modes, measuring accurate target range, and re-acquiring lost contacts.

LFA is a set of acoustic transmitting source elements suspended by cable under an ocean surveillance vessel, such as the USNS IMPECCABLE (T-AGOS 23) and the VICTORIOUS Class (T-AGOS 19 Class) (Figure ES-2). These elements, called projectors, are devices that produce the active sound pulse, or ping. The projectors transform electrical energy to mechanical energy that set up vibrations, or pressure disturbances, within the water to produce a ping.

The characteristics and operating features of the active component (LFA) are:

- The source is a vertical line array (VLA) of up to 18 source projectors suspended below the vessel. LFA's transmitted beam is omnidirectional (360 degrees) in the horizontal, with a narrow vertical beamwidth that can be steered above or below the horizontal.
- The source frequency is between 100 and 500 Hz. A variety of signal types can be used, including continuous wave (CW) and frequency-modulated (FM) signals.
- The source level (SL) of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB re 1 µPa at 1 m (rms) or less. As measured by sound pressure level (SPL), the sound field of the array can never be higher than the SL of an individual source projector.

- The typical LFA signal is not a constant tone, but rather a transmission of various waveforms that vary in frequency and duration. A complete sequence of sound transmissions is referred to as a wavetrain (also known as a ping). These wavetrains last between 6 and 100 seconds with an average length of 60 seconds. Within each wavetrain the duration of each continuous frequency sound transmission is no longer than 10 seconds.
- Average duty cycle (ratio of sound "on" time to total time) is less than 20%. The typical duty cycle, based on historical LFA operational parameters (2003 to 2011), is nominally 7.5 to 10%.
- The time between wavetrain transmissions is typically 6 to 15 minutes.

The passive, or listening, part of the system is SURTASS, which detects returning echoes from submerged objects, such as threat submarines, through the use of hydrophones. These devices transform mechanical energy (received acoustic sound wave) to an electrical signal that can be analyzed by the processing system of the sonar. Advances in passive acoustic technology have led to development of the SURTASS Twin-Line (TL-29A) horizontal line array (HLA), a shallow water variant of the single line SURTASS system. TL-29A consists of a "Y" shaped array with two apertures. The array is approximately 1/5th the length of a standard SURTASS array, or approximately 305 m (1,000 ft) long. The TL-29A delivers enhanced capabilities, such as its ability to be towed in shallow water environments in the littoral zones, to provide significant directional noise rejection, and to resolve bearing ambiguities without having to change vessel course.

The passive capability of the USNS IMPECCABLE (T-AGOS 23) was recently upgraded with the installation of the TL-29A array. The three VICTORIOUS class vessels, which are, or will be, equipped with CLFA, will be outfitted with the newer SURTASS TL-29A passive array.

The SURTASS LFA sonar vessel typically maintains a speed of at least 5.6 kilometers per hour (kph) (3 knots [kt]) through the water in order to tow the HLA. The return signals, which are usually below background or ambient noise level, are processed and evaluated to identify and classify potential underwater threats.

An interrelated federal action is the issuance of regulations and LOAs under Section 101(a)(5)(A) of the MMPA, by NMFS, for the incidental taking of marine mammals during SURTASS LFA sonar activities, in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea. If NMFS makes all necessary legal determinations under the MMPA, it will issue regulations. These regulations allow NMFS to: (1) issue LOAs for the incidental take of marine mammals during the Navy's specified activities and timeframes; (2) set forth the permissible methods of taking; (3) set forth other means of effecting the least practicable adverse impact on marine mammal species and their habitat; and (4) set forth requirements pertaining to the monitoring and reporting of the incidental taking.

ES.2.2 ALTERNATIVES

NEPA requires federal agencies to prepare an EIS that discusses the environmental effects of a reasonable range of alternatives (including the No Action Alternative). These alternatives are described in Subchapter 2.6 of this FSEIS/SOEIS. The FOEIS/EIS (DoN, 2001) initially analyzed all potential technologies, both acoustic and non-acoustic, and determined that only active sonar (specifically LFA) would meet the Navy's purpose and need. In addition to the No Action Alternative, analyses in this document are provided for two alternatives. The analyses of these alternatives are intended to take into account the additional analysis contained in this FSEIS/SOEIS on the issue of OBIAs and coastal standoff ranges. Alternatives 1 and 2 also include the same mitigation measures presented in the 2007 FSEIS Subchapters 2.4, 5.1, 5.2, and 5.3, which are incorporated herein by reference.

The alternatives considered in this FSEIS/SOEIS are:

- No Action;

- Alternative 1—Same as the 2007 FSEIS Preferred Alternative; and
- Alternative 2—Alternative 1 with new proposed list of OBIAs (total 21) (the Navy's preferred alternative).

ES.3 AFFECTED ENVIRONMENT

The environments that could potentially be affected by Navy employment of the SURTASS LFA sonar system, include:

- **Marine Environment**, including ambient noise in the oceans, physical environmental factors affecting underwater acoustic propagation, and ocean acoustic regimes;
- **Marine Organisms,** including marine mammals and threatened and endangered species; and
- **Socioeconomic**, including commercial and recreational fisheries, other recreational activities, research and exploration activities, and coastal zone management consistency.

ES.3.1 MARINE ENVIRONMENT

There have been no significant changes to the knowledge or understanding of the marine environment, underwater acoustic propagation, or propagation modeling. The information in Subchapter 3.1 (Marine Environment) in the FOEIS/EIS remains valid, and its contents are incorporated herein by reference.

Anthropogenic sounds that could affect underwater ambient noise levels arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include:

- Transportation (ship-generated noise);
- Dredging;
- Construction;
- Hydrocarbon and mineral exploration and recovery;
- Geophysical (seismic) surveys;
- Sonars;
- Explosions; and
- Ocean science studies.

The dominant source of anthropogenic sound in the sea stems from the propulsion of ships (Tyack, 2008). At the lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background. Shipping noise centers in the 20 to 200 Hz frequency band, and is increasing yearly (Ross, 2005). Ross (1976) estimated that between 1950 and 1975 shipping had caused a rise of 10 dB SPL in ambient ocean noise levels, and he predicted that the level would increase by another 5 dB SPL by the beginning of the 21st century. Andrew et al. (2002) collected ocean ambient sound data from 1994 to 2001 using a receiver on the continental slope off Point Sur, California. These data were compared to measurements made from 1963 to 1965 by an identical receiver. The data demonstrated an increase in ambient noise over the 33-year period of approximately 10 dB SPL in the frequency range of 20 to 80 Hz, primarily due to commercial shipping. There were also increases as large as 9 dB SPL in the frequency range from 100 Hz up to 400 Hz, for which the cause was less obvious (Andrews et al., 2002). McDonald et al. (2006a) compared data sets from 1964 to 1966, and 2003 to 2004 for continuous measurements west of San Nicolas Island, California and found an increase in ambient noise levels of 10 to 12 dB SPL at 30 to 50 Hz.

When combined with the naturally occurring and other man-made noise in the world's oceans, SURTASS LFA sonar barely contributes a measurable portion of the total acoustic energy. This and LFA's low duty cycle (LFA is transmitting only 7.5 to 10% of the time during the projected maximum 432 hours of operations per vessel annually) support the conclusion that the operation of up to four SURTASS LFA sonar systems will not significantly add to oceanic ambient noise.

ES.3.2 SCIENTIFIC SCREENING OF MARINE ANIMAL SPECIES FOR POTENTIAL SENSITIVITY TO LF SOUND

Marine species must be able to hear underwater LF sound and/or have some organ or tissue capable of changing sound energy into mechanical effects to be affected by LF sound. In order to be affected by LF sound, the organ or tissue must have an acoustic impedance different from water, where impedance is the product of density (kg/m^3 or lb/yd^3) and sound speed (m/sec or ft/sec). Thus, many organisms would be unaffected, even if they were in areas of LF sound, because they do not have an organ or tissue with acoustic impedance different from water. These factors immediately limit the types of organisms that could be adversely affected by LF sound. In other words, to be evaluated for potential impact in this FSEIS/SOEIS, the marine species must: 1) occur within the same ocean region and during the same time of year as the SURTASS LFA sonar operation, 2) possess some sensory mechanism that allows it to perceive the LF sounds, and/or 3) possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. Species that did not meet these criteria were excluded from consideration. Species that met the screening selection were fish, sea turtles, and marine mammals.

The process by which a marine species' potential to be affected by SURTASS LFA sonar is discussed in Subchapter 3.2.1 of the FSEIS (DoN, 2007a). Except as noted in Chapter 3 of this FSEIS/SOEIS, there have been no significant changes to the knowledge or understanding relating to species screening. The information in Subchapter 3.2.1 (Species Screening) in the 2007 FSEIS remains valid, and the contents are incorporated herein by reference.

ES.3.3 MARINE ORGANISMS

A thorough review of available literature on fish, sea turtles, and marine mammals was conducted with emphasis on data developed after the completion of the FSEIS in 2007. These data are presented in this FSEIS/SOEIS, Subchapter 3.2. Subchapter 3.2.6 provides a discussion of potential habitats to include critical habitats, essential fish habitates, and marine protected areas.

ES.3.4 SOCIOECONOMIC

As SURTASS LFA sonar operates in open ocean areas it has the potential to interact with other activities taking place in these areas, including: commercial fishing, aboriginal subsistence hunting for cetaceans and pinnipeds, oceanographic research, and recreational activities. Many aquatic activities take place in nearshore or inland water areas where SURTASS LFA sonar is not proposed to operate. Pertinent socioeconomic data are presented in this FSEIS/SOEIS, Subchapter 3.3.

ES.4 IMPACTS OF THE PROPOSED ACTION AND ALTERNATIVES

The basis for the analysis of potential impacts to marine species presented in this FSEIS/SOEIS is consistent with the 2001 FOEIS/EIS and the 2007 FSEIS and has been updated based on the best available literature, the Long Term Monitoring Program of current SURTASS LFA sonar operations, and continuing research. Further, no new data contradict any of the assumptions or conclusions presented in Chapter 4 of both the FOEIS/EIS and FSEIS; hence, their contents are incorporated herein by reference.

For SURTASS LFA sonar alternatives, potential impacts should be reviewed in the context of the basic operational characteristics of the system:

- A maximum of four systems, with the potential to be deployed in the Pacific-Indian Ocean area and in the Atlantic Ocean-Mediterranean Sea area.

- The USNS IMPECCABLE (T-AGOS 23) is equipped with a SURTASS LFA sonar system. Three additional VICTORIOUS class (T-AGOS 19) platforms have been equipped with or, are scheduled to be outfitted with, compact LFA systems (see Subchapter 2.1). These vessels are, or will be, U.S. Coast Guard-certified for operations. In addition, they will operate in accordance with all applicable Federal and U.S. Navy rules and regulations related to environmental compliance. SURTASS LFA sonar vessel movements are not unusual or extraordinary and are part of routine operations of seagoing vessels. Therefore, there should be no unregulated environmental impacts from the operation of SURTASS LFA sonar vessels.
- At-sea missions would be temporary in nature. Of an estimated maximum 294 underway days per year per vessel, the SURTASS LFA sonar would be operated in the active mode a maximum of 240 days. During these 240 days, active transmissions would occur for a maximum of 432 cumulative hours per year per vessel. Average duty cycle (ratio of sound "on" time to total time) of the SURTASS LFA sonar active transmission mode, based on historical LFA operational parameters since 2003, is nominally 7.5 to 10%. That is, 7.5 to 10% of the time the LFA transmitters could be on; and 90 to 92.5% of the time the LFA transmitters would be off, thus adding no sound into the water. On an annual basis, each SURTASS LFA vessel is limited to transmitting no more than 4.9% of the time (432 hrs/yr or 18 days/yr).

The types of potential effects on marine animals from SURTASS LFA sonar operations can be broken down into several categories:

- **Non-auditory injury**: This includes the potential for resonance of the lungs/organs, tissue damage, and mortality from direct acoustic impacts on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas.
- **Permanent threshold shift (PTS)**: A severe situation occurs when underwater sound intensity is very high or of such long duration that the result is a permanent hearing loss on the part of the listener, which is referred to as PTS. This constitutes Level A "harassment" under the MMPA, as does any other injury to a marine mammal. The intensity and duration of an underwater sound that will cause PTS varies across species and even among individual animals. PTS is a consequence of the death of the sensory hair cells of the auditory epithelia of the ear and a resultant loss of hearing ability in the general vicinity of the frequencies of stimulation (Salvi et al., 1986; Myrberg, 1990; Richardson et al., 1995). PTS results in a permanent elevation in hearing threshold—an unrecoverable reduction in hearing sensitivity (Southall et al., 2007).
- **Temporary threshold shift (TTS)**: Underwater sounds of sufficient loudness can cause a temporary condition known as TTS in which an animal's hearing is impaired for a period of time. After termination of the sound, normal hearing ability returns over a period that may range anywhere from minutes to days, depending on many factors, including the intensity and duration of exposure to the sound. Hair cells may be temporarily affected by exposure to the sound, but they are not permanently damaged or killed. Thus, TTS is not considered an injury (Richardson et al., 1995; Southall et al., 2007), although during a period of TTS, animals may be at some disadvantage in terms of detecting predators or prey.
- **Behavioral change**: Various vertebrate species are affected by the presence of intense underwater sounds in their environment (Salvi et al., 1986; Richardson et al., 1995). Behavioral responses to these sounds vary from subtle changes in surfacing and breathing patterns, to cessation of vocalization, to active avoidance or escape from regions of high sound levels (Wartzok, et al., 2004). For military readiness activities, such as the use of SURTASS LFA sonar, Level B "harassment" under the MMPA is defined as any act that disturbs or is likely to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or significantly altered. Behaviors include migration, surfacing, nursing, breeding, feeding, and

sheltering. The National Research Council (NRC, 2005) discusses biologically significant behaviors and possible effects. It states that an action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce. These are the effects on individuals that can have population-level consequences and affect the viability of the species (NRC, 2005). While sea turtles and fish do not fall under MMPA harassment definitions, like marine mammals, it is possible that loud sounds could disturb the behavior of fish and sea turtles, resulting in similar consequences as for marine mammals.

- **Masking and Impaired Communications**: The presence of intense underwater sounds in the environment can potentially interfere with an animal's ability to hear sounds of relevance to it and reduce acoustic information essential to conspecies communications. This effect, known as "auditory masking," could interfere with the animal's ability to detect biologically-relevant sounds, such as those produced by predators or prey, thus increasing the likelihood of the animal not finding food or being preyed upon.
- **Stress:** The potential for acoustically-induced stress in marine mammals is presented as part of the cumulative effects discussion in Subchapters ES.4.6 and 4.7.1.2.

For the purposes of the SURTASS LFA sonar analyses presented in this FSEIS/SOEIS, all marine animals exposed to underwater sound with ≥180 dB re 1 µPa (rms) SPL received level (RL) are evaluated as if they are injured, which includes non-acoustic injury and permanent hearing loss. Even though actual injury would not occur unless animals were exposed to sound at a level greater than this value (Popper et al., 2007; Southall et al., 2007; Kane et al., 2010), the analysis in this document will continue to define LFA's injury level as ≥180 dB re 1 µPa (rms) RL. This should be viewed as a conservative value, used to maintain consistency in the analytical methodologies previously utilized in SURTASS LFA sonar environmental impact statements (DoN, 2001 and 2007a), in incidental take applications under the MMPA, and in consultations under the ESA.

ES.4.1 POTENTIAL IMPACTS ON FISH SPECIES AND STOCKS

Since the original FOEIS/EIS and the subsequent FSEIS, there have been a number of relevant studies on the potential effects of underwater sound on fish, including sharks, and several other pertinent studies that have come forth. This FSEIS/SOEIS provides summaries of the recent research and updates the analysis of the potential effects of the proposed alternatives based on the following SURTASS LFA sonar operational parameters:

- Small number of SURTASS LFA sonar systems to be deployed;
- Geographic restrictions imposed on system employment;
- Narrow bandwidth of SURTASS LFA sonar active signal (approximately 30 Hz);
- Slowly moving ship, coupled with low system duty cycle, would mean that fish would spend less time in the LFA mitigation zone (180-dB SPL sound field); therefore, with a ship speed of less than 9.3 km/hr (5 kt), the potential for animals being in the sonar transmit beam during the estimated 7.5 to 10% of the time the sonar is actually transmitting is very low; and
- Small size of the LFA mitigation zone (180-dB SPL sound field) relative to fisheries provinces and open ocean areas.

Due to the lack of more definitive data on fish/shark stock distributions in the open ocean, it is not feasible to estimate the percentage of a stock that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth during an LFA sound transmission.

There have been several studies on the effects of both Navy sonar and seismic airguns[7] that are relevant to potential effects of SURTASS LFA sonar on Osteichthyes (bony fish). In the most pertinent of these, the Navy funded independent scientists to analyze the effects of SURTASS LFA sonar on fish. Results from this study were originally presented in the FSEIS. The findings from this study have been presented at conferences, peer-reviewed and published in scientific journals (Popper et al., 2005a, 2007; Halvorsen et al., 2006). These results have now been updated with a related study that examined in detail the effects of SURTASS LFA sonar on fish physiology (Kane et al., 2010). Several other studies have assessed the effects of seismic airguns on fish. Thus, while most research before 2001 studied the effects of sounds using pure tones of much longer duration than the SURTASS LFA sonar signals, many of the more recent studies provide insight into the impact of each of these sounds on fish. With the caveat that only a few species have been examined in these studies, the investigations found little or no effect of high intensity sounds on a number of taxonomically and morphologically diverse species of fish; and there was no mortality as a result of sound exposure, even when fish were maintained for days post-exposure.

The Navy-funded study on the effects of SURTASS LFA sonar sounds on three species of fish (rainbow trout, channel catfish, and hybrid sunfish), also examined long-term effects on sensory hair cells of the ear. In all species, even up to 96 hours post-exposure, there were no indications of damage to sensory cells (Popper et al., 2005a, 2007; Halvorsen et al., 2006).

If SURTASS LFA sonar operations occur in proximity to fish stocks, members of some fish species could potentially be affected by LFA sounds. Even then, the impact on fish is likely to be minimal to negligible, since only an inconsequential portion of any fish stock would be present within the 180-dB SPL sound field at any given time. Moreover, recent results from direct studies of the effects of LFA sounds on fish (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010) provide evidence that SURTASS LFA sonar sounds at relatively high received levels (up to 193 dB re 1 µPa [rms] SPL) have minimal impact on at least the species of fish that have been studied. Nevertheless, the 180-dB SPL criterion is maintained for the analyses presented in this FSEIS/SOEIS, with emphasis that this value is *highly conservative* and protective of fish.

ES.4.2 POTENTIAL IMPACTS ON SEA TURTLE SPECIES AND STOCKS

The best available sea turtle population estimates (abundances) underestimate the sea turtle populations, as they only represent counts of nesting females and do not account for non-nesting females, males, or juveniles of the species. Few sea turtle density estimates are available worldwide and are usually only for nearshore nesting waters that are not representative of the majority of the open ocean. Nearly all species of sea turtles occur in low numbers over most of their ranges, resulting in distributions in the open ocean that are greatly and widely dispersed. Coupled with low numbers dispersed over enormous areas is the additional complexity of some sea turtle species, such as the leatherback and olive ridley turtles, spending their entire lives dispersed widely in pelagic waters, while the early lifestages of other sea turtle species spend the “lost years” drifting around the central ocean gyres. Due to the lack of more definitive data on sea turtle stock distributions in the open ocean, it is not feasible to estimate the percentage of a stock that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth, during an LFA sound transmission.

Data on sea turtle sound production and hearing are very limited. The best available data on sea turtle hearing are presented in Chapter 3 of this document. Further, there are no new data that contradict any of the assumptions or conclusions regarding potential effects to sea turtles in Subchapter 4.2 of the FSEIS

---

7 Seismic airguns differ from SURTASS LFA sonar in that they generally transmit in the 5 to 20 Hz frequency band and their typical airgun array firing rate is once every 9 to 14 seconds, but for very deep water surveys, the rate could be once every 42 sec. Airgun acoustic signals are typically measured in peak-to-peak pressures, which are generally higher than continuous sound levels from other ship and industrial noise. Broadband SLs of 248 to 255 dB SPL (peak-to-peak) are typical for a full-scale array but can be as high as 259 dB SPL. Airgun onset is generally much more rapid (sharper) than that of sonar.

(DoN, 2007a), which is incorporated herein by reference. Very few studies of the potential effects of underwater sound on sea turtles exist and most of those available examined the effects of sounds of much longer duration or of different types (e.g., seismic airgun) than SURTASS LFA sonar signals. This FSEIS/SOEIS provides summaries of the recent research on underwater sound on sea turtles.

In this FSEIS/SOEIS, the conservative SPL threshold for injury to sea turtles is 180 dB re 1 µPa (rms), which is coincident with the LFA mitigation zone. The LFA mitigation zone covers a volume ensonified to a received level ≥180 dB re 1 µPa (rms) around the SURTASS LFA sonar array, which is centered at a nominal depth of 122 m (400 ft) below the water surface. Based on spherical spreading, the LFA mitigation zone will vary between the approximate ranges of 750 to 1,000 m (2,461 to 3,481 ft) from the source array, over a depth of approximately 87 to 157 m (285 to 515 ft).

The small size of the LFA mitigation zone relative to the enormous area and volume of the ocean, as well as the depth of the mitigation zone are important considerations when evaluating the potential for impacts on sea turtles. Most sea turtle species spend a high percentage of their lives in the upper 100 m (328 ft) of the water column, particularly if they are transiting between foraging and nesting grounds in the open ocean. Sea turtles may be found in the open ocean or oceanic environment not only as adults migrating between nesting and foraging habitats but also during early lifestages (post-hatchlings or juveniles) or as foraging adult leatherback and olive ridley turtles. The distribution of sea turtles in the open ocean is greatly and widely dispersed due to the vast area of oceanic waters worldwide over which sea turtles potentially can occur. Turtle foraging grounds do not encompass all available continental shelf waters but are typically in restricted areas of the productive shelf and inshore estuarine waters. Thus, most frequently, sea turtles would occur in the water column above the LFA mitigation zone and, thus, would not encounter transmissions ≥180 dB re 1 µPa (rms), the threshold at which they are conservatively considered to be injured.

In the shallow, nearshore continental shelf waters where foraging and nesting/breeding turtles would most often occur, SURTASS LFA sonar operations are geographically constrained due to operational depth restrictions and the coastal standoff range (no transmissions above 180 dB re 1 µPa (rms) SPL within 22 km [12 nmi] of any coastlines). Also, visual and acoustic monitoring measures are conducted during active LFA sonar transmissions to further reduce the potential for surface animals potentially diving into the LFA mitigation zone. The position of the HF/M3 sonar system above the top of the LFA sonar array means that a sea turtle would have to swim from the surface through the HF/M3 sonar detection zone to enter into the 180-dB LFA mitigation zone, making an acoustic detection of the animal likely. While visual monitoring is less effective for sea turtles due to their smaller size and low surface profile, visual sightings of sea turtles have occurred during mitigation monitoring of SURTASS LFA sonar and resulted in the suspension of the sonar to ensure safety of the observed turtle (DoN, 2011).

In addition to the water column usage by sea turtles, the geographic restrictions for LFA sonar use, and the mitigation measures that together result in a reduced potential for injury to sea turtles, other operational parameters of the sonar further reduce the already small likelihood for injury to individual sea turtles. These operational parameters include the small number of SURTASS LFA sonar systems to be deployed (no more than four under the requested five-year Rule), the narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz), the slow speed at which the SURTASS LFA vessels travel (<5 kt), and the low duty cycle of the sonar system (7.5 to 10%). Any masking effects of the sonar would be temporary and not significant.

For these reasons, the potential for SURTASS LFA sonar operations to expose individual sea turtles to injurious sound levels or to cause TTS and/or behavioral changes is considered negligible. Due to the small likelihood for injury to individual sea turtles, the potential impact is not significant to sea turtles on a stock level. Therefore, the operation of SURTASS LFA sonar would not adversely impact sea turtle stocks.

ES.4.3 POTENTIAL IMPACTS ON MARINE MAMMAL SPECIES AND STOCKS

Potential effects on marine mammals from SURTASS LFA sonar operations include: 1) non-auditory injury; 2) permanent loss of hearing; 3) temporary loss of hearing; 4) behavioral change; and 5) masking (including impaired communications). Richardson et al. (1995) provided the most comprehensive review of contemporary knowledge on the sources and effects of underwater anthropogenic sound on marine mammals, and Nowacek et al. (2007) provide a more recent review of the effects of underwater anthropogenic sound on cetaceans. Nowacek et al. (2007) included an update on the documented behavioral, acoustic and some physiological responses of cetaceans to man-made noise. They focused on literature that reported quantitatively on the sound field and some indicator of response. Southall et al. (2007) reported on the results from a panel of acoustic research experts in the behavioral, physiological, and physical disciplines. The panel's purpose was to review the expanding literature on marine mammal hearing, and physiological and behavioral responses to anthropogenic sound, with the objective of proposing exposure criteria for certain effects. More recently, Hatch et al. (2008) and Clark et al. (2009) have addressed the issue of acoustic masking and presented metrics for quantifying the influences of anthropogenic noise sources on whales that communicate in the LF band.

These papers, additional literature reviews, and research indicate that there are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS and the FSEIS. Thus, the findings presented in the 2001 FOEIS/EIS and the 2007 FSEIS regarding potential effects on marine mammals remain valid and are incorporated by reference herein. This FSEIS/SOEIS provides a summary of the recent literature reviews and the overall potential for effects of SURTASS LFA sonar operations on marine mammals.

The potential effects from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) are considered negligible, and the potential effects on the stock of any marine mammal from temporary loss of hearing or behavioral change (significant change in a biologically important behavior) are considered minimal. Any auditory masking in marine mammals due to LFA sonar signal transmissions is not expected to be severe and would be temporary. The likelihood of LFA sonar transmissions causing marine mammals to strand is negligible.

ES.4.4 RISK ASSESSMENT APPROACH FOR SURTASS LFA SONAR OPERATIONS

The goal of the risk assessment is to analyze the proposed action and alternatives for the employment by the U.S. Navy of up to four SURTASS LFA sonar systems for routine training, testing, and military operations in oceanic areas (Figure ES-1). Based on current U.S. national security and operational requirements, routine training, testing and military operations using these sonar systems could occur in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea. These potential operating areas are the same as those assessed in the 2001 FOEIS/EIS and 2007 FSEIS except for additional OBIAs. To reduce adverse effects on the marine environment, areas would be excluded as necessary to prevent 180-dB SPL RL or greater in coastal waters within 22 km (12 nmi) of land and in OBIAs during biologically important seasons; to prevent greater than 145-dB SPL RL at known recreational and commercial dive sites; to prevent exposure of marine mammals and sea turtles to below 180 dB SPL RL within the LFA mitigation zone plus 1-km buffer zone by monitoring for their presence with visual, passive acoustic, and active acoustic mitigation methods, and suspending transmissions when one of these animals enters the zone; planning missions to ensure that the potential annual takes are within limitations required by the Rule and LOAs; and reporting quarterly to NMFS on all SURTASS LFA sonar active operations.

Risk assessments must provide decision-makers and regulators results that demonstrate:

- Under the MMPA, the total taking will have a negligible impact on the marine mammal species or stock(s), and will not have an unmitigable adverse impact on the availability of species or stock(s) for subsistence uses; further, the information can be used to inform the permissible methods of taking and requirements pertaining to the mitigation, monitoring, and reporting of such takings (including consideration of personnel safety, practicability of implementation, and impact on the effectiveness of military readiness activities); and

- Under the ESA, employment of SURTASS LFA sonar is not likely to jeopardize the continued existence of threatened/endangered marine species or result in the destruction or adverse modification of critical habitat.

Since it was neither reasonable nor practicable to model all areas of the world's oceans in which SURTASS LFA sonar could operate, the initial risk assessment in the 2001 FOEIS/EIS analyzed 31 potential operating sites. This initial analytical process was refined to provide sensitivity and risk analyses sufficient to identify and select potential SURTASS LFA sonar mission areas with minimal marine mammal/animal activity consistent with the Navy's operational readiness requirements. These analyses were used to provide NMFS with reasonable and realistic pre- and post-operational risk estimates for marine mammal stocks in the proposed SURTASS LFA sonar operating areas. This process was documented in the 2007 FSEIS.

The modeling of the 31 sites represented the upper bound of potential effects (both in terms of possible underwater acoustic propagation conditions, and marine mammal population and density) that could be expected from operation of the SURTASS LFA sonar system. The conservative assumptions of the FOEIS/EIS and FSEIS are still valid. Moreover, there are no new data that contradict any of the assumptions or conclusions made in the FOEIS/EIS and FSEIS.

In this FSEIS/SOEIS's supplemental analysis, 19 additional potential SURTASS LFA sonar operating sites have been analyzed. These sites were chosen because they represent, based on today's political climate, areas where SURTASS LFA sonar could potentially conduct testing, training, or military operations during the 5-year period of the next MMPA Rule.

Under the MMPA Rule, the Navy must apply for annual LOAs. In these applications, the Navy projects where it intends to operate for the period of the next annual LOAs, and provides NMFS with reasonable and realistic risk estimates for marine mammal stocks in the proposed SURTASS LFA sonar mission areas. The LOA application analytical process uses a conservative approach by integrating mission planning needs and a cautious assessment of the limited data available on specific marine mammal populations, seasonal habitat, and activity. Because of the use of conservative assumptions, it is likely that the aggregate effect of such assumptions is an overestimation of risk—a prudent approach for environmental conservation when there are data gaps and other sources of uncertainty. The total annual risk for each stock of marine mammal species is estimated by summing a particular species' risk estimates within that stock, across SURTASS LFA sonar mission areas. Each stock, for a given species, is then examined. Based on this approach, the highest total annual estimated risk (upper bound) for marine mammal species' stocks are provided in the LOA applications.

Information on how the density and stock/abundance estimates are derived for the selected SURTASS LFA sonar mission areas is provided in the LOA applications. These data are derived from current, available published source documents, and provide general information for each mission area with species-specific information on the marine mammals that could potentially occur in that area, including estimates for their stock/abundance and density.

Estimates of the percentage of marine mammal stocks affected by SURTASS LFA sonar operations in the 19 potential operating areas, for the seasons specified, have been derived for this document (Tables 4-5 through 4-23). The estimated stock values support the conclusion that estimates of potential effects to marine mammal stocks are below the conditions delineated by NMFS in the LOAs issued under the 2007 Final Rule.

ES.4.4.1 Court's Concerns

The following three areas address the primary concerns of the Court in its 6 February 2008 Opinion and Order, in relation to compliance with NEPA and the MMPA.

Additional Offshore Biologically Important Areas (OBIAs)

Offshore biologically important areas (OBIA) are initially defined in the 2001 SURTASS LFA Sonar FOEIS/EIS as those areas of the world's oceans outside of 22 km (12 nmi) of a coastline where marine animals of concern (those animals listed under the ESA and/or marine mammals) congregate in high densities to carry out biologically important activities. These areas include migration corridors; breeding and calving grounds; and feeding grounds.

NMFS revised the screening criteria for the 2011 DSEIS/SOEIS and the 2011 Proposed Rule to determine an area's eligibility to be considered as a nominee for an OBIA for marine mammals. These OBIA screening criteria are: (1) Areas with: (a) High densities of marine mammals; or (b) Known/defined breeding/calving grounds, foraging grounds, migration routes; or (c) Small, distinct populations of marine mammals with limited distributions; and (2) Areas that are outside of the coastal standoff distance and within potential operational areas for SURTASS LFA (i.e., greater than 22 km (13.6 mi; 12 nmi) from any shoreline and not in polar regions). These OBIA criteria differ from the criteria in the 2001 FOEIS/EIS (as continued in the 2007 SEIS) and the 2007-2012 MMPA Final Rule in two respects. First, under the 2001 FOEIS/EIS, 2007 SEIS, and the 2007 Final Rule, an area could be designated as an OBIA only if it met a conjunctive test of being an area where: (a) marine mammals congregate in high densities, and (b) for a biologically important purpose. Under the new NMFS criteria, high density alone can be sufficient. Second, the new criteria include an additional criterion that, standing alone, could be a basis for designation; i.e., "Small, distinct populations with limited distributions." The analysis of the OBIAs (for marine mammals and the potential for non-marine mammal OBIAs) is presented in Subchapter 4.5 and Appendix D of this document.

As a result of this further analysis, NMFS concluded that there was adequate biological basis to designate 22 SURTASS LFA sonar marine mammal OBIAs. The Navy also reviewed the potential OBIAs to assess personnel safety, practicality of implementation, and impacts on the effectiveness of SURTASS LFA sonar testing, training, and military operations. After reviewing these sites, the Navy proposed 21 of the 22 OBIAs (Table ES-1). The proposed Southern California Bight OBIA was determined by the Navy not to be practicable based upon current naval operations in the Southern California ranges. No other issues were found that would affect the practical implementation of the SURTASS LFA sonar marine mammal OBIA geographic restrictions. These OBIAs, as part of a comprehensive suite of LFA mitigation measures, will further reduce the potential for effects from SURTASS LFA sonar. Consistent with the current 2007 Rule, these LFA marine mammal OBIAs are not intended to apply to other Navy activities and sonar operations.

Practicability of Greater Coastal Standoff Range Where the Continental Shelf Extends Further than Current Coastal Standoff Range (22 km [12 nmi])

The Navy also used the OBIA analysis to consider whether dual criteria to determine the coastal exclusion zones in some locations where the shelf (≤200 m [656 ft] depth) extends farther than the current 22 km (12 nmi) coastal standoff range, is necessary based on the best available scientific information and operational practicability. This analysis was a part of the OBIA analysis (Subchapter 4.5 and Appendix D), because NMFS and the Navy considered the biological importance of coastal areas outside the current 22 km (12 nmi) coastal standoff range as well as their practicability for SURTASS LFA sonar operations. For example, of the initial listing of 73 recommended LFA MM OBIAs by NMFS' expert panelists, 32 were either completely or partially within shelf waters and outside of the coastal standoff range. After analyses and rankings, NMFS and the Navy agreed on the proposed final 21 SURTASS LFA sonar OBIAs for the MMPA proposed rulemaking. Of the 21 OBIAs, 17 included important areas for coastal protection, such as continental shelf/slope areas and similar coastal areas.

Table ES-1. Twenty-one marine mammal OBIAs proposed for SURTASS LFA sonar.

OCEAN BASIN/WATER BODY	OBIA NUMBER	OBIA NAME AND LOCATION
Atlantic Ocean	1	Georges Bank/East of Cape Cod, Massachusetts
	2	Roseway Basin Right Whale Conservation Area/South of Nova Scotia, Canada
	3	Great South Channel, Stellwagen Bank National Marine Sanctuary, and U.S. Gulf of Maine/East of Maine and Massachusetts
	4	Southeastern U.S. Right Whale Seasonal Habitat/East of Georgia and Florida
Pacific Ocean	5	North Pacific Right Whale Critical Habitat/Western Gulf of Alaska[8]
Atlantic Ocean	6	Silver and Navidad Banks/North of Dominican Republic
	7	Coastal Waters of Gabon, Congo, and Equatorial Guinea/Central Western Africa
	8	Patagonian Shelf Break/East of Argentina
	9	Southern Right Whale Seasonal Habitat/Northern Argentina
Pacific Ocean	10	Central California National Marine Sanctuaries/West of Central California
Southern Ocean	11	Antarctic Convergence Zone/Roughly between latitudes 45° and 60°[9]
Pacfic Ocean/Sea of Okhotsk	12	Piltun and Chayvo Offshore Feeding Grounds/East of northern Sakalin Island in southern Sea of Okhotsk
Indian Ocean	13	Coastal Waters off Madagascar/Off eastern Madagascar
	14	Madagascar Plateau and Ridge and Walters Shoal/South of Madagascar
Mediterranean Sea	15	Ligurian-Corsican-Provençal Basin and Western Pelagos Sanctuary/Between France/Italy and Corsica in northern Mediterranean Sea
Pacific Ocean	16	Penguin Bank, Hawaiian Islands Humpback Whale National Marine Sanctuary/West of Molokai, Main Hawaiian Islands
	17	Costa Rica Dome/Offshore west of Costa Rica

8 Does not include the portion of the North Pacific right whale critical habitat designated in the Bering Sea.

9 See Subchapter 4.5 for specific details on boundary.

Table ES-1. Twenty-one marine mammal OBIAs proposed for SURTASS LFA sonar.

OCEAN BASIN/WATER BODY	OBIA NUMBER	OBIA NAME AND LOCATION
	18	Great Barrier Reef Australia north coast—16°S to 21°S/Northeastern Australia in Coral Sea
Indian Ocean	19	Bonney Upwelling/Southern Australia
	20	Northern Bay of Bengal and Swatch-of-No-Ground (SoNG)/Northern Bay of Bengal, south of India and Bangladesh border
Pacific Ocean	21	Olympic Coast and The Prairie, Barkley Canyon, and Nitnat Canyon and offshore of Olympic Peninsula, Washington

Potential Cumulative Impacts with Concurrent Use of SURTASS LFA Sonar with Other Active Sonar Sources

Although the SURTASS LFA and mid-frequency active (MFA) sonars (AN/SQS 53C and AN/SQS 56) are similar in the underlying transmission types, specifically frequency-modulated (FM) sweeps and continuous wave (CW) transmissions, LFA and MFA sonars are dissimilar in other respects (see Table 4-28). In addition to these multiple differences, the duty cycle, (i.e., the amount of time during sonar operations that the sonar is actually transmitting), is different for SURTASS LFA sonar as opposed to MFA sonar. During SURTASS LFA sonar operations, LFA sonar transmits approximately 10% of the time (1 minute out of 10). During MFA sonar operations, MFA sonar transmits approximately 1.7% of the time (1 second out of 60)[10]. This means that for any given period of time that both SURTASS LFA and MFA sonars are operating concurrently, the LFA 60-sec transmission will be overlapped by 1 sec of MFA transmission, or 1.7% of the 60-sec LFA ping (1 sec/60 sec). During the 10-min LFA transmission cycle, the most an animal could be simultaneously exposed from both transmissions is 1 sec for every 600 sec, or about 0.17%[11] of the time that both sonars are operating.

The ocean volumes of Level A harassment RLs for each source are relatively small (1 km [0.54 nmi] radius or less). It is not reasonably foreseeable that SURTASS LFA and MFA sonars would operate simultaneously within ranges less than 9.3 km (5 nmi). Thus, it is not reasonably foreseeable that the Level A harassment volumes of the two sonars could ever overlap during simultaneous transmissions (see Subchapter 4.7.4.1).

The results of two separate analysis methodologies, parametric analysis and underwater acoustic model analysis, were consistent—concurrent MFA/SURTASS LFA sonar operations produce no level B harassment risk greater than that obtained by simply adding the risks from the individual sources. Therefore, two separate analytic approaches have concluded that there is no potential increase in risk for Level B harassment from concurrent MFA/SURTASS LFA sonar operations. Thus, the conclusion in the FSEIS that the potential for this occurring is small, remains valid, and should be considered very conservative.

10 MFA sonar operating characteristics are based on the Navy's AN/SQS 53C sonar. The nominal sonar ping is approximately 1 second every 60 to 90 seconds (Nissen, 2011). For analysis, 1 sec/60 sec was used as it is the most conservative.

11 MFA overlaps 1 sec for every 10 min (600 sec) of LFA duty cycle (1 sec/600 sec = 0.0017 or 0.17%).

ES.4.4.2 Marine Mammal Strandings

The use of SURTASS LFA sonar was not associated with any of the reported 27 mass stranding events or unusual mortality events (UME) that occurred globally between 2006 and early 2010. There is no evidence that SURTASS LFA sonar transmissions resulted in any difference in the stranding rates of marine mammals in Japanese coastal waters adjacent to SURTASS LFA sonar operating areas. As has been reported previously (DoN, 2001 and 2007a) and has been further documented in this FSEIS/SOEIS, the employment of SURTASS LFA sonar is not expected to result in any sonar-induced strandings of marine mammals. Given the large number of natural factors that can result in marine mammal mortality, the high occurrence of marine mammal strandings, and the many years of SURTASS LFA sonar operations without any reported associated stranding events, the likelihood of SURTASS LFA sonar transmissions causing marine mammals to strand is negligible.

ES.4.5 SOCIOECONOMICS

This FSEIS/SOEIS addresses the potential impact to commercial and recreational fisheries, other recreational activities, and research and exploration activities that could result from implementation of the alternatives under consideration.

ES.4.5.1 Commercial and Recreational Fisheries

SURTASS LFA sonar operations are geographically restricted such that SURTASS LFA sonar RLs are less than 180 dB dB re 1 µPa (rms) SPL within 22 km (12 nmi) from coastlines and within OBIAs during biologically important seasons, where fisheries productivity is generally high. SURTASS LFA sonar operations occur in proximity to fish stocks, and members of some fish species could potentially be affected by LF sounds. Even then, the impact on fish is likely to be minimal to negligible since only an inconsequential portion of any fish stock would be present within the 180-dB SPL sound field at any given time. Moreover, recent results from direct studies of the effects of LFA sounds on fish (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010) provide evidence that SURTASS LFA sonar sounds at relatively high received levels (up to 193 dB dB re 1 µPa [rms] SPL) have minimal impact on at least the species of fish that were studied. Nevertheless, the 180-dB SPL criterion has been maintained for the analyses presented in this FSEIS/SOEIS, with emphasis that this value is *highly conservative* and protective of fish. Therefore, SURTASS LFA sonar operations are not likely to affect fish populations and, thus, are not likely to affect commercial and recreational fisheries.

ES.4.5.2 Other Recreational Activities

There are no new data that contradict any of the assumptions or conclusions in Subchapter 4.3.2 (Other Recreational Activities) in the 2001 FOEIS/EIS and Subchapter 4.5.2 in the 2007 FSEIS regarding recreational swimming, snorkeling, and diving. Hence, the contents of the FOEIS/EIS and FSEIS subchapters are incorporated herein by reference. Whale watching typically takes place during times of year and in geographic locations where the probability of observing cetaceans are greatest. The probability of occurrence is higher because cetaceans have aggregated in specific areas to participate in some biologically important activity, such as feeding or migrating. Due to the water depth and accessibility, the vast majority of recreational swimming, snorkeling, and diving occurs within 22 km (12 nmi) of shore. Since SURTASS LFA sonar operations are restricted from transmitting ≥180 dB dB re 1 µPa (rms) SPL RL within 22 km (12 nmi) from shore, more than 145 dB dB re 1 µPa (rms) SPL RL near known recreational[12] and commercial dive sites, and in OBIAs during biologically important seasons, there is no reasonably foreseeable likelihood that operation of the sonar will affect recreational diving, swimming, snorkeling, or whale watching.

12 Recreational dive sites are generally defined as coastal areas from the shoreline or island(s) out to the 40-m (130-ft) depth contour, which are frequented by recreational divers; but it is recognized that there are other sites that may be outside this boundary.

ES.4.5.3 Research and Exploration Activities

There are no new data that contradict any of the assumptions or conclusions in Subchapter 4.3.3 in the 2001 FOEIS/EIS and Subchapter 4.5.3 in the 2007 FSEIS regarding research and exploration activities; hence, their contents are incorporated herein by reference. SURTASS LFA sonar operations are highly unlikely to affect oceanographic research that utilize submersibles (remotely operated vehicles [ROVs], autonomous undersea vehicles [AUVs], or manned submersibles) but could potentially affect other types of oceanographic research or oil and gas exploration activities that employ underwater acoustic equipment or instruments such as airguns, hydrophones, and ocean-bottom seismometers. If transmitted near oceanographic or exploration activities using underwater acoustic instrumentation, SURTASS LFA sonar could possibly interfere with the acoustic instruments or saturate the hydrophones. Conversely, research and exploration activities using underwater acoustic instruments or sources could interfere with SURTASS LFA sonar operations. For these reasons, SURTASS LFA sonar will not operate in the vicinity of known oceanographic or oil and gas exploratory operations and, thus, will not have an effect on these activities.

ES.4.6 POTENTIAL CUMULATIVE EFFECTS

The operations of up to four SURTASS LFA sonars are evaluated in this FSEIS/SOEIS for the potential for cumulative effects in the following foreseeable areas:

- Anthropogenic oceanic noise levels;
- Injury and lethal takes from anthropogenic causes;
- Socioeconomics; and
- Cumulative effects from concurrent LFA and MFA sonar operations.

Given the information provided in this FSEIS/SOEIS, the potential for cumulative effects from the operations of up to four SURTASS LFA sonars has been addressed by limitations proposed for employment of the system (i.e., geographical restrictions and monitoring mitigation). Even if considered in combination with other underwater sounds, such as commercial shipping, other operational, research, and exploration activities (e.g., acoustic thermometry, hydrocarbon exploration and production), recreational water activities, commercial and military sonars, and naturally-occurring sounds (e.g., storms, lightning strikes, subsea earthquakes, underwater volcanoes, whale vocalizations, etc.), the proposed four SURTASS LFA sonar systems do not add appreciably to the underwater sounds to which fish, sea turtles and marine mammal stocks are exposed. Because LFA transmissions will not significantly increase anthropogenic oceanic noise and the potential for masking is negligible, cumulative effects related to the potential for inducing stress from the proposed four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine animals. Moreover, SURTASS LFA sonar is not likely tol cause injury or lethal takes of marine mammals or other marine animals. SURTASS LFA sonar operations are not likely to affect commercial and recreational fisheries, or research and exploration activities; and there is no reasonably foreseeable likelihood of affecting recreational diving, swimming, snorkeling, or whale watching. Analysis of the potential impacts from concurrent LFA and MFA sonar operations demonstrates that the overall risks of Level A and Level B impacts are no greater than the risks obtained by simply adding the risks from the individual LFA and MFA sources. Therefore, cumulative effects from the operation of up to four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine animals.

ES.4.7 EVALUATION OF ALTERNATIVES

NEPA requires federal agencies to prepare an EIS that discusses the environmental effects of a reasonable range of alternatives (including the No Action Alternative). Reasonable alternatives are those that will accomplish the purpose and meet the need of the proposed action, and are practical and feasible from a technical and economic standpoint.

This FSEIS/SOEIS is the third environmental impact statement for SURTASS LFA sonar prepared under NEPA and Executive Order 12114. Previous to this document a final environmental impact statement (under NEPA) and final overseas environmental impact statement (under Executive Order 12114) were prepared in 2001 (DoN, 2001) and supplemented in 2007 (DoN, 2007). In these documents, numerous potential alternatives have been analyzed including: acoustic and non-acoustic detection methods such as radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, biological technologies, passive sonar and high- or mid-frequency active sonar; unrestricted SURTASS LFA sonar operations; monitoring and mitigation for fish; the use of small boats and aircraft for pre-operational surveys; and an extended coastal standoff range of 46 km (25 nmi) vice 22 km (12 nmi). The analysis of coastal standoff range of 46 km (25 nmi) did not meet the standard of effecting the least practicable adverse impact on the species or stock under the MMPA (vs using the standard 22 km [12 nmi] coastal standoff) (DoN, 2007a). It has been concluded in the FOEIS/EIS and the FSEIS that none of these potential alternatives met the purpose and need of the proposed action to provide U.S. Naval forces with reliable long-range underwater threat detection and, thus, did not provide adequate reaction time to counter potential threats. Furthermore, they were not considered practical and/or feasible for technical and economic reasons.

The following alternatives were considered in this FSEIS/SOEIS (Table ES-2):

- No Action;
- Alternative 1—Same as the 2007 FSEIS Preferred Alternative; and
- Alternative 2—Alternative 1 with new OBIA list (total 21) (the Preferred Alternative).

Table ES-2. Alternatives considered in this FSEIS/SOEIS for SURTASS LFA sonar operations.

PROPOSED RESTRICTIONS/MONITORING	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2
Dive Sites	NA[13]	RL not exceed 145 dB SPL	RL not exceed 145 dB SPL
Coastline Restrictions	NA	RL <180 dB SPL within 12 nmi of coast	RL <180 dB SPL within 12 nmi of coast
2007 NMFS Final Rule (NOAA, 2007c) OBIAs (total 10)[14]	NA	Yes	No
Updated OBIAs (total 21)	NA	No	Yes
Visual Monitoring	NA	Yes	Yes
Passive Acoustic Monitoring	NA	Yes	Yes
Active Acoustic Monitoring	NA	Yes	Yes
Reporting	NA	Yes	Yes

13 NA = Not applicable.

14 In the 2007 FSEIS (DoN, 2007a), the Navy's alternatives analyses included 9 OBIAs. During the rulemaking process, NMFS added The Gully as the 10th OBIA,

ES.4.7.1 NO ACTION ALTERNATIVE

Under this alternative, operational deployment of the active component (LFA/CLFA) of SURTASS LFA sonar will not occur. Although the No Action Alternative would avoid all environmental effects of employment of SURTASS LFA sonar, the Navy's stated priority ASW need for long-range underwater threat detection would not be achieved. The implementation of this alternative would allow potentially hostile submarines to clandestinely threaten U.S. Fleet units and land-based targets. Without SURTASS LFA sonar long-range surveillance capability, the reaction times to enemy submarines would be greatly reduced and the effectiveness of close-in, tactical systems to neutralize threats would be seriously, if not fatally, compromised.

Because the Navy would not conduct SURTASS LFA sonar operations, marine mammals present in the Atlantic, Pacific, and Indian Oceans, and the Mediterranean Sea would not be incidentally harassed by the SURTASS LFA sonar. This alternative would eliminate any potential risk to the environment from the proposed activities. In such a case, the Navy would not need nor receive authorization under the MMPA and ESA for incidental takes.

ES.4.7.2 ALTERNATIVE 1

This alternative proposes the employment of SURTASS LFA sonar technology the overall suite of mitigation designed to effect the least practicable impact om marine mammals and their habitat, and the availability for subsistence uses. These comprise: 1) geographic restrictions to include maintaining SURTASS LFA sonar received levels below 180 dB re 1 µPa (rms) within 22 km (12 nmi) of any coastline, 2) geographic restrictions to include maintaining SURTASS LFA sonar received levels below 180 dB re 1 µPa (rms) within ten designated OBIAs (see Table 2-4 of the FSEIS [DoN, 2007a]) and the MMPA Final Rule (NOAA, 2007c) that are located outside of 22 km (12 nmi), 3) SURTASS LFA sonar sound fields will not exceed received levels of 145 dB re 1 µPa (rms) within known recreational and commercial dive sites, and 4) monitoring mitigation includes visual, passive acoustic, and active acoustic (HF/M3 sonar) to prevent injury to marine animals when employing SURTASS LFA sonar by providing methods to detect these animals within the LFA mitigation zone and protocols for the delay/suspend of transmissions accordingly.

Under Alternative 1, as was concluded in the FSEIS, the potential effects on any stock of marine mammals from injury is considered to be negligible, and the effect on the stock of any marine mammal from significant change in a biologically important behavior is considered to be minimal. Any momentary behavioral responses are considered not to be biologically significant effects. Any auditory masking in mysticetes, odontocetes, or pinnipeds is not expected to be severe and would be temporary. Further, the potential effects on any stock of fish or sea turtles from injury is also considered to be negligible, and the effect on the stock of any fish, or sea turtles from significant change in a biologically important behavior is considered to be negligible to minimal. Any auditory masking in fish or sea turtles is expected to be of minimal significance and, if occurring, would be temporary.

Under this alternative, NMFS would incorporate mitigation and monitoring measures and reporting requirements into the MMPA rulemaking and Letters of Authorization.

ES.4.7.3 ALTERNATIVE 2 (THE PREFERRED ALTERNATIVE)

This alternative is the same as Alternative 1 but includes a comprehensive review and recommendation of OBIAs. Under Alternative 2, additional geographic restrictions would be levied on SURTASS LFA sonar operations through the inclusion of more marine mammal OBIAs (Table ES-1). The general summary provided in the above paragraph regarding the potential for injury on any stock of marine mammals, fish, or sea turtles, or significant change in a biologically important behavior of marine mammals, fish, or sea turtles from the operation of SURTASS LFA sonar would also apply to this alternative. Potential effects to marine animals from SURTASS LFA sonar operations under this alternative would be expected to be slightly decreased when compared to Alternative 1 due to the more limited geographic employment of SURTASS LFA sonar systems.

Under this alternative, NMFS would incorporate mitigation and monitoring measures and reporting requirements into the MMPA rulemaking and Letters of Authorzation.

ES.5 MITIGATION MEASURES

Mitigation, as defined by the Council on Environmental Quality (CEQ), includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. In this document, three alternatives for the operation of SURTASS LFA sonar are presented, two of which will meet, to varying degrees, the Navy's purpose and need and reduce potential impacts through the mitigation measures discussed in this document. The mitigation and monitoring measures presented for SURTASS LFA sonar are similar to those in the FSEIS.

The objective of these mitigation measures is to effect the least practicable adverse impact on marine mammal species or stocks and to avoid risk of injury to marine mammals, sea turtles, and human divers. These objectives are met by:

- Ensuring that coastal waters within 22 km (12 nmi) of shore are not exposed to SURTASS LFA sonar signal RLs ≥180 dB re 1 µPa (rms) SPL;
- Designating OBIAs and ensuring that no OBIAs are exposed to SURTASS LFA sonar signal RLs ≥180 dB re 1 µPa (rms) SPL during biologically important seasons;
- Preventing exposure of marine mammals and sea turtles to SURTASS LFA sonar signal RLs below 180 dB re 1 µPa (rms) SPL by monitoring for their presence via three different methods (visual, passive acoustic, and active acoustic monitoring) and suspending/delaying transmissions when one of these animals enters the prescribed LFA mitigation zone plus a 1 km buffer zone; and
- Ensuring that no known recreational or commercial dive sites are subjected to SURTASS LFA sonar signal RLs >145 dB re 1 µPa (rms) SPL.

In the 2007-2012 Final Rule, NMFS required a 1-km (0.54-nmi) buffer zone operational restriction as discussed in Subchapter 2.5.2. In the Proposed Rule for the period 2012 to 2017, NMFS also proposes that the SURTASS LFA sonar sound field does not exceed 180 dB re 1 µPa received level at a distance of 1 km (0.54 nmi) beyond the LFA mitigation zone and 1 km (0.54 nmi) seaward of the outer boundary of any OBIA (NOAA, 2012). The mitigation measures presented in this chapter include this 1-km buffer zone requirement. Strict adherence to these measures will minimize impacts on marine mammal stocks and species, as well as on sea turtle stocks, and recreational/commercial divers.

There are geographic restrictions that apply to the operation of SURTASS LFA sonar as well as three types of mitigation measures that will be applied during the operation of SURTASS LFA sonar (Table ES-3).

ES.6 CONCLUSIONS

Based on the results of the analyses in this FSEIS/SOEIS document and the two previous NEPA EISs, operation of SURTASS LFA sonars, when employed in accordance with the mitigation measures (geographic restrictions and monitoring/reporting) detailed in Chapter 5.0 of this document, support a negligible impact determination.

The results presented in this FSEIS/SOEIS include:

- Potential effects on most if not all individual marine mammals are expected to be limited to Level B harassment. The Navy does not expect those effects to impact rates of recruitment or survival on the associated marine mammal species and stocks.

Table ES-3. Summary of mitigation measures for operation of SURTASS LFA sonar.

Mitigation Measure	Criteria	Actions
Geographic Restrictions		
22 km (12 nmi) from coastline	Sound field below 180 dB re 1 µPa (rms) RL, based on SPL modeling	Delay/suspend SURTASS LFA sonar operations if sound field criterion is exceeded
Offshore biologically important areas (OBIA) during biologically important seasons	Sound field below 180 dB re 1 µPa (rms) RL, based on SPL modeling, at 1 km (0.54 nmi) seaward of outer boundaries of OBIAs	Delay/suspend SURTASS LFA sonar operations if sound field criterion is exceeded
Recreational and commercial dive sites	Sound field not to exceed 145 dB re 1 µPa (rms) RL, based on SPL modeling	Delay/suspend SURTASS LFA sonar operations if sound field criterion is exceeded
Monitoring to Prevent Injury to Marine Mammals and Sea Turtles		
Visual Monitoring	Potentially affected species near the vessel but outside of the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Notify Military Detachment Officer in Charge (MILDET OIC)
	Potentially affected species sighted inside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Delay/suspend SURTASS LFA sonar operations
Passive Acoustic Monitoring	Potentially affected species' vocalizations detected	Notify MILDET OIC
Active Acoustic Monitoring	Contact detected and determined to have a track that would pass within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Notify MILDET OIC
	Potentially affected species detected inside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Delay/suspend SURTASS LFA sonar operations

- Navy's impact analysis does not anticipate any mortality nor any injury of marine mammals to occur as a result of SURTASS LFA sonar operations, and the potential to cause strandings of marine mammals is negligible. Thus, effects on recruitment or survival are expected to be negligible.
- Potential for injury to sea turtle and fish species or stocks is negligible.
- Potential for non-injurious effects (TTS, masking, modification of biologically important behavior) to marine mammals, sea turtles, and fish is minimal to negligible.
- Cumulative effects are not a reasonably foreseeable adverse impact.

Since the initial LOA was issued for the operation of SURTASS LFA sonar systems in 2002, the percent of Level B incidental takes of marine mammals has consistently been below the amounts authorized in the LOAs. There have been no reported strandings and no Level A takes incidental to SURTASS LFA sonar operations.

Therefore, this document supports the Navy application under the MMPA for take authorizations incidental to the operation of SURTASS LFA sonar by providing the means of effecting the least practicable adverse impact on the species or stock and its habitat and on the availability of the species or stock for "subsistence" uses. These results will also support interagency consultations, or Section 7 consultations, under the ESA to ensure the operations of SURTASS LFA sonar do not jeopardize the continued existence of a species or destroy or adversely modify critical habitat.

ES.7 PUBLIC PARTICIPATION

Public involvement in the review of the Draft SEIS/SOEIS is stipulated in 40 CFR Part 1503.1 of the CEQ regulations implementing NEPA and in OPNAVINST 5090.1C CH-1. These regulations and guidance provide for active solicitation of public comment via public comment periods and public hearings/meetings.

On January 21, 2009, the Navy, with NMFS as a cooperating agency, published a Notice of Intent (NOI) to prepare a SEIS/SOEIS for the employment of SURTASS LFA sonar in the *Federal Register* (DoN, 2009a). The NOI described the decision of DASN(E) to further the purposes of NEPA, support the issuance of a new Final Rule under the MMPA for the taking of marine mammals incidental to operation of SURTASS LFA sonar systems, and to continue the Navy's commitment to environmental stewardship by preparing an additional supplemental analysis for operation of SURTASS LFA sonar. DASN(E) called for the additional supplemental analysis to focus on potential OBIAs in regions of the world's oceans where SURTASS LFA sonar might be used for routine training, testing, and military operations, as well as the potential for cumulative effects associated with the use of SURTASS LFA sonar with other active sonar systems, and the potential for a greater coastal standoff range, where operationally practicable. In the NOI, the Navy and NMFS solicited scoping comments on the above topics, to include OBIAs, greater coastal standoff ranges, and cumulative effects. At the end of the 45-day public scoping period, no comments had been received (DoN, 2009a).

Commencing with the filing of the DSEIS/SOEIS with the U.S. EPA, copies of the SURTASS LFA Sonar DSEIS/SOEIS were distributed to agencies and officials of the federal, state, and local governments, citizens groups and associations, and other interested parties. The U.S. EPA published a notice of availability (NOA) for the SURTASS LFA sonar Draft SEIS/SOEIS on 19 August 2011 (EIS No. 20110269).

A 60-day public review and comment period on the Draft SEIS/SOEIS commenced when the NOA was published in the *Federal Register* on 19 August 2011 and ended on 17 October 2011. Per the NEPA regulations, no public hearings or meetings were scheduled by the Navy. There were no timely requests by the public for meeting or hearing under the NEPA regulations. There were no requests for an extension of the comment period.

A total of five comment letters/emails on the Draft SEIS/SOEIS were received from three federal agencies, one non-governmental organization, and one individual. Chapter 7 of this FSEIS/SOEIS has been prepared to document the public involvement process and to also present the response to questions and comments raised by the commenters during the public comment period for the DSEIS/SOEIS, as presented in Subchapter 7.3.

TABLE OF CONTENTS

Page

Page

Page

Page

Page

Page

Page

Page

LIST OF TABLES

Page

Page

Page

Page

APPENDIX E

LIST OF FIGURES

Page

APPENDIX D

Page

APPENDIX E

LIST OF ACRONYMS AND ABBREVIATIONS

3MDS	Multi-mode Magnetic Detection System
°C	Degrees Centigrade/Celsius
°F	Degrees Fahrenheit
µm	Micrometer
µPa	MicroPascal(s)
ABR	Auditory brainstem response
AEP	Auditory evoked potential
AGISC	Ad-hoc group on the impacts of sonar on cetaceans and fish
AFAST	Atlantic Fleet Active Sonar Training
AIA	Areas of Increased Awareness
AIM	Acoustic Integration Model©
AIP	Air-independent propulsion
AM	Amplitude modulated
ANSI	American National Standards Institute
APA	Administrative Procedure Act
APPS	Act to Prevent Pollution from Ships
APR	Annual percentage growth rate
ASN (I&E)	Assistant Secretary of the Navy (Installations and Environment)
ASW	Anti-submarine warfare
ATOC	Acoustic Thermometry of Ocean Climate
AUSI	Autonomous Undersea Systems Institute
AUTEC	Atlantic Undersea Test and Evaluation Center
AUV	Autonomous undersea vehicle
AUVAC	Autonomous Undersea Vehicle Applications Center
AWMP	Aboriginal Whaling Management Procedure
BiOp	Biological Opinion
BRS	Behavioral Response Study
CEE	Controlled exposure experiment
CEQ	Council on Environmental Quality
CetMap	Cetacean Density and Distribution Mapping Group
CFMC	Caribbean Fishery Management Council
CFR	Code of Federal Regulations
CIA	Central Intelligence Agency
CITES	Convention on International Trade in Endangered Species
CLFA	Compact Low Frequency Active
cm	Centimeter(s)
CNO	Chief of Naval Operations
COTS	Commercial off-the-shelf
CSG	Carrier Strike Group

CSIP	Cetacean Strandings Investigation Programme
CSM	Cross spatial matrix
CT	Computer tomography
CV	Coefficient of variation
CW	Continuous wave
CZ	Convergence zone
CZMA	Coastal Zone Management Act
DASN(E)	Deputy Assistant Secretary of the Navy for Environment
dB	Decibel(s)
dB re 1 µPa @ 1 m	Decibels relative to one micropascal measured at one meter from center of acoustic source
dB re 1 µPa²-sec	Decibels relative to one micropascal squared per second
DoC	Department of Commerce
DoD	Department of Defense
DoI	Department of Interior
DoN	Department of the Navy
DOSITS	Discovery of Sound in the Sea
DPS	Distinct population segment
DSEIS	Draft supplemental environmental impact statement
Dtag	Digital tag
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat
EIS	Environmental impact statement
ELF	Extremely low frequency
EO	Presidential Executive Order
EP	Evoked potential
ESA	Endangered Species Act
ESG	Expeditionary Strike Group
ESU	Evolutionary significant unit
ETP	Eastern Tropical Pacific
FAO	Food and Agriculture Organization
FEIS	Final environmental impact statement
FHWG	Fisheries Hydroacoustic Working Group
FLIR	Forward looking infrared
FM	Frequency modulated
FMC	Fishery Management Council
FMP	Fishery management plan
FMZ	Fishery management zone
FOEIS	Final overseas environmental impact statement
FR	*Federal Register*
FSEIS	Final supplemental environmental impact statement
ft	Foot or feet
FY	Fiscal year
GDEM	General digital enviornmental model
GDP	Gross domestic product

GIS	Geographic information system
GMFMC	Gulf of Mexico Fishery Management Council
GNP	Gross national product
GOMEX	Gulf of Mexico
GPS	Global positioning system
HAPC	Habitat area of particular concern
HESS	High-energy seismic survey
HF	High frequency
HFM	Hyperbolic frequency-modulated
HF/M3	High frequency /marine mammal monitoring
HLA	Horizontal line array
HMS	Highly migratory species
HOV	Human occupied vehicle
hr	Hour(s)
Hz	Hertz
IAW	In accordance with
ICES	International Council for the Exploration of the Sea
ICP	Integrated common processor
ICW	Intracoastal Waterway
in	Inch(es)
ITS	Incidental take statements
ISAR	Inverse synthetic aperture radar
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IUCN	International Union for Conservation of Nature
IUSS	Integrated Undersea Surveillance System
IWC	International Whaling Commission
JNCC	Joint Nature Conservation Committee
JSOTS	Joint Subcommittee on Ocean Science & Technology
kg	Kilogram(s)
km	Kilometer(s)
kph	Kilometers per hour
kt/kts	Knot(s)
kHz	KiloHertz
L	Liter
lb/yd	Pound per yard
LDEO	Lamont-Doherty Earth Observatory
LF	Low frequency
LFA	Low frequency active
LFAS	Low frequency active sonar
LFS SRP	Low Frequency Sound Scientific Research Program
LINTS	Linear Threshold Shift
LO	Lack of Objections
LOA	Letter of Authorization
LTM	Long term monitoring

m	Meter(s)
M3	Marine mammal monitoring
MAD	Magnetic Anomaly Detection
MFA	Mid-frequency active
MILDET	Military detachment
min	Minute(s)
MIT	Massachusetts Institute of Technology
MM	Marine mammal
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MPA	Marine protected area
MRR	Marine resources reserve
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
mt	Metric ton(s)
NA	Not available
NARW	North Atlantic right whale
NARWC	North Atlantic Right Whale Consortium
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NGO	Non-governmental organization
NM	National Monument
NMFS	National Marine Fisheries Service
nmi	Nautical mile(s)
NMNS	Natural Museum of Nature and Science
NMPAC	National Marine Protected Area Center
NMS	National Marine Sanctuary
NOA	Notice of availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
Non-Nuc	Non-Nuclear
NORLANT	North Atlantic
NOSC	Naval Ocean Systems Center
NP	National Park
NPAL	North Pacific Acoustic Laboratory
NPS	National Park System
NRC	National Research Council
NRDC	Natural Resources Defense Council
NS	National Seashore
NSMRL	Navy Submarine Medical Research Laboratory
NUWC	Naval Undersea Warfare Center
NW	Northwest
NWHI	Northwest Hawaiian Islands

NWR	National Wildlife Refuge
OAML	Ocean and Atmospheric Master Library
OBIA	Offshore biologically important areas
OCRM	Office of Ocean and Coastal Resource Management (NOAA)
OCS	Outer continental shelf
OIC	Officer in Charge
OEIS	Overseas Environmental Impact Statement
OMP	Office of Marine Programs
ONI	Office of Naval Intelligence
ONR	Office of Naval Research
OPAREA	Operating area
PADI	Professional Association of Diving Instructors
PE	Parabolic equation
PLAN	Peoples Liberation Army Navy
PRN	Pseudo-random noise
PTS	Permanent threshold shift
R&D	Research and development
RAM	Range-dependent acoustic model
RL	Received level
rms	Root mean square
ROD	Record of Decision
ROV	Remotely operated vehicle
R/V	Research vessel
SAC	Special Area of Conservation
SAG	Surface active group
SAR	Synthetic Aperture Radar
SARA	Species At Risk Act (Canada)
SCB	Southern California Bight
SD	Standard Deviation
sec	Second(s)
SEIS	Supplemental environmental impact statement
SEL	Sound exposure level
SEM	Scanning electron microscope
SL	Source level
SME	Subject matter expert
SMRU	Sea Mammal Research Unit, St. Andrews University
SOCAL	Southern California
SOCAL-BRS	Southern California Behavioral Response Study
SOEIS	Supplemental overseas environmental impact statement
Sonar	SOund NAvigation and Ranging
SoNG	Swatch-of-No-Ground
sp./spp.	Specie/species
SPD	Sound pressure difference
SPE	Single ping equivalent
SPL	Sound pressure level

SPLASH	Structure of Populations, Levels of Abundance and Status of Humpback Whales
SRP	Scientific Research Program
SSG	Surface Strike Group
SSP	Sound speed profile
SURTASS	Surveillance Towed Array Sensor System
T-AGOS	Tactical-Auxiliary General Ocean Surveillance
TL	Twin-line or transmission loss
TOTO	Tongue of the Ocean
TTS	Temporary threshold shift
TZCF	Transition Zone Chlorophyll Front
UK	United Kingdom
UME	Unusual mortality event
UN	United Nations
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOLS	University-National Oceanographic Laboratory System
U.S.	United States
USC	United States Code
USDC-NDC	U.S. District Court, Northern District of California
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	US Geological Survey
USNS	U.S. Navy ship
USS	U.S. ship
VLA	Vertical line array
WCPA	World Commission on Protected Areas
WDCS	Whale and Dolphin Conservation Society
WDPA	World Database on Protected Areas
WHOI	Woods Hole Oceanographic Institute
WTO	World Trade Organization

THIS PAGE IS INTENTIONALLY LEFT BLANK

1.0 PURPOSE AND NEED

This Supplemental Environmental Impact Statement (SEIS)/Supplemental Overseas Environmental Impact Statement (SOEIS) for Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems[1] provides supplemental analyses to the Final Overseas Environmental Impact Statement/Environmental Impact Statement (FOEIS/EIS) for SURTASS LFA Sonar (Department of the Navy [DoN], 2001) and the Final Supplemental Environmental Impact Statement (FSEIS) for SURTASS LFA Sonar (DoN, 2007a), which were filed with the United States (U.S.) Environmental Protection Agency in January 2001 and April 2007, respectively. This second supplemental analysis has been prepared in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [USC] §4321 et seq.)[2]; the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [40 CFR] §§1500-1508); Navy Procedures for Implementing NEPA (32 CFR §775); and Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions[3].

References to Underwater Sound Levels
• **References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa @ 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).** • **In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).** • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS/SOEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for the energy of all the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for details. As discussed in Appendix C, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001 and 2007a).**

1 In this SEIS/SOEIS, "SURTASS LFA sonar systems" refers to both the LFA and compact LFA (CLFA) systems, each having similar acoustic operating characteristics.

2 The provisions of NEPA apply to major federal actions that occur or have effects in the U.S., its territories, or possessions.

3 The provisions of EO 12114 apply to major federal actions that occur or have effects outside of U.S. territories (the U.S. its territories, and possessions).

To meet long range-submarine detection necessary to provide U.S. forces with the time to react to and defend against potential undersea threats, the Navy developed the SURTASS LFA Sonar System. The federal actions considered are:

- The employment by the U.S. Navy of up to four SURTASS LFA sonar systems for routine training, testing, and military operations[4] in the oceanic areas occurring in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea (Figure 1-1); and
- The interrelated actions of NMFS' issuance of five-year regulations and subsequent letters of authorization (LOAs) under Section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA) for the incidental, but not intentional, taking of marine mammals during routine training, testing, and military operations using SURTASS LFA sonar, following NMFS' regulatory process for issuing such regulations and LOAs.

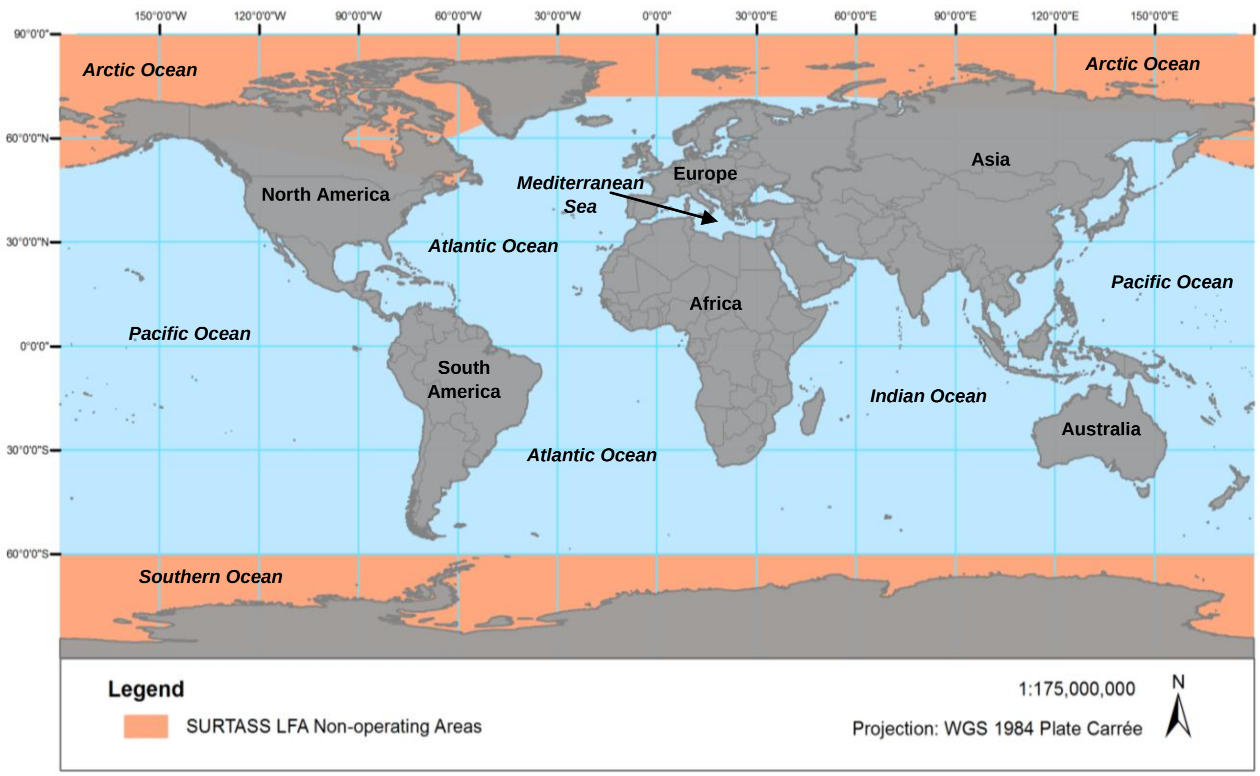


Figure 1-1. Potential areas of operation for SURTASS LFA sonar.

To reduce potential adverse effects on the marine environment, the Navy will use a suite of mitigation measures including: 1) visual, passive acoustic, and active acoustic monitoring; 2) delay/shutdown protocols for LFA transmissions; 3) geographic restrictions to prevent 180-decibel (dB) sound pressure level (SPL) or greater within 22 kilometers (km) (12 nautical miles [nmi]) of land, and in offshore biologically important areas (OBIA) during biologically important seasons; and 4) geographic restrictions

4 The phrase "military operations" does not include use of SURTASS LFA sonar in armed conflict or direct combat support operations or use of SURTASS LFA sonar during periods of heightened threat conditions as determined by the National Command Authorities.

to prevent greater than 145-dB SPL at known recreational and commercial dive sites. Mission planning for annual LOA applications will include the identification of marine areas based on updated scientific data and information for SURTASS LFA sonar routine testing, training, and military operations that contribute to the least practicable adverse impacts on marine mammals while meeting National Security requirements.

SURTASS LFA sonar systems are long-range sensors with both active and passive acoustic components that are able to operate day and night in most weather conditions. These systems operate in the low frequency (LF) band (below 1,000 Hertz [Hz]) within the frequency range of 100 to 500 Hz. The passive component, SURTASS, is a towed horizontal line array detection system that uses hydrophones to detect sound emitted or reflected from submerged targets. The active component of the system, LFA, is an augmentation to SURTASS and is planned for use when passive system performance is inadequate. LFA is comprised of a set of acoustic transmitting source elements suspended by cable from underneath ocean surveillance ships, such as the U.S. Navy Ship (USNS) IMPECCABLE (T-AGOS 23) and the VICTORIOUS Class (T-AGOS 19 Class) vessels. The active array transmits LF sound pulses that reflect off objects that they encounter in the water. These reflected pulses return in the form of echoes that are received by the passive towed array through listening devices (hydrophones).

The FOEIS/EIS for SURTASS LFA sonar was completed in January 2001 by the Department of the Navy (DoN) with the National Marine Fisheries Service (NMFS) as a cooperating agency, in accordance with the requirements of NEPA and EO 12114. The Deputy Assistant Secretary of the Navy for Environment (DASN(E)) signed the Record of Decision (ROD) on 16 July 2002 (DoN, 2002), authorizing the operational employment of two SURTASS LFA sonar systems contingent upon the issuance by NMFS of a 5-year Final Rule and LOAs under the Marine Mammal Protection Act (MMPA), and a biological opinion and incidental take statements (ITS) under the Endangered Species Act (ESA) for each vessel.

In April 2007, the DoN, with NMFS as a cooperating agency, completed the FSEIS for SURTASS LFA sonar in accordance with NEPA and EO 12114 (DoN, 2007a). On 15 August 2007, the Assistant Secretary of the Navy (Installations and Environment) (ASN (I&E)) signed the ROD authorizing the employment of four SURTASS LFA sonar systems (DoN, 2007b). The document focused on providing additional information regarding the environment that could potentially be affected by employment of SURTASS LFA sonar; providing additional information related to mitigation of the potential impacts from the system; addressing pertinent deficiencies raised by the U.S. District Court for the Northern District of California (herein referred to as the Court), including additional mitigation and monitoring, additional alternatives analysis, and analysis of the potential impacts of LF sound on fish; and providing the information necessary to apply for and receive a new MMPA Rule to govern the issuance of LOAs for another 5-year period, and related ESA coverage. The FSEIS also discussed proposed modifications to mitigation/interim operational restrictions, and provided details of updated analyses and research on the potential effects on fish, sea turtles, and marine mammals; marine mammal stranding events potentially related to anthropogenic noise; cumulative impacts; long-term monitoring; and ongoing and planned research.

Due to concerns raised during a second round of litigation over employment of the SURTASS LFA sonar system and to support issuance of a third five-year Rule under the MMPA for employment of SURTASS LFA sonar systems, DASN(E) determined on 14 November 2008 that the purposes of NEPA and EO 12114 would be furthered by the preparation of an additional supplemental analysis related to the employment of the system. This analysis takes the form of this new SEIS/SOEIS.

Accordingly, DASN(E) directed that the new SEIS/SOEIS provide: 1) further analysis of potential additional offshore (greater than 22 km [12.2 nmi]) biologically important areas (OBIA) in regions of the world where the Navy intends to use the SURTASS LFA sonar systems for routine training, testing, and military operations; 2) further analysis of whether using a greater coastal standoff distance where the continental shelf extends further than current standoff distance is practicable for SURTASS LFA sonar, at least in some locations; and 3) further analysis of cumulative impacts involving other active sonar sources. Once completed, information from these analyses will be used to assist the Navy in determining how to employ SURTASS LFA sonar, including the selection of operating areas that the Navy requires for routine training, testing, and military operations in annual requests for MMPA LOAs submitted to NMFS of the Department of Commerce's (DoC's) National Oceanic and Atmospheric Administration (NOAA).

The purpose of the SURTASS LFA sonar FSEIS/SOEIS is to:

- Address concerns of the Court in its 6 February 2008 Opinion and Order in relation to compliance with NEPA and MMPA;
- Provide information to support the proposed issuance of MMPA incidental take regulations, the 2012 LOAs, and future LOAs as appropriate; and
- Provide additional information and analyses pertinent to the proposed action.

The Navy is the lead agency with NMFS as the cooperating agency, in accordance with NEPA regulations (40 CFR §1501.6). NMFS anticipates receipt of annual applications to take marine mammals incidental to routine training, testing, and military operations using SURTASS LFA sonar pursuant to Sections 101(a)(5)(A) of the MMPA. This SEIS/SOEIS is intended to assist NMFS in its MMPA decision-making process related to projected requests for LOAs in the Atlantic, Pacific, and Indian Oceans, and the Mediterranean Sea for future years. NMFS intends to use this SEIS/SOEIS as the required NEPA documentation for the issuance of regulations and LOAs for the incidental taking of marine mammals during routine training, testing, and military operations using SURTASS LFA sonar.

On 21 January 2009, the Navy published a Notice of Intent (NOI) to prepare a SEIS/SOEIS for the employment of SURTASS LFA sonar, with NMFS as a cooperating agency (DoN, 2009a). In the NOI the Navy and NMFS solicited scoping comments on the above topics, to include OBIAs, greater coastal standoff, and cumulative effects. At the end of the 45-day scoping period, no comments had been received.

1.1 PURPOSE AND NEED FOR PROPOSED ACTION

The Navy's primary mission is to maintain, train, equip, and operate combat-ready naval forces capable of accomplishing American strategic objectives, deterring maritime aggression, and assuring freedom of navigation in ocean areas. The Secretary of the Navy and Chief of Naval Operations (CNO) have continually validated that Anti-Submarine Warfare (ASW) is a critical part of that mission—a mission that requires unfettered access to both the high seas and littorals[5]. In order to be prepared for all potential threats, the Navy must maintain ASW core competency through continual training and operations in open-ocean and littoral environments.

The challenges faced by the U.S. Navy today are very different from those faced at the end of the Cold War two decades ago. Since the early 1990s, U.S. Navy ASW strategy has had to shift from a known Soviet adversary to "uncertain potential adversaries" with less well understood and defined strategies and goals (Benedict, 2005). The wide proliferation of diesel-electric submarines, a Chinese undersea force that is growing in size and tactical capability, and a resurgent Russian submarine service mean that U.S. ASW capability must meet more technologically-capable threats in a wider range of ocean environments (Benedict, 2005; ONI, 2009a and 2009b). Due to the advancement and use of quieting technologies in diesel-electric and nuclear submarines, undersea threats are becoming increasingly difficult to locate using the passive acoustic technologies that were effective during the Cold War. The range at which U.S. ASW assets are able to identify submarine threats is decreasing, and at the same time, improvements in torpedo design are extending the effective weapons range of those same threats (Benedict, 2005).

5 See Subchapter 1.1.3 below for definition of "littoral."

To meet this long-range submarine detection need, the U.S. Navy has investigated the use of a broad spectrum of acoustic and non-acoustic technologies. These are discussed in detail in Subchapter 1.1.4. Of the technologies evaluated, low frequency active sonar is the only system capable of meeting the U.S. Navy's long-range ASW detection needs in a variety of weather conditions during the day and night. SURTASS LFA sonar is providing a quantifiable improvement in the Navy's undersea detection capabilities and therefore markedly improving the survivability of U.S. Naval forces in hostile ASW scenarios.

Excerpts from Declaration of Rear Admiral John M. Bird, U.S. Navy to the United States District Court Northern District of California, 15 November 2007
SURTASS LFA (sonar) has enabled the Navy to meet the clearly defined, real-world national security need for improved ASW capability by allowing Navy Fleet units to reliably detect quieter and harder-to-find submarines at long range, before they get within their effective weapons range and can launch missiles or torpedoes against our ships or missiles against land targets, foreign or domestic. The operative word here is <u>has</u>. SURTASS LFA is a combat-ready system. But in order to protect U.S. and allied fleet assets, and merchant shipping, the operation of SURTASS LFA sonar and the training of our personnel must continue uninterrupted.

The proposed action meets the need of the U.S. Navy for improved long-range submarine detection capability, which is essential to providing U.S. forces the time necessary to react to and defend against potential undersea threats. It is critical that U.S. forces be able to identify threats while remaining at a safe distance beyond a submarine's effective weapon's range (Davies, 2007).

Sections 101(a)(5)(A) and (D) of the MMPA direct NMFS to allow, upon request, the incidental, but not intentional, taking of marine mammals of a species or population stock by U.S. citizens who engage in a specified military readiness activity if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of proposed authorization is provided to the public for review. Authorization for incidental taking shall be granted if NMFS finds that the taking will have a negligible impact on the affected species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses. NMFS must also prescribe: the permissible methods of taking pursuant to the activity; other means of effecting the "least practicable adverse impact" on the affected species or stock and its habitat and on the availability of such species or stock for subsistence uses; and requirements pertaining to the monitoring and reporting of such take.

NMFS anticipates receipt of applications to take marine mammals incidental to routine training, testing, and military operations using SURTASS LFA sonar pursuant to Section 101(a)(5)(A) of the MMPA. This FSEIS/SOEIS will assist NMFS in its MMPA decision-making process related to projected requests for LOAs in the Atlantic, Pacific, and Indian Oceans, and the Mediterranean Sea for future years. NMFS intends to use this FSEIS/SOEIS as the required NEPA documentation for the issuance of regulations and LOAs for the incidental taking of marine mammals during routine training, testing, and military operations using SURTASS LFA sonar. If necessary, NMFS may tier from this FSEIS/SOEIS to support future SURTASS LFA authorization decisions if such activities fall outside the scope of this FSEIS/SOEIS.

1.1.1 NATURE OF THE SUBMARINE THREAT

Today's maritime strategies rely heavily on quiet submarines to accomplish various offensive and defensive missions: patrol the littorals, blockade strategic chokepoints[6], and stalk aircraft carrier battle groups. Being inherently covert, submarines can conduct intrusive operations in sensitive areas, and can be inserted into a conflict situation early with a minimal likelihood of being detected. These vessels also have the ability to carry many different weapons systems: torpedoes, long-range cruise missiles, anti-ship mines, and ballistic nuclear missiles (Benedict, 2005; ONI, 2009a). These capabilities make submarines, both nuclear and diesel-electric powered, stealthy and flexible strategic assets. Under competent command a submarine is an excellent weapon and a capable intelligence-gathering platform (Davies, 2007). Because they require fewer operational and support resources, submarines are being increasingly seen as an effective and cost-efficient way to ensure domestic defense and to pursue blue-water power projection (Goldstein and Murray, 2003). For countries that lack or cannot afford large conventional naval forces these benefits are amplified even more.

Technologically, the submarines being produced today are much more advanced than those of even a few decades ago (Friedman, 2007a). Submarines from many nations are better armed, more capable, and able to stay submerged for a longer period of time than earlier vessels (Davies, 2007). For both conventional diesel-electric and nuclear submarines, quieting technology has increased stealth and thus operational effectiveness. These technologies include hull coatings that minimize echoes, sound isolation mounts for machinery, and improved propeller design, and are being employed in new submarine projects and as upgrades to older boats. As this technology has improved the predominant sources of ship noise (i.e., hull flow noise, propeller noise, and propulsion machinery noise) have been reduced. As an example, between 1970 and 1990 the sound signature levels of Soviet submarines were reduced dramatically, by over 30 dB SPL, due to the implementation of quieting technology. Depending on the characteristics of the ocean environment the vessel was operating in, this could "decrease surveillance ranges by thirtyfold to a thousandfold" and reduce passive detection ranges from hundreds of miles to only a few (Tyler, 1992).

Toward the end of the Cold War passive sonars increasingly relied on "non-traditional"[7] sound signatures to identify submarine threats (Friedman, 2007a). Since the early 1990s this trend has continued, with the addition of air-independent propulsion (AIP) systems leading to as much as a 10 to 20 dB SPL additional reduction in diesel/electric submarine noise signatures. In many cases this employment of "low observability" technology is able to minimize a submarine's sound signature, and prevent or delay detection and identification, while simultaneously increasing the efficiency of a submarine's own sensors through the reduction of "self noise" (Nitschke, 2007). Improvements in submarine operational performance and quieting technology are further complimented by the proliferation of advanced weapons and delivery systems, including submarine-launched cruise missiles, such as the supersonic BrahMos being jointly developed by Russia and India, and the submarine-launched ballistic missile capability being refined by China (Friedman, 2007b; DoD, 2009; ONI, 2009a).

At the same time as technological innovation has taken place, an increasing number of nations are developing or purchasing the technical expertise and capability necessary for the domestic manufacture of undersea assets. Although the proliferation of undersea capability through the purchase of the latest vessels and armament from Russian and Western Europe is troubling, the real threat comes from the transfer of submarine-related technology and training that often appends such transactions (Benedict,

6 A chokepoint is a strategic strait or canal that can be closed or blocked to stop sea traffic. Major chokepoints in the Indian Ocean area include the Straits of Hormuz, Straits of Malacca, and the Bab el-Mandab Strait.

7 The traditional sounds used to passively detect and identify ASW targets include; engine noise, sound from cavitation, or in the case of a nuclear powered submarine, sound from constant reactor cooling. These types of "traditional" sound signatures can be reduced though improved propeller design, the use of hull coatings, or sound isolating engine mounts. More difficult to control are "non-traditional" sounds, these might include crew noises or sounds from improperly maintained shipboard equipment.

2005; Davies, 2007). The number of countries that possess and operate nuclear submarines is also continuing to grow, with China rapidly improving its capacity to build effective nuclear-powered vessels, and India launching its first indigenously build nuclear submarine, the INS ARIHANT (ONI, 2009a; Rai, 2009).

In the early 21st century, the global submarine threat is becoming more diverse, with a greater number of nations operating newer and more-advanced submarines in a variety of environments. Many nations, including the Russian Federation and the People's Republic of China, have publicly declared that their submarines are the single most potent ship in their fleets, and the centerpiece of their respective navies. Iran, India, and Pakistan have made similar statements concerning the importance of submarines in national strategic planning. Iran has even gone so far as to suggest that Iranian undersea forces could be used for power projection into the Indian Ocean and to limit access to the Persian Gulf by blocking the Straits of Hormuz (Iranian State Television, 2008; ONI, 2009a and 2009b).

Kaplan (2009) notes that the Indian Ocean, bounded by two strategic chokepoints, the Straits of Malacca and Hormuz, will be the site of the major maritime arms race of the 21st century. Approximately 90 percent of all global goods and 65 percent of all oil currently travel by sea. Already an important waterway, the Indian Ocean is expected to grow more important economically and strategically in the coming decades (Kaplan, 2009). Throughout the western Pacific and Indian Oceans, a sea area which bridges the Arabian Peninsula through Southeast Asia and Japan, a striking number of nations are acquiring and modernizing their submarine forces (ONI, 2009b).

The Russian Federation has refocused its efforts on naval modernization and innovation (Yemelyanenkov, 2008). This has meant the completion of a number of pending submarine projects as well as the modernization and re-commissioning of several capable vessels, including the Typhoon Class *Dmitry Donskoy*, a nuclear-powered ballistic missile submarine. In addition, on 15 April 2007, the first of the new *Borei*-class of nuclear-powered ballistic missile submarine, the *Yuriy Dolgorukiy,* was launched at Sevmash Severodvinsk shipyard (Yemelyanenkov, 2008). The reinvigoration of Russian shipyards has additionally meant the greater availability of platforms and subsequent technology transfer to other countries in the region, including India, the Peoples Republic of China, and Indonesia.

Chinese development of undersea technology has accelerated noticeably in the last decade. It is likely that the rapid growth of the Chinese economy, from a Gross Domestic Product of $1.95 trillion in 2000 to $4.19 trillion in 2008, has contributed to an expanding military budget. Though Chinese maritime strategy has generally favored a policy of “offshore active defense,” recent activity suggests that the nation is attempting to project power further into the South China and Philippine Seas (DoD, 2009). One example of this is the 8 March 2009 harassment of the USNS IMPECCABLE (T-AGOS 23)[8], which is one of the current SURTASS LFA platforms, by several Chinese vessels, including an intelligence-gathering ship, a fisheries patrol vessel, an oceanographic administration vessel, and two trawlers. The Peoples Liberation Army Navy (PLAN) has approximately 60 operational submarines, of which eight are nuclear-powered (Funnel, 2009). Since the early 1990s the PLAN has shifted to focus efforts on the construction of a smaller number of high-capability platforms (ONI, 2009a). The PLAN is already quite capable and of concern to other regional powers that fear Chinese projection of power in the Indian Ocean and potential impacts in the Taiwan Strait and regional shipping lanes.

In India, more than two decades of effort culminated in the launching of the INS ARIHANT on 26 July 2009 (Rai, 2009). The nuclear-powered ballistic missile submarine was developed with design assistance from the Russian Navy and is anticipated to be the first of five indigenously built submarines of the Indian ARIHANT class (Indian Express, 2007; Unnithan, 2009). These vessels would be a compliment to the

8 This 5,370-ton ship is managed by the U.S. Military Sealift Command, under U.S. Navy operational command. T-AGOS stands for Tactical-Auxiliary General Ocean Surveillance. The IMPECCABLE was conducting standard underwater ocean surveillance in international waters, 139 km (75 nmi) off Hainan Island, at the time of the incident.

existing German-built and Russian-built submarines in the Indian fleet. India may also be leasing two *Akula*-class Russian submarines, and recently completed negotiations to build six *Scorpene*-class diesel-electric submarines in India that will be equipped with Mesma® AIP systems.

Pakistan is also seeking to bolster its submarine fleet through domestic construction, with the commissioning on 26 September 2008 of its second domestically built *Agosta* 90B vessel. This is Pakistan's third vessel of the class under a contract with the French shipbuilding firm DCN International, which involves not only the construction of submarines but also the transfer of technology (Pakistan Newswire, 2008). Additionally, the Pakistani Navy is in negotiations for the construction of several German-designed U 214 submarines, which would also be built in Pakistan. Other Southeast Asian nations that are in negotiations for or are seeking to acquire submarines in the region include Bangladesh, Indonesia, Singapore, Taiwan, and Malaysia (Choong, 2007; Liton, 2009).

Over 40 countries have operational submarines, and many are planning to increase the numbers in their naval fleets (Table 1-1). When the FSEIS was completed in 2007, there were 470 submarines operational or being built. Since that time, the number of submarines has increased substantially to between 582 and 613 that are operational or being built.

1.1.2 UNIQUE THREAT POSED BY DIESEL-ELECTRIC SUBMARINES

During the Cold War, the principal ASW threat to U.S. forces came from nuclear-powered Soviet missile and attack submarines in an open-ocean environment. These submarines, though fast, well armed, and capable, could be effectively monitored using passive sonar. Passive systems technology has traditionally been the dominant means used by U.S. Naval forces to conduct long-range surveillance and initial classification of enemy undersea threats. These passive systems, which were developed to a high degree of sophistication during the Cold War, had the benefit of stealth, emitting no noise that could be detected by enemy forces. They were particularly effective tools against the relatively noisy Soviet submarines and allowed effective, accurate tracking at significant distance (Tyler, 1992).

In recent years, the use of relatively inexpensive diesel-electric submarines has caused interest in submarine technology and undersea capability to increase dramatically. World War II-era diesel-electric submarines were quiet; however, they were restricted in their underwater operations by a requirement to surface or snorkel frequently to recharge their batteries, which left them more vulnerable to detection during those periods. With the advent of AIP systems, these quiet, diesel-electric submarines can operate for much longer periods of time underwater and are the primary ASW threat facing the U.S. military today. AIP, a term that encompasses several technologies, allows conventional submarines to operate submerged for much longer periods without the need to surface to run their diesel generators from atmospheric oxygen to recharge batteries. One of the most promising AIP technologies uses fuel cells such as those being installed on German U 212A and U 214 submarines. Conventional submarines rely on electric motors for propulsion while submerged, and underwater performance is hampered by the limited capacity of marine batteries and the need to periodically surface and recharge. AIP greatly increases their capability by allowing the diesel-electric submarine to operate submerged for greater lengths of time, potentially for several weeks to a month (Whitman, 2001).

Diesel electric submarines, with and without the inclusion of AIP, have several characteristics which make their operation different from that of nuclear submarines. These include their ability to operate in several modes, some of which are almost entirely silent, such as when they run entirely on battery power. A significant capability of diesel-electric submarines is their ability to shut down most machinery while hovering motionless near the ocean floor. An experienced diesel-electric submarine operator could remain stationary and nearly undetectable in this state for as long as breathable air was available. Additionally, diesel-electric submarines have benefited from the same advances in quieting technology used on larger nuclear-powered submarines. Due to their smaller size, the current generation of diesel-electric submarines is ideally suited for operation in littoral and near-shore areas. The combination of advanced quieting technologies and AIP makes the modern diesel-electric submarine a formidable threat.

Table 1-1. World inventory of operational and building submarines[9] (Funnell, 2009; ONI, 2009a and 2009b; Rai, 2009).

COUNTRY	TOTAL NUCLEAR POWERED	TOTAL NUCLEAR BUILDING	TOTAL CONVENTIONAL & NON-NUC AIP	TOTAL CONVENTIONAL BUILDING	MINI-SUBS[10]
ATLANTIC/BALTIC/MEDITERRANEAN/BLACK[11]					
Algeria			2		
Bulgaria			1		
Canada			4		
Egypt[12]			4		
Germany			10	6	
Greece			8	4	
Israel			3	2	
Italy			7	2	
Netherlands			4		
Norway			6		
Poland			5		
Portugal			1	2	
Spain			4	4	
Sweden			5		
Turkey			14		
Ukraine			1		
SOUTH AMERICA					
Argentina			3		
Brazil			5		
Chile			4		
Columbia			2		2
Ecuador			2		
Peru			6		
Venezuela			2	3	

9 World submarine inventory does not include training, research, or rescue subs. Additionally, this inventory does not include underwater autonomous or swimmer delivery vehicles.

10 Included are mini-subs of tactical value; non-swimmer delivery vehicles with the ability to deliver torpedoes or mines.

11 Libya possesses two Foxtrot class submarines of questionable operational capability. The country may be acquiring one or two Kilo class Russian diesel-electric submarines in the near future.

12 Egypt may be in negotiations with Germany for the acquisition of several Dolphin class submarines.

Table 1-1. **World inventory of operational and building submarines[9] (Funnell, 2009; ONI, 2009a and 2009b; Rai, 2009).**

Country	Total Nuclear Powered	Total Nuclear Building	Total Conventional & Non-Nuc AIP	Total Conventional Building	Mini-Subs[10]
Western Pacific/Indian Ocean[13, 14]					
Australia			6		
Indonesia			2		
Iran			3	3	9
Japan			19	4	
Malaysia				2	
North Korea			23		65
Pakistan			5	3 to 4	3
Singapore			4		
South Africa			3		
South Korea			10	12 to 13	2
Taiwan			2		
US/UK/France/Russia/China/India					
United States	70	18			
United Kingdom	12	4 to 7			
France	9	10			
Russia	42	5 to 10	19	2	
Peoples Republic of China	9	4 to 6	53	2 to 10	
India	1	4 to 12	16	6	
Total Nuclear	142				
Total Nuclear Building		45 to 63			
Total Conventional/Non-Nuclear AIP			269		
Total Conventional/Non-Nuclear AIP Building/Conversion				54 to 64	
Total Mini-Subs					76
Projected World Submarine Population (42 Countries)					582 to 613

13 The Bangladesh Navy has pledged, in a recently released 10-year naval development plan, to purchase an undisclosed number of submarines by 2019 (Liton, 2009).

14 In December 2009, the Vietnamese government assigned a contract to purchase six Russian Kilo class diesel-electric submarines along with a variety of other military hardware (Pham, 2009).

With batteries and fuel cells achieving higher capacities and as AIP technology matures, the advantages of nuclear-powered submarines over diesel-electric submarines equipped with AIP will continue to narrow. Quite the contrary, future naval activities are no longer principally designed to combat open-ocean, nuclear submarine threats; will most likely occur throughout the strategic areas of the World's oceans and sea lanes; and will utilize quieter, advanced diesel-electric submarines.

1.1.3 ASW CHALLENGES IN THE LITTORAL ENVIRONMENT

The Navy defines "littoral" as the region that horizontally encompasses the land/water mass interface from 50 statute miles (80 km) ashore to 200 nmi (370 km) at sea; extends vertically from the bottom of the ocean to the top of the atmosphere and from the land surface to the top of the atmosphere (Naval Oceanographic Office, 1999). The term littoral is one of the most misunderstood terms used in naval warfare. The common definition of littoral means pertaining to the shore or a shore or coastal region, while the marine science definition refers to the shallow-water zone between low- and high-tide. The Navy's meaning differs because it is based on a tactical, not geographic or environmental, perspective relating to overall coastal operations, including all assets supporting a particular operation regardless of how close, or far, from the shore they may be operating.

The U.S. military anticipates that future naval conflicts are most likely to occur within the littoral or coastal areas. This is a further complication to the Naval ASW mission and a distinct change from the Cold War era, where conflicts were most likely to occur in mid-ocean areas. The shift from open ocean areas to shallower, acoustically complex, near-shore areas forces extensive changes in the ways in which ASW operations can be conducted. Littoral areas have greatly variable and frequently high underwater background noise. This is largely a result of commercial shipping and complex underwater acoustic propagation conditions, such as multi-path propagation, which makes detection of underwater threats much harder and detection ranges shorter (Farrel, 2003)

A predominant factor affecting passive sonar usefulness in the littoral environment is the fact that over the past decades, while submarines have been becoming quieter, underwater ambient noise levels in littoral ocean areas have increased (Ort et al., 2003). With passive sonar alone, it is likely that U.S. Forces would not have adequate time to react to and defend against enemy submarine threats. SURTASS LFA sonar provides the U.S. Navy with the most effective and best available means to monitor submarines at long range in littoral areas, at distances sufficient to allow them to be detected and tracked before they pose a threat to U.S. or allied naval/land forces, or civilian coastal targets.

The U.S. and other nations have conducted research on numerous acoustic and non-acoustic solutions to this problem, including active sonar. According to the Netherlands Organization for Applied Scientific Research–Physics and Electronics Laboratory, "The smaller and quieter coastal diesel-electric and midget submarines can only be detected in the noisy coastal environments by a low frequency active sonar (LFAS) approach" (Ort et al., 2003). Their work and the research of other organizations have shown that LFAS is successful at long-range detection, even in shallow water. Active sonar does not depend on the submarine target to generate noise; therefore, the use of active sonar eliminates advantages gained by the use of quieting technologies.

A prime example of the importance of littoral areas is in the waters of Eastern Asia, including the shallow waters of the South China Sea, East China Sea, Sea of Japan, and Philippine Sea. Other areas are in the Middle East, the Persian Gulf, Strait of Hormuz, and Gulf of Oman. Many of the world's busiest sea lanes pass through these waters, carrying billions of dollars in American investments and a significant amount of the world's trade goods (Farrell, 2003).

1.1.4 NON-ACOUSTIC ALTERNATIVE ASW DETECTION TECHNOLOGIES

Non-acoustic ASW detection technologies were reviewed in the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001) to determine their usefulness in the long-range detection of submarines. These technologies included radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, and biologic detection systems. The analysis presented in Subchapter 1.2.1 of the FOEIS/EIS was reviewed and updated. The analysis presented in the FOEIS/EIS remains valid except as noted below and the contents are incorporated herein by reference.

- **Radar:** Synthetic Aperture Radar (SAR) allows for the long-range detection of surfaced submarine wakes or periscope "feathers" from satellites and aircraft. This system is of limited operational use because 1) the submarine must either be underway on the surface or at periscope depth with the periscope deployed, and 2) there must be a confluence of near-perfect meteorological and oceanographic conditions (which rarely occur) for the system to function. Additionally, SAR is most effective when being used to observe fixed objects, such as terrain, cities, and military bases. Inverse Synthetic Aperture Radar (ISAR) is a technique to generate a two-dimensional high resolution image of a target. In situations where other radars display only a single unidentifiable bright moving pixel, the ISAR image is often adequate to discriminate between various missiles, military aircraft, and civilian aircraft. ISAR is best used against moving targets, including surfaced submarines (FAS, 1998).
- **Magnetic:** The AN/ASQ-233 Multi-Mode Magnetic Detection System (3MDS) is the latest generation of airborne Magnetic Anomaly Detection (MAD) technology for use by rotary-wing and fixed-wing ASW platforms. This system is based on the helium-4 atomic magnetometer technology. Helium sensor technology has been incorporated into experimental and developmental airborne and sea bottom sensor systems going back to the 1970s. 3MDS provides the warfighter with a MAD localization and attack sensor that performs better than the MAD sensor systems currently fielded in the U.S. Navy's P-3C Orion aircraft and SH-60B Seahawk helicopter fleets. 3MDS will also provide detection capability of extremely low frequency (ELF) electromagnetic signatures, which does not exist with the older systems (ONR, 2008). However, 3MDS only provides short-range detection.
- **Infrared:** High Performance Mobility Forward Looking Infrared (FLIR), is based on the SeaFLIR® III imaging system and includes a laser rangefinder, a choice of mid or large format thermal imager, an image intensified television and laser pointer, coupled with navigation inputs to provide precise geo-locating capability. However, infrared detection is limited to "line-of-sight" and, therefore, if deployed from an aircraft or surface vessel, can only provide short- to medium-range detection (AIA, 2009).
- **Optical:** Over the last two decades research has been conducted at universities and Navy laboratories in an attempt to exploit spectral and polarization information present in the light reflected from targets and backgrounds relevant to naval missions. Missions can range from the detection and targeting of specific platforms to the monitoring of marine mammals whose presence will impact naval acoustic testing. Other missions include naval search and rescue, near-shore mine detection, and many other surveillance and reconnaissance operations. This research has revealed that spectral and polarization information is exploitable using an appropriate electro-optical system. Current Naval electro-optical imaging systems are designed for very general applications utilizing three-color video technologies. While producing high quality pictures and subsequent situational awareness, the systems are not designed for target detection and are not capable of exploiting narrowband spectral or polarization information present in the light reflected from the target (ACT, 2009).

Although non-acoustic detection methods have demonstrated some utility in detecting submarines, this review supports the conclusion in the FOEIS/EIS that they cannot reliably provide U.S. forces with long-range detection (hundreds of nautical miles) and longer reaction times due to a number of critical factors:

- Limited range of detection;
- Meteorological and oceanographic limitations;
- Unique operating requirements; and/or
- Requirements for the submarine to be at or near the surface for detection.

Active and passive acoustic sensors continue to be the primary and most effective detection method for diesel and nuclear submarines in deep ocean and littoral areas.

1.2 BACKGROUND

Consistent with responsible stewardship of the environment, the U.S. Navy is firmly committed to the protection of marine species and is mindful of the potential effects that man-made sound may have upon marine life. The Navy has conducted research on the potential for effects of low- and mid-frequency active sonar systems on some marine species, and has demonstrated that, under certain circumstances and conditions, use of active sonar can have an effect upon particular marine species.

Compliance with numerous environmental laws and regulations is mandatory. This process of balancing national security with environmental stewardship of the oceans is complex, costly, and lengthy.

1.2.1 2002 TO 2007 REGULATORY COMPLIANCE AND LITIGATION

Prior to NMFS promulgating the 2007 five-year Rule (NOAA, 2007a) and LOAs, there were a number of key regulatory and litigation events. The timeline and details about these events are included here for context and perspective.

1.2.1.1 2002 NEPA Compliance

The NEPA process for SURTASS LFA sonar began on 18 July 1996, when the Navy published its notice of intent (NOI) to prepare an EIS/OEIS for SURTASS LFA sonar under NEPA and EO 12114 (DoN, 1996). The process culminated with the signing of the ROD on 16 July 2002 (DoN, 2002). During the NEPA analysis the Navy recognized there were scientific data gaps concerning the potential for moderate-to-low exposure levels to affect cetacean hearing ability or modify biologically important behavior. As a result of this limitation, the Navy sponsored independent, scientific field research referred to as the Low Frequency Sound Scientific Research Program (LFS SRP). This groundbreaking research program found that the potential for SURTASS LFA sonar to cause these effects would be minimal.

1.2.1.2 2002 to 2007 MMPA and ESA Authorizations

Based on the scientific analyses detailed in the Navy LOA application and further supported by information and data contained in the Navy's FOEIS/EIS (DoN, 2001), NMFS determined that the operations of SURTASS LFA sonar would employ means of effecting the least practicable adverse impact on the species or stock, that would result in the incidental harassment of only small numbers of marine mammals, have no more than a negligible impact on the affected marine mammal stocks or habitats, and would not have an unmitigable adverse impact on the availability of such species or stocks for taking for subsistence uses. Consequently NMFS issued the initial LOA (NOAA, 2002a) under the MMPA Final Rule (50 CFR Part 216 Subpart Q) (NOAA, 2002b) for the operation of SURTASS LFA Sonar on research vessel (R/V) *Cory Chouest*. The ESA section 7 consultation on the issuance of the above MMPA Final Rule and the associated LOAs found that the Navy and NMFS' actions were not likely to jeopardize the continued existence of threatened or endangered species under NMFS' jurisdiction or destroy or adversely modify critical habitat that has been designated for those species. The first biological opinion (BiOp) issued by NMFS was a 5-year programmatic document on the operation of SURTASS LFA sonar and the MMPA rule making (NMFS, 2002a). It was followed by the annual BiOp for the LOAs. After the initial LOA was issued in 2002, the Navy requested annual renewals in accordance with 50 CFR §216.189 for the remaining four years of the 2002 Final Rule for the R/V *Cory Chouest* and USNS IMPECCABLE. NMFS subsequently issued the LOAs (NOAA, 2003a, 2004, 2005, and 2006a).

1.2.1.3 National Defense Authorization Act

On November 24, 2003 the National Defense Authorization Act for Fiscal Year 2004 (NDAA FY04) (Public Law 108-136) was passed by Congress. Included in this law were amendments to the MMPA (16 U.S.C. 1361 et seq.) that apply where a "military readiness activity" is concerned. Of special importance for SURTASS LFA sonar take authorization, the NDAA amended Section 101(a)(5) of the MMPA, which governs the taking of marine mammals incidental to otherwise lawful activities. The term "military readiness activity" is defined in Public Law 107-314 (16 U.S.C. §703 note) to include all training and operations of the Armed Forces that relate to combat; and the adequate and realistic testing of military equipment, vehicles, weapons and sensors for proper operation and suitability for combat use. NMFS and the Navy determined that the SURTASS LFA sonar testing, training and military operations that are the subject of NMFS' Final Rules constituted military readiness activities because those activities constitute "training and operations of the Armed Forces that relate to combat" and constitute "adequate and realistic testing of military equipment, vehicles, weapons and sensors for proper operation and suitability for combat use."

The provisions of this act that specifically relate to SURTASS LFA sonar concern revisions to the MMPA, as summarized below:

- Amended definition of "harassment" as it applies to military readiness activities and scientific activities conducted by or on behalf of the Federal government.
- Level A "harassment" defined as any act that injures or has the *significant* potential to injure a marine mammal or marine mammal stock in the wild.
- Level B "harassment" defined as any act that disturbs or is *likely to disturb* a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering *to a point where the patterns are abandoned or significantly altered*.
- Secretary of Defense may invoke a national defense exemption not to exceed two years for Department of Defense (DoD) activities after conferring with the Secretary of Commerce and the Secretary of Interior, as appropriate.[15]
- NMFS' determination of "least practicable adverse impact on species or stock" must include consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.
- Eliminated the "small numbers" and "specified geographic region" requirements from the incidental take permitting process for military readiness activities.

1.2.1.4 2002 Litigation

As a result of litigation filed in August 2002, the Court issued a tailored Preliminary Injunction on 15 November 2002 for operations of SURTASS LFA sonar in a stipulated area in the northwest Pacific Ocean/Philippine Sea, and south and east of Japan. The Court issued a ruling on the parties' motions for summary judgment in the SURTASS LFA sonar litigation on 26 August 2003. The Court found deficiencies in the Navy's and NMFS' compliance under NEPA, ESA, and MMPA. The Court, however, indicated that a total ban of employment of SURTASS LFA sonar would pose a hardship on the Navy's ability to protect national security by ensuring military preparedness and the safety of those serving in the military from hostile submarines. Based on Court-directed mediation between the parties, the Court issued a tailored Permanent Injunction on 14 October 2003, allowing SURTASS LFA sonar operations from both R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23) in stipulated areas in the northwest Pacific Ocean/Philippine Sea, Sea of Japan, East China Sea, and South China Sea with certain year-round and seasonal restrictions. On 7 July 2005, the Court amended the injunction to expand the potential areas of operation based on real-world contingencies.

15 SURTASS LFA sonar has never been deployed under this national defense exemption.

Under the Court's opinion, NMFS was found to have improperly conflated its negligible impact determinations with small numbers requirements. As a result of the NDAA FY04 amendments to the MMPA eliminating this issue, the Court vacated and dismissed the MMPA small numbers and specific geographic regions claims on 2 December 2004.

1.2.2 2007 TO 2012 REGULATORY COMPLIANCE AND LITIGATION

In response to the Court's October 2002 Opinion and Order granting a Preliminary Injunction, the DASN(E) decided that the purposes of NEPA would be served by supplemental analysis for employing SURTASS LFA sonar systems. On 11 April 2003, DASN(E) directed the Navy to prepare a SEIS to address concerns identified by the Court to provide additional information regarding the environment that could potentially be affected by SURTASS LFA sonar systems, and additional information related to mitigation. On 26 September 2003, NMFS agreed to be a cooperating agency in the preparation and review of the SEIS. The information developed from this analysis was used to support the Navy's application for the second five-year Rule under the MMPA (DoN, 2006a) and the Navy's Biological Assessment for Section 7 consultation under the ESA (DoN, 2006b).

1.2.2.1 Supplemental Regulatory Compliance and Litigation

The Draft SEIS (DSEIS) was completed in November 2005 (DoN, 2005a) with the 90-day comment period ending in February 2006. During this period, three public hearings were held, in Washington, D.C.; San Diego, CA; and Honolulu, HI. Ninety-seven (97) comments were received on the DSEIS. The Final SEIS (FSEIS), which included detailed responses to all comments received, was completed in May 2007 (DoN, 2007a).

The purpose of the first SURTASS LFA Sonar SEIS was to:

- Address concerns of the U.S. District Court for the Northern District of California in its 26 August 2003 Opinion and Order in relation to compliance with the NEPA, ESA, and MMPA[16];
- Provide information necessary to apply for a new five-year Rule that would provide for incidental takes under the MMPA when the 2002 Rule expired in 2007, taking into account legislative changes to the MMPA and the need to employ up to four SURTASS LFA sonar systems;
- Analyze potential impacts for LFA system upgrades; and
- Provide additional information and analyses pertinent to the proposed action.

1.2.2.2 2007 to 2012 MMPA and ESA Authorizations

On 12 May 2006, the Navy submitted an Application to NMFS requesting an authorization under Section 101(a)(5)(A) of the MMPA for the taking of marine mammals by Level A and Level B harassment incidental to the deployment of SURTASS LFA sonar systems for military readiness activities, to include routine training, testing, and military operations (DoN, 2006a). The activities were associated with the employment of up to four SURTASS LFA sonar systems for a period of five years (16 August 2007 to 15 August 2012).

The Navy submitted a Biological Assessment for the Employment of SURTASS LFA Sonar on 9 June 2006, requesting that NMFS review the document (DoN, 2006b). The Navy further requested a Biological Opinion/Incidental Take Statement under Section 7 of the ESA for a period of five years (16 August 2007 to 15 August 2012).

On 28 September 2006, NMFS published a Notice of Receipt of Application and a request for public comments on the Navy's application for authorization to take marine mammals incidental to the operation

16 On 2 December 2004, the Court vacated and dismissed the MMPA claims based on the National Defense Authorization Act Fiscal Year 2004 (NDAA FY04) amendments to the MMPA.

of SURTASS LFA sonar systems (NOAA, 2006b). The public comment period closed on 30 October 2006. These comments were considered in the development of the Proposed and Final Rules. A Proposed Rule for the renewal of the regulations governing SURTASS LFA sonar MMPA authorization was published on 9 July 2007 (NOAA, 2007b) with a 15-day public comment period. NMFS filed the Final Rule on 15 August 2007 and published on 21 August 2007 (NOAA, 2007c). The initial LOAs under the 2007 Rule were issued by NMFS to the Chief of Naval Operations (N872A) for the R/V *Cory Chouest* and the USNS IMPECCABLE for the period 16 August 2007 to 15 August 2008 (NOAA, 2007a).

NMFS issued, on 14 August 2007, its Biological Opinion on the effects of NMFS' Permits, Conservation and Education Division's proposal to promulgate regulations allowing NMFS to authorize the taking of marine mammals incidental to the Navy's employment of SURTASS LFA sonar in accordance with Section 7 of the ESA, as amended (16 U.S.C. 1531 et seq.) (NMFS, 2007a). On 15 August 2007 (as amended on 17 August 2007), NMFS issued its Biological Opinion/Incidental Take Statement on the effects of the proposed LOAs (effective 16 August 2007 to 15 August 2008) to take marine mammals incidental to the Navy's employment of SURTASS LFA sonar in accordance with Section 7 of the ESA, as amended (16 U.S.C. 1531 et seq.) (NMFS, 2007b and 2007c). The opinions concluded that the proposed LOAs and any takes associated with activities authorized under those regulations were not likely to jeopardize threatened or endangered species in the action area, and that the proposed action was not likely to destroy or adversely modify designated critical habitats.

1.2.2.3 2007 Litigation of Current Regulatory Compliance

On 17 September 2007, a number of plaintiffs filed a lawsuit challenging actions by the Navy and NMFS regarding compliance with NEPA, MMPA, ESA, and the Administrative Procedure Act (APA) for the operation of SURTASS LFA sonar.

On 6 February 2008, the Court issued its Opinion and Order granting in part Plaintiffs' motion for a Preliminary Injunction and required the parties to meet and confer on the precise terms of the Preliminary Injunction. Mediation sessions were held on 26 March 2008 and 27 May 2008 at the U.S. District Court, Northern District of California, in San Francisco, CA.

During the mediation on 26 March 2008, agreement was reached that SURTASS LFA sonar would operate in the Western Pacific areas stipulated in the 2003 Permanent Injunction, as amended in 2005, with the following modifications:

- Stipulated LFA Operational Agreement permitting SURTASS LFA sonar operations up to, but not within, 22 km (12 nmi) from the coast—when necessary to continue tracking an existing underwater contact or when operationally necessary to detect a new underwater contact to maximize opportunities for detection.
- Additional terms include assuring the LFA sound field does not exceed 180 dB re 1 µPa (rms) at a distance of less than 33 km (18 nmi) from:
  - Islands of the Luzon Strait, including the Bashi Channel; and
  - Eastern coastlines of the islands of the Ryukyu Archipelago.

During the mediation on 27 May 2008, agreement was reached on overall settlement of the litigation, which included the agreement that SURTASS LFA sonar could operate in the Hawaii operating areas. The settlement also permits SURTASS LFA sonar operations up to 22 km (12 nmi) from the coast when necessary to continue tracking an existing underwater contact, or when operationally necessary to detect a new underwater contact to maximize opportunities for detection within the Hawaii operating areas.

On 12 August 2008, the Court approved the settlement; and on 29 August 2008, the Court signed the Stipulated Voluntary Dismissal with Prejudice, which effectively ended the litigation. The LOAs issued by NMFS to the USNS ABLE, USNS IMPECCABLE, USNS EFFECTIVE, and USNS VICTORIOUS for the remainder of the 2007 Rule were based on the expanded operating areas described above.

1.2.3 SYSTEM UPGRADES

SURTASS LFA is part of the Integrated Undersea Surveillance System (IUSS), which is designed to detect, classify, and track diesel-electric and nuclear submarines operating in both shallow and deep regions of littoral and oceanic waters. The majority of IUSS operational sensors were developed based on deep-water, open-ocean threat scenarios. However, to meet current and future surveillance requirements, IUSS sensors must be adapted or developed to operate in littoral or regional ocean areas where conflicts are most likely to occur. Additionally, IUSS active sensors must possess the ability to work independently or cooperatively with other IUSS, Navy, and allied nations' assets. Three different modes of operation are considered: 1) mono-static[17] or independent operations, 2) bi-static operations where one system functions as the active source and other assets function as the receiver; and 3) multi-static operations where multiple active sources are employed cooperatively with multiple receivers.

To meet these emergent requirements, the Navy initiated a program to upgrade individual undersea surveillance systems. This included SURTASS LFA sonar system upgrades and modifications necessary to install and operate LFA from the smaller VICTORIOUS Class (T-AGOS 19 Class) ocean surveillance ships (Figure 1-2). For the active system, this upgrade is known as Compact LFA, or CLFA, and is currently installed onboard the USNS ABLE (T-AGOS 20) and USNS EFFECTIVE (T-AGOS 21). Also included are upgrades to the SURTASS array capabilities for shallow-water operations and enhanced passive detection capabilities.

Figure 1-2. VICTORIOUS class (T-AGOS 19 Class) ocean surveillance ship.

17 Mono-static means the active source and receiver are co-located. For SURTASS LFA sonar, the LFA transducers in a vertical line array are the source and the horizontal towed line array is the receiver.

1.3 ENVIRONMENTAL IMPACT ANALYSIS

As stated earlier, the purpose of this SEIS/SOEIS is to address recent concerns raised during litigation over employment of the SURTASS LFA sonar system, and to support issuance of a third five-year Rule under the MMPA for employment of SURTASS LFA sonar systems. This SEIS/SOEIS provides further analyses of the following:

- Potential additional OBIAs (greater than 22 km [12 nmi]) in regions of the world where the Navy intends to use the SURTASS LFA sonar systems for routine training, testing, and military operations.
- Whether using a larger coastal standoff distance where the continental shelf extends further than current standoff distance is practicable for SURTASS LFA sonar, at least in some locations.
- Potential cumulative impacts involving concurrent use of SURTASS LFA sonar with other active sonar sources.

Additional SEIS/SOEIS analyses include:

- Updating literature reviews, especially for fish, sea turtles, and marine mammals;
- New subchapter on protected habitats, including ESA Critical Habitat, Essential Fish Habitat, and Marine Protected Areas;
- Updated literature review on commercial fisheries, marine mammal strandings, cumulative effects from anthropogenic oceanic noise, cumulative effects on socioeconomic resources; and
- Mitigation measures: changes due to increased number of OBIAs.

Information from these analyses is used to assist the Navy in determining how to employ SURTASS LFA sonar, including the selection of operating areas that the Navy requires for routine training, testing, and military operations in requests for MMPA LOAs submitted to NMFS.

1.4 ANALYTICAL CONTEXT

For the most part, there have been no substantial changes to the framework for the development of the analytical context since the FSEIS (DoN, 2007a). The following Subchapters address this topic in more detail.

1.4.1 ADEQUACY OF SCIENTIFIC INFORMATION ON HUMAN DIVERS

There have been no significant changes to the knowledge or understanding for the potential effects of LF sound on humans in water since the FSEIS relating to the establishment of the 145-dB re 1 µPa (rms) (RL) criterion for recreational and commercial divers (DoN, 2007a). The information in Subchapter 1.4.1 of the FOEIS/EIS (DoN, 2001) concerning the research by the Naval Submarine Medical Research Laboratory, numerous universities, and private organizations, which was the basis for establishing the criterion, remains valid, and the contents are incorporated herein by reference.

1.4.2 ADEQUACY OF SCIENTIFIC RESEARCH ON MARINE ANIMALS

There have been changes to the knowledge and understanding of the potential for LF sound to affect marine species since the FSEIS. Although some of the new information is substantial, it does not change the framework of the analytical context of the FOEIS/EIS and FSEIS. Where there were scientific data gaps regarding the potential for effects from LF sound on marine life, conservative assumptions were made (see Subchapter 1.4.3 below). Therefore, the analyses and conclusions in both the FOEIS/EIS and FSEIS were conservative, meaning that the analysis overstates the potential impacts to marine mammals.

Several key scientific papers and research that are relevant to the conservative assumptions of the FOEIS/EIS and FSEIS are discussed in this subchapter.

Based on Southall et al. (2007), the criteria utilized in the FOEIS/EIS and FSEIS were conservative and remain valid for those documents' analyses of the potential effects of LF sound on marine animals. The contents of Subchapter 1.4.2 of the FOEIS/EIS and FSEIS relating to data gaps on marine species for the assessment of potential risk through exposure to LF sound and the research funded by the Navy to fill these gaps are incorporated herein by reference. Additional and updated information on the potential effects on marine mammals and fish from LF sound are included in this SEIS/SOEIS, and are outlined below.

For the purposes of the SURTASS LFA sonar analyses presented in the FOEIS/EIS and FSEIS, marine animals exposed to received levels ≥180 dB re 1 µPa (rms) were evaluated as if they were injured. This level was considered conservative.

1.4.2.1 Estimating the Potential for Injury to Marine Mammals

There have been changes to the knowledge and understanding of the potential for LF sound to affect marine mammal species since the FSEIS. Southall et al. (2007) is a benchmark paper written by a panel of scientific experts in the fields of biology and acoustics, with the purpose of: 1) reviewing the expanding literature on marine mammal hearing and physiological and behavioral responses to anthropogenic sound, and 2) proposing [acoustic] exposure criteria for certain effects; i.e., the exposure levels above which adverse effects on various groups of marine mammals are expected. The paper addresses the potential for onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) from underwater acoustic exposure and discusses options for attempting to address adverse behavioral response. These topics are covered without directly linking them to existing laws such as the MMPA or ESA. Extant research on these topics is discussed in some detail and recommendations for overcoming shortfalls in both data and basic research issues are presented in this SEIS/SOEIS.

Southall et al. (2007) proposed injury criteria based on the onset of PTS for LF/mid frequency (MF)/high frequency (HF) marine mammal groups exposed to non-pulse sound types, which included discrete acoustic exposures from SURTASS LFA sonar:

- For LF, MF, and HF cetaceans: SPL: 230 dB re 1 µPa (peak) (flat); SEL: 215 dB re 1 μPa^2-sec.
- For pinnipeds (in water): SPL: 218 dB re 1 µPa (peak) (flat); SEL: 203 dB re 1 μPa^2-sec.

As stated in the 2001 FOEIS/EIS (p. 10-47), the sound field of the LFA array (i.e., the actual pressure or maximum [rms] SPL received levels observed surrounding the LFA array) can never be higher than the source level of an individual projector, or 215 dB re 1 µPa at 1 m (rms). The theoretical "point source" level and beam pattern for the whole array is only valid when range from the array is sufficient for the array to appear as a point source (i.e., the receiver location is in the far field or approximately 100 m or more from the array). Thus, when compared to the dual criteria for "non-pulse" sources as presented in Southall et al. (2007), the SPL criterion of 230 dB re 1 µPa (peak) (flat) cannot be exceeded, while the SEL criterion of 215 dB re 1 μPa^2-sec, can only be exceeded if an animal stays within approximately 10 m of the array for the full 60 seconds of a typical transmission (i.e., the animal must be adjacent to the source and then move in the speed and direction of the source ship for the entire 60 seconds). Therefore, it is highly unlikely that SURTASS LFA sonar creates sound fields that exceed either of the above dual proposed injury criteria. Southall et al. (2007) considered the noise exposure criteria to be an initial step in an iterative process to understand and predict the effects of noise on marine mammals. To remain consistent with the previous FOEIS/EIS (DoN, 2001), FSEIS (DoN, 2007a), MMPA Rules and LOAs, and ESA biological opinions, this SEIS/SOEIS will continue to utilize the 180-dB SPL (RL) criteria for injury to marine mammals with the understanding that this value is now considered to be extremely conservative. As an illustration of this conservativeness, if it is assumed that an animal remains at a range where it receives an SPL of 180 dB re 1 µPa (rms) (i.e., within about 1 km of the moving source and it remains undetected) for over 10 hours of LFA transmissions at 12 minute intervals (or 5 transmissions per hour) and with 60-sec durations, the equivalent SEL received level for this situation is 215 dB re 1 μPa^2-sec (i.e., 180 + 10×Log [60 sec] + 10×Log [50 signals] = 180 + 18 + 17 = 215).

Since the FOEIS/EIS, concerns have been raised about direct impacts on marine mammal tissue, indirect impacts on tissues surrounding a structure, and acoustically-mediated gas bubble growth within tissues from supersaturated dissolved nitrogen gas. These issues were discussed in the FSEIS. Regarding bubble formation as a causal mechanism between acoustic exposure and stranding events, Southall et al. (2007) states that at present there is scientific disagreement and/or complete lack of existing information regarding important points to establish explicit exposure criteria for this proposed mechanism.

There has been no direct evidence of any injury or stranding of marine mammals either during the brief periods of the SURTASS LFA sonar research projects in the late 1990s (which were conducted close to land, with extensive monitoring and during periods of high marine mammal densities, and in areas where SURTASS LFA sonar will not operate) nor since LFA operations were resumed in 2003 (DoN, 2007c and 2008).

1.4.2.2 Estimating the Potential for Behavioral Effects to Marine Mammals

There have been no significant changes to the knowledge or understanding of the potential for SURTASS LFA sonar sound to significantly modify biologically important behavior in marine mammals since the FSEIS. Findings from the Navy-funded Low Frequency Sound Scientific Research Program (LFS SRP) did not reveal any significant change in a biologically important behavior in LF marine mammals, and the risk analysis estimated very low risk. The information in Subchapter 1.4.2.2 of the FOEIS/EIS concerning the LFS SRP remains valid, and the contents are incorporated herein by reference.

1.4.2.3 Masking

The recent research reviewed in Subchapter 4.3.2.4 provides no substantial changes to the knowledge or understanding for the potential of SURTASS LFA sonar to cause acoustic masking and impaired communications in marine mammals that would change the information and conclusions in Subchapter 4.2.7.7 of the FOEIS/EIS (DoN, 2001) and Subchapters 4.3.5, 4.3.6, and 4.6.1.2 of the FSEIS (DoN, 2007a). In fact, these recent studies provide additional support for the statement in the FOEIS/EIS that broadband low frequency shipping noise is likely to be more detrimental than low duty-cycle SURTASS LFA sonar (Andrew et al., 2002; McDonald et al., 2006a; Parks et al., 2007; Clark et al., 2009). Therefore, the subchapters noted above of the FOEIS/EIS and FSEIS remain valid, and the contents are incorporated by reference herein; any masking in marine mammals due to narrowband, intermittent (low duty cycle) LFA sonar signal transmissions is expected to be minimal and unlikely.

1.4.2.4 Estimating the Potential for Injury to Fish Stocks

There has been significant advancement in the knowledge and understanding of the potential for SURTASS LFA sound to affect marine fish species since the FSEIS. Several recent studies have shown that sounds substantially above 180 dB re 1 μPa (rms) (RL) have little or no effects on the physiology of fish (e.g., Popper et al., 2005a and 2007; Hastings et al., 2008).

Due to the lack of scientific data relating to the potential for LF sound to affect fish stocks, an independent scientific research program was funded to examine whether exposure to high-intensity, low frequency sonar, such as SURTASS LFA, would affect fish. The fish controlled exposure experiment (CEE), which was conducted in 2005 and 2006 by the University of Maryland, was designed to examine the effects of LFA on hearing, the structure of the ear, and selected non-auditory systems in a salmonid (rainbow trout) channel catfish and hybrid sunfish. The results, first presented in the FSEIS (pp. 4-10 to 4-18) (Popper et al., 2005a; Halvorsen et al., 2006), have been updated based on peer-reviewed, published results (Popper et al., 2007). The results clearly show that there are no pathological effects from sound exposures up to received levels of 193 dB re 1 µPa (rms) (Kane et al., 2010). This is consistent with the initial results reported in the FSEIS.

1.4.2.5 Marine Mammal Strandings

There have been no significant changes to the knowledge or understanding of the potential for strandings caused by use of SURTASS LFA sonar. The data presented on beaked whale strandings in Subchapter 3.2.5.1 of the FOEIS/EIS are still valid and are incorporated herein by reference. Additional information on marine mammal strandings was presented in Subchapter 4.4.3 of the FSEIS and its contents are incorporated herein by reference. None of these strandings involved SURTASS LFA sonar and there have been no strandings reported since the FSEIS was published that were coincident with recent SURTASS LFA sonar operations. This topic is discussed in more detail in Subchapter 4.3.3.

1.4.3 Analytical Approach

There have been no significant changes to the basic SURTASS LFA sonar analytical approach and the associated conservative assumptions. The information concerning the conservative procedures and assumptions in research and modeling, developed by the independent scientific team and utilized in the analyses in Subchapter 1.4.3 of the FOEIS/EIS, remains valid, and the contents are incorporated herein by reference and also listed below. The details of the analytical approach used in this document are presented in Appendix C—Marine Mammal Impact Analysis and Harassment Level Calculation.

Even though the injury criteria proposed by Southall et al. (2007) is higher than the criteria used for the impact analyses in the FOEIS/EIS and FSEIS, this SEIS/SOEIS will continue to utilize the 180-dB criteria for injury to marine mammals as stated in Subchapter 1.4.2 above, with the understanding that this value is now considered to be extremely conservative. With either criterion, no injuries to marine species are anticipated.

1.4.3.1 Conservative Assumptions in Research and Modeling

The FOEIS/EIS (DoN, 2001) sought a realistic scenario, which would reveal conservative but plausible risk estimates, by incorporating a consistent moderately conservative bias. Where necessary, the analysis relied on conservative procedures and assumptions in research and modeling that were independently developed by the scientific team associated with the SURTASS LFA sonar program. This conservative approach continues through the analysis and modeling completed for this document and includes the following procedures and assumptions:

1. Human Diver Hearing—The comprehensive study conducted by the Office of Naval Research (ONR) and Navy Submarine Medical Research Laboratory (NSMRL) between June 1997 and November 1998 in conjunction with a consortium of university and military laboratories (see FOEIS/EIS Technical Report 3) concluded that the maximum intensity used during testing (157 dB re 1 µPa [rms] RL) did not produce evidence of physiological damage in human subjects. Furthermore, there was only a 2% aversion reaction subjectively reported as "very severe" by divers at 148 dB re 1 µPa (rms) RL. NSMRL adopted a very conservative approach and determined that scaling back the intensity by 3 dB (which equates to a 50% reduction in signal strength) would provide a suitable margin of safety for commercial and recreational divers. Hence, operation of SURTASS LFA sonar systems would be restricted to 145 dB re 1 µPa (rms) in known areas of recreational and commercial diving.

    - 145-dB Diver Geographic Restrictions Not Included in Modeling—To facilitate the modeling of potential impacts to marine mammals, the geographic restriction of 145 dB re 1 µPa (rms) for recreational and commercial dive sites was not included in the Acoustic Integration Model© (AIM) analysis. For regions with known recreational and commercial dive sites (predominantly coastal areas), this is more restrictive, in that its application overrides the 180-dB restriction, usually requiring the SURTASS LFA sonar vessel to operate farther offshore.

2. Use of Baleen Whales as Indicator Species—As described in the FOEIS/EIS, Subchapters 1.4.1.1 and 4.2 (DoN, 2001), baleen whales (mysticetes) were used as indicator species for other marine animals in the LFS SRP studies because they are the animals that are the most likely to have the greatest sensitivity to LF sound, have protected status, and have shown avoidance responses to LF sounds.
3. Use of 180-dB Criterion—For the purposes of the SURTASS LFA sonar analyses presented in the FOEIS/EIS, the FSEIS and this SEIS/SOEIS, all marine animals exposed to RLs ≥180 dB re 1 µPa (rms) are evaluated as if they are injured. A single-ping RL of 180 dB re 1 µPa (rms) was assumed for the modeling; this level is considered conservative, as detailed herein.
4. Risk Transition—The parameter of the risk continuum (for SURTASS LFA sonar) that controls how rapidly risk transitions from low to high values with increasing RL was set at a value that produced a curve with a more gradual transition than curves developed by the analyses of migratory gray whale studies of Malme et al. (1984). The choice of a more gradual slope than the empirical data was consistent with other decisions to make conservative assumptions when extrapolating from other data sets.
5. Risk Threshold—The assumption that risk (for SURTASS LFA sonar) could begin at 119 dB re 1 µPa (rms) is a practical approximation of the RL below which the risk of a significant change in a biologically important behavior approaches zero. In all three phases of the LFS SRP (Clark et al., 2001), most animals showed little to no response to SURTASS LFA sonar signals at RLs up to 155 dB re 1 µPa (rms), and those individuals that did show a response resumed normal activities within tens of minutes.
6. Cumulative Exposure—Another conservative assumption involved the potential effects of cumulative exposure. The analysis assumed that the single-ping equivalent (SPE) level scaled in accordance with previous studies of TTS that dealt with continuous sound, even though SURTASS LFA sonar pings would be separated by 6 to 15 minutes of silence. The 7.5 to 10% (nominal) duty cycle of SURTASS LFA sonar transmissions implies that any cumulative exposure would be less than that for continuous sounds.
7. Number of Marine Mammals Potentially Affected—The acoustic modeling simulations incorporated conservative assumptions regarding the fraction of the regional stock in the area potentially affected by the hypothetical SURTASS LFA sonar operation and their animal movement patterns. Scientific data are typically reported with 95 percent confidence intervals. However, to run the acoustic model, an exact number of animals must be specified. Therefore, the upper end of the 95% confidence interval was used for stock densities and abundances.

1.4.4 NEPA Disclosure Statement for Incomplete and Unavailable Information

There have been no significant changes to the NEPA disclosure statement. The information in Subchapters 1.4.4 of the FOEIS/EIS and FSEIS concerning incomplete and unavailable information remain valid and the contents are incorporated herein by reference.

Therefore, under 40 CFR §1502.22(b), the Navy acknowledges that there is incomplete and unavailable information. This information is not expected to change the evaluation of the potential effects of SURTASS LFA sonar in relationship to reasonably foreseeable significant impacts. This SEIS/SOEIS updates the information and data provided in the FOEIS/EIS and FSEIS and provides evaluations and summaries of existing credible scientific evidence.

1.4.5 Adaptive Management

The Navy, in concert with NMFS, will consider on a case-by-case basis, new/revised, peer-reviewed, and published scientific data and information from qualified and recognized sources within academia, industry, and government/non-government organizations to determine (with input regarding practicability) whether

SURTASS LFA sonar mitigation, monitoring, or reporting measures should be modified (including additions or deletions); if new scientific data indicate that such modifications would be appropriate. This allows for updates to marine mammal stock estimates to be included in annual LOA applications which, in turn, provides for the use of the best available scientific data for predictive models, including AIM. Unanticipated changes in the geo-political climate may also necessitate consideration of modifications to SURTASS LFA sonar mitigation, monitoring, or reporting measures.

THIS PAGE IS INTENTIONALLY LEFT BLANK

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter provides a description of SURTASS LFA sonar technology and the alternatives being considered for its employment, including the No Action Alternative. The proposed action is Navy employment of up to four SURTASS LFA sonar systems.

Pursuant to direction by the Deputy Assistant Secretary of the Navy (Environment) (DASN(E)) to the Chief of Naval Operations (N8) to develop a second supplemental EIS (SEIS)/supplemental OEIS (SOEIS), this document provides additional information regarding the environment that could potentially be affected by employment of SURTASS LFA sonar. This SEIS/SOEIS provides further analysis of potential additional offshore (greater than 22 km [12 nmi]) biologically important areas (OBIAs) in regions of the world where the Navy intends to employ the SURTASS LFA sonar systems for routine training and testing as well as for military operations; further analysis of whether, in some locations, using a larger coastal standoff range for SURTASS LFA sonar where the continental shelf extends further than the current standoff range, is practicable; and further analysis of the potential for cumulative impacts involving other active sonar sources.

References to Underwater Sound Levels
• **References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa at 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).** • **In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).** • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS/SOEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for the energy of all of the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for details. As discussed in Appendix C, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001 and 2007a).**

2.1 GENERAL SYSTEM DESCRIPTIONS

SURTASS LFA sonars are long-range systems operating in the LF band (below 1,000 Hz). These systems are composed of both active and passive components (Figure 2-1). SONAR is an acronym for SOund NAvigation and Ranging, and its definition includes any system that uses underwater sound, or acoustics, for observations and communications. Sonar systems are used for many purposes, ranging from commercial off-the-shelf (COTS) "fish finders" to military ASW systems for detection and classification of submarines.

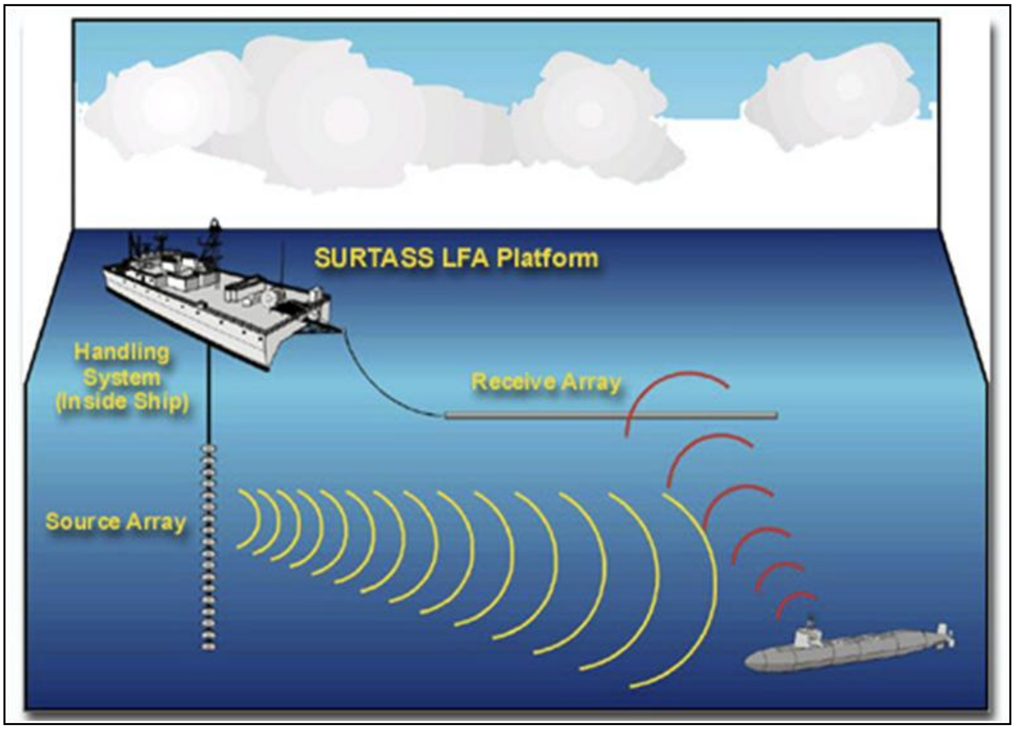


Figure 2-1. SURTASS LFA sonar systems.

There are two basic types of sonar:

- Passive sonar detects the sound created by an object (source) in the water. This is a one-way transmission of sound waves traveling through the water from the source to the receiver and is the same as people hearing sounds that are created by another source and transmitted through the air to the ear.
- Active sonar detects objects by creating a sound pulse, or "ping," that is transmitted through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver). Some marine mammals locate prey and navigate utilizing this form of echolocation.

LFA systems were initially installed on two SURTASS vessels: R/V *Cory Chouest*, which was retired in 2008, and USNS IMPECCABLE (T-AGOS 23). As future undersea warfare requirements continue to transition to littoral ocean regions, the introduction of a compact active system deployable on SURTASS ships was needed. This system upgrade is known as Compact LFA, or CLFA. CLFA consists of smaller, lighter-weight source elements than the current LFA system, and is compact enough to be installed on the VICTORIOUS Class platforms (T-AGOS 19 Class). The initial CLFA installation was completed on the USNS ABLE (T-AGOS 20) in 2008 and at-sea-testing commenced in August 2008. CLFA improvements include:

- Operational frequency, within the 100 to 500 Hz range as stated in Chapter 1, matched to shallow water environments with little loss of detection performance in deep water environments.
- Improved reliability and ease of deployment.
- Lighter-weight design with mission weight of 64,410 kilograms (kg) (142,000 pounds [lb]) for CLFA vice 155,129 kg (324,000 lb) mission weight for LFA.

With the R/V *Cory Chouest*'s retirement in fiscal year (FY) 2008, two systems are currently operational. At present, there is one SURTASS LFA sonar system onboard USNS IMPECCABLE (T-AGOS 23) and one SURTASS CLFA sonar system onboard the USNS ABLE (T-AGOS 20). Two additional CLFA systems are planned for the T-AGOS 19 Class (Figure 2-2). Late in FY 2011, the CLFA system onboard the USNS EFFECTIVE (T-AGOS 21) commenced at sea testing and training. The CLFA system to be installed onboard the USNS VICTORIOUS (T-AGOS 19) is scheduled for at sea testing and training in FY2012. Therefore, no more than four systems are expected to be in use through FY 2017, and thus this SEIS/SOEIS considers the employment of up to four systems.

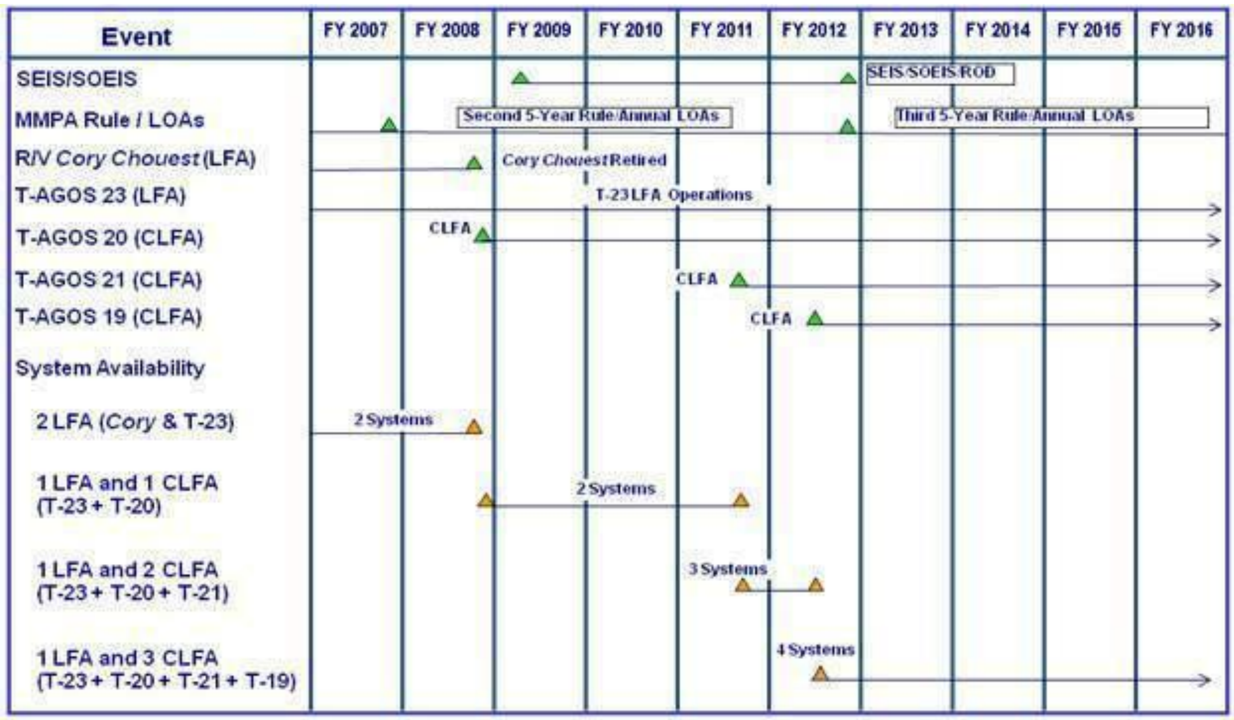


Figure 2-2. Projected LFA and CLFA sonar systems availability.

The operational characteristics of the compact system are comparable to the existing LFA systems as presented in Subchapter 2.1 of the FOEIS/EIS, FSEIS (DoN, 2007a), and this document. Therefore, the potential impacts from CLFA are expected to be similar to, and not greater than, the effects from the existing SURTASS LFA systems. Hence, for this analysis, the term low frequency active, or LFA, will be used to refer to both the existing LFA system and/or the compact (CLFA) system, unless otherwise specified.

2.1.1 ACTIVE SYSTEM COMPONENT

The active component of the existing SURTASS LFA sonar system, LFA, is an active adjunct to the SURTASS passive capability and is planned for use when passive system performance is inadequate. LFA complements SURTASS passive operations by actively acquiring and tracking submarines when they are in quiet operating modes, measuring accurate target range, and re-acquiring lost contacts.

LFA is a set of acoustic transmitting source elements suspended by cable under an ocean surveillance vessel, such as the USNS IMPECCABLE (T-AGOS 23) and the VICTORIOUS Class (T-AGOS 19 Class) (see Figure 2-1). These elements, called projectors, are devices that produce the active sound pulse, or ping. The projectors transform electrical energy to mechanical energy that set up vibrations, or pressure disturbances, within the water to produce a ping.

The characteristics and operating features of the active component (LFA) are:

- The source is a vertical line array (VLA) of up to 18 source projectors suspended below the vessel. LFA's transmitted beam is omnidirectional (360 degrees) in the horizontal, with a narrow vertical beamwidth that can be steered above or below the horizontal.
- The source frequency is between 100 and 500 Hz. A variety of signal types can be used, including continuous wave (CW) and frequency-modulated (FM) signals.
- The source level (SL) of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB re 1 µPa at 1 m (rms) or less. As measured by SPL, the sound field of the array can never be higher than the SL of an individual source projector.
- The typical LFA signal is not a constant tone, but rather a transmission of various waveforms that vary in frequency and duration. A complete sequence of sound transmissions is referred to as a wavetrain (also known as a ping). These wavetrains last between 6 and 100 seconds with an average length of 60 seconds. Within each wavetrain the duration of each continuous frequency sound transmission is no longer than 10 seconds.
- Average duty cycle (ratio of sound "on" time to total time) is less than 20%. The typical duty cycle, based on historical LFA operational parameters (2003 to 2011), is nominally 7.5 to 10%.
- The time between wavetrain transmissions is typically from 6 to 15 minutes.

2.1.2 PASSIVE SYSTEM COMPONENT

The passive, or listening, part of the system is SURTASS. SURTASS detects returning echoes from submerged objects, such as threat submarines, through the use of hydrophones. These devices transform mechanical energy (received acoustic sound wave) to an electrical signal that can be analyzed by the processing system of the sonar. Advances in passive acoustic technology have led to the development of SURTASS Twin-Line (TL-29A) horizontal line array (HLA), a shallow water variant of the single line SURTASS system. TL-29A consists of a "Y" shaped array with two apertures. The array is approximately 1/5th the length of a standard SURTASS array, or approximately 305 m (1,000 ft) long. The TL-29A delivers enhanced capabilities, such as its ability to be towed in shallow water environments in the littoral zones, to provide significant directional noise rejection, and to resolve bearing ambiguities without having to change vessel course. The SURTASS TL-29A HLA provides improved littoral capability.

The passive capability of the USNS IMPECCABLE (T-AGOS 23) was recently upgraded with the installation of the TL-29A array. The three VICTORIOUS Class vessels, which are, or will be, equipped with CLFA, will be outfitted with the newer SURTASS TL-29A passive arrays.

The SURTASS LFA sonar vessel typically maintains a speed of at least 5.6 kilometers per hour (kph) (3 knots [kt]) through the water in order to tow the HLA. The return signals, which are usually below background or ambient noise level, are then processed and evaluated to identify and classify potential underwater threats.

2.2 OPERATING PROFILE

Due to the uncertainties in the world's political climate, a detailed account of future operating locations and conditions cannot be predicted. However, for analytical purposes, a nominal annual deployment schedule and operational concept were developed, based on actual LFA operations since January 2003 and projected Fleet requirements. This information, provided in subchapter 2.2 and Table 2-1 of the SURTASS LFA Sonar FSEIS (DoN, 2007a), remains valid; and the contents are incorporated herein by reference. The SURTASS LFA sonar vessels usually operate independently but may operate in conjunction with other naval air, surface, or submarine assets. The vessels generally travel in straight lines or racetrack patterns depending on the operational scenario.

Annually, each vessel will be expected to spend approximately 54 days in transit and 240 days performing active operations. Between missions, an estimated total of 71 days per year will be spent in port for upkeep and repair to maintain both the material condition of the vessel and its systems, and the morale of the crew. The actual number and length of the individual missions within the 240 days are difficult to predict, but the maximum number of actual transmission hours will not exceed 432 hours per vessel per year.

2.3 FOCUS OF THE ANALYSIS

Due to recent concerns raised during litigation over employment of the SURTASS LFA sonar system, and to support issuance of a third Final Rule under the MMPA for employment of SURTASS LFA sonar systems, the DASN(E) directed the development of a new supplement to the existing SURTASS LFA sonar FOEIS/EIS and FSEIS (DoN, 2001; 2007a). This SEIS/SOEIS will provide: 1) further analysis of potential additional OBIAs (located greater than 12 nmi [22.2 km]) in regions of the world where the Navy intends to use the SURTASS LFA sonar systems for routine training, testing, and military operations; 2) further analysis of whether using a greater coastal standoff range where the continental shelf extends further than current standoff range is practicable for SURTASS LFA sonar, at least in some locations; and 3) further analysis of cumulative impacts involving other active sonar sources.

Results from these analyses will be used to assist the Navy in determining how to employ SURTASS LFA sonar and meet the MMPA requirement for negligible impacts on affected species or stocks; no unmitigable adverse impacts on the availability of the species or stocks for taking for subsistence uses; and employing the means of effecting the least practicable adverse impact on a species or stock of marine mammals and satisfy the purpose and need for SURTASS LFA sonar. This information will be considered in the selection of operating areas that the Navy requires for routine training and testing as well as for military operations in annual requests for MMPA LOAs submitted to the NFMS of the Department of Commerce's (DoC) National Oceanic and Atmospheric Administration (NOAA).

2.3.1 ADDITIONAL OBIAS

Offshore biologically important areas are initially defined in the 2001 SURTASS LFA Sonar FOEIS/EIS as those areas of the world's oceans outside the geographic stand-off range of a coastline where marine animals of concern (those animals listed under the ESA and/or marine mammals) congregate in high densities to carry out biologically important activities. These areas include migration corridors; breeding and calving grounds; and feeding grounds.

NMFS developed the following screening criteria for the 2011 DSEIS/SOEIS and the 2011 Proposed Rule to determine an area's eligibility to be considered as a nominee for an OBIA for marine mammals. These OBIA screening criteria included: (1) Areas with: (a) High densities of marine mammals; or (b) Known/defined breeding/calving grounds, foraging grounds, migration routes; or (c) Small, distinct populations of marine mammals with limited distributions; and (2) Areas that are outside of the coastal standoff distance and within potential operational areas for SURTASS LFA (i.e., greater than 22 km (13.6 mi; 12 nmi) from any shoreline and not in polar regions). These OBIA criteria differ from the criteria in the 2001 FOEIS/EIS (as continued in the 2007 SEIS) and the 2007-2012 MMPA Final Rule in two respects. First, under the 2001 FOEIS/EIS, 2007 SEIS, and the 2007 Final Rule, an area could be designated as an OBIA only if it met a conjunctive test of being an area where: (a) marine mammals congregate in high densities, and (b) for a biologically important purpose. Under the new NMFS criteria, high density alone can be sufficient. Second, the new criteria include an additional criterion that, standing alone, could be a basis for designation; i.e., "Small, distinct populations with limited distributions." The analysis of the OBIAs (for marine mammals and the potential for non-marine mammal OBIAs) is presented in Subchapter 4.5 and Appendix D of this document.

2.3.2 COASTAL STANDOFF

Based on the analysis in the SURTASS LFA Sonar FSEIS (DoN, 2007a), it was determined that the best coastal standoff range for providing low overall risk to marine mammals was 22 km (12 nm). The Navy considered the practicability of SURTASS LFA sonar operations further offshore where the continental shelf break is greater than the current standoff range of 22 km (12 nmi). This analysis is presented in Chapter 4.

2.3.3 CUMULATIVE IMPACTS WITH OTHER ACTIVE SONAR SOURCES

This SEIS/SOEIS provides additional analysis on the question of whether, with multiple active sonar systems operating, some animals may be at a greater risk from exposure from the multiple sources than they would be if they were exposed to each source independently. The analysis of such a multiple exposure event must consider both the potential for injury and behavioral impact (i.e., Level A and B harassment, respectively, under the MMPA). The methodology and analyses to estimate the potential for Level A and B harassment from concurrent LFA and MFA sonar operations are presented in Chapter 4 and an associated appendix as part of the cumulative impacts analysis.

2.4 POTENTIAL OPERATIONAL AREAS

Because of uncertainties in the world's political climate and the time limits on NMFS' authority under the MMPA to issue a Final Rule for a period exceeding five years, future operating locations and conditions can only be projected over the next five years. Potential operations for SURTASS LFA sonar vessels over the next five years, based on current operational requirements, will most likely include areas located in the Pacific, Indian and Atlantic Oceans, and the Mediterranean Sea. SURTASS LFA sonar routine training and testing as well as military operations will potentially take place within any of the operational areas defined in Chapter 1 (see Figure 1-1). Polar Regions are excluded because of the inherent inclement weather conditions, including the danger of icebergs. To reduce adverse effects on the marine environment, areas will also be excluded as necessary to prevent 180-dB SPL or greater within 22 km (12 nmi) of land, in offshore biologically important areas during biologically important seasons, and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites.

As an integral part of the SEIS/SOEIS, the Navy must anticipate, or predict, where they may need to operate in the next five years or so. Naval forces are presently operating in several areas strategic to U.S national and international interests, including areas in the Mediterranean Sea, the Indian Ocean and Persian Gulf, and the Pacific Rim. National Security needs may dictate that many of these operational areas will be close to ports and choke points, such as straits, channels, and canals. It is anticipated that future naval conflicts are likely to occur within littoral or coastal areas. The Navy must balance National Security needs with environmental requirements and the potential for impacts, while protecting both our freedom and the world's natural resources.

2.4.1 OVERALL MARINE ENVIRONMENT ANALYSES

To predict the potential effects of SURTASS LFA sonar operations on marine species, the FOEIS/EIS (DoN, 2001) analyzed 31 worldwide sites for marine mammal stocks for multiple seasons. Because of the very conservative factors utilized in these analyses (see FOEIS/EIS page 4.2-3), the results of the FOEIS/EIS underwater acoustic modeling analyses for those 31 sites remain valid. In the first FSEIS (DoN, 2007a), the Navy analyzed an additional nine (9) sites in the Pacific Rim region. In addition to updating these nine (9) sites, this document analyzes an additional 10 sites in areas strategic to U.S. National Security interests. These are provided in subchapter 4.4. The total of 50 sites, for which underwater acoustic modeling for potential impacts to marine mammals has been performed, provide the foundation for the analysis of potential effects of SURTASS LFA sonar operations on the overall marine environment and for the annual LOA application process.

2.4.2 Annual LOA Application Process

The Navy is required to develop an annual process in consultation with NMFS that identifies, through LOA application procedures, the locations that the Navy intends to operate within that year. Additional analysis (including underwater acoustic modeling, if needed) is undertaken if it is deemed necessary (e.g., updated marine mammal distribution or density data available for potential operating areas). This analytical process is undertaken to identify marine areas for SURTASS LFA sonar routine testing, training, and military operations that contribute to the least practicable adverse impacts on marine mammals, while meeting National Security requirements.

2.4.2.1 Testing, Training, and Military Operations in Areas with the Least Practicable Adverse Impacts on Marine Mammals

The identification of SURTASS LFA sonar operating areas and seasons is based on the SURTASS LFA OBIA and coastal standoff analyses identified above, which support the goal of conducting SURTASS LFA sonar testing, training, and military operations in areas that support/contribute to the activity having the least practicable adverse impacts on marine mammals.

In the 2007 FSEIS, the methodology to meet this requirement involved the identification of areas of high marine life concentrations through a sensitivity/risk process and avoiding them when/where practicable. The analysis in this document included the following factors:

- Designating and avoiding offshore (greater than 22 km [12 nmi]) biologically important areas (OBIAs); and
- Coastal zones with greater standoff ranges (greater than 22 km [12 nmi]) where practicable.

For the Navy to meet the MMPA requirements and satisfy the purpose and need for SURTASS LFA sonar, this analysis must:

- Determine areas of biologically important behavior for marine mammal species sensitive to SURTASS LFA sonar.
- Minimize risk to marine mammal species sensitive to SURTASS LFA sonar.
- Meet the criteria and conditions provided in the ROD, Final Rule, and LOAs.
- Meet National Security requirements.

The determination of operating areas that meets the MMPA requirements must also support the ESA section 7 consultation and the biological opinion's jeopardy analysis for listed species and destruction/ adverse modification analysis for critical habitat.

2.4.2.2 Risk Assessment Approach

Subchapter 4.4 of this document provides the risk assessment approach for addressing this issue, which starts with the Navy's ASW requirements to be met by SURTASS LFA sonar (Figure 2-3). Based on this information, mission areas are proposed by the CNO and Fleet commands. These mission areas are then reviewed to determine whether they are within or near OBIAs, as defined previously in this chapter and later in Chapter 4, or known dive sites. If they are, the proposed mission area is changed or revised, and the process is re-initiated. Then, available published data are collected, collated, reduced and analyzed with respect to marine mammal stocks, marine mammal habitat and seasonal activities, and marine mammal behavioral activities. These best scientific data are developed as part of the current NEPA and MMPA application processes that includes review of pertinent literature on small localized marine mammal stocks. Where data are unavailable, scientific population estimates are made by highly-qualified marine biologists, based on known oceanic/biologic conditions and data for like species and/or geographic areas, and known marine mammal seasonal activity. Next, acoustic modeling and risk analysis are performed for the appropriate SURTASS LFA sonar operations area, including spatial,

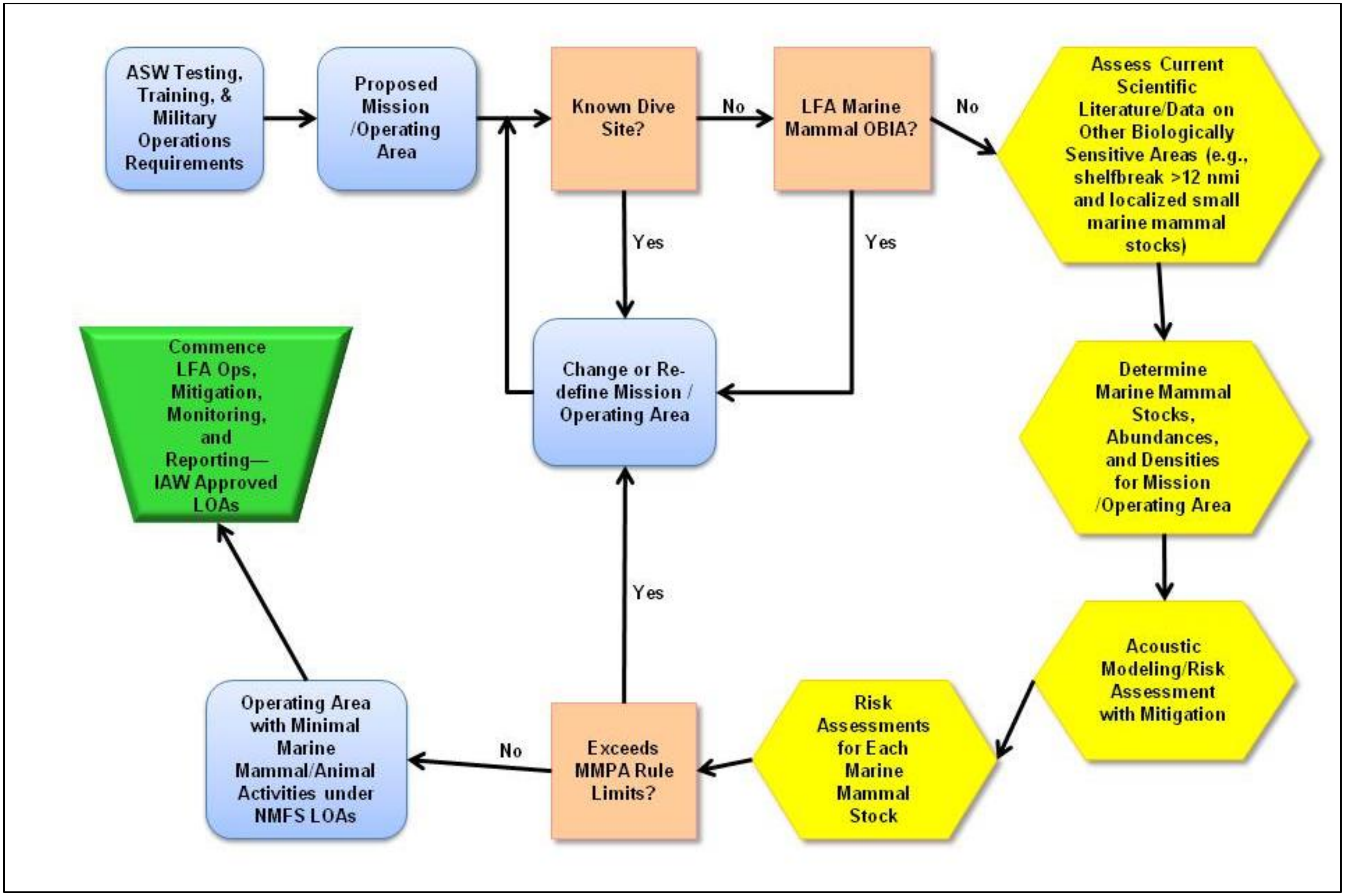


Figure 2-3. Overview of the SURTASS LFA sonar sensitivity/risk assessment approach.

temporal, or operational restrictions. Then, mitigation is applied and risk estimates for each marine mammal stocks in the proposed mission area are calculated. Based on these risk estimates, a decision is made as to whether the proposed mission area meets the restrictions on marine mammal/animal impacts from SURTASS LFA sonar required under the 2007 NMFS 5-year Rule and ESA section 7 consultation. If not, the proposed mission area is changed or refined, and the process is re-initiated. If the mission area risk estimates are below the required restrictions, than the Navy has identified and selected the potential mission area with minimal marine mammal/animal activity based on the best available science and is consistent with regulations and its operational readiness requirements. Furthermore, because this determination of operating areas meets the MMPA Rule and ESA section 7 consultation restrictions, this methodology assures that the selection of operating areas meets the MMPA requirement of least practicable adverse impacts on marine mammals and the ESA biological opinion's jeopardy determination for listed species and destruction/adverse modification to critical habitat. This process is discussed further in Chapter 4.

2.5 MITIGATION

Based on the results of the FSEIS (DoN, 2007a) and the review process for the SURTASS LFA sonar 2007 to 2012 Final Rule under the MMPA (NOAA, 2007c), the ASN(I&E) carefully weighed the operational, scientific, technical, and environmental implications of the alternatives considered. Based on this analysis, the Navy announced its decision to employ SURTASS LFA sonar systems with certain geographical restrictions and monitoring mitigation protocols designed to reduce potential adverse effects on the marine environment (DoN, 2007b). All practicable means to avoid or minimize environmental impacts were adopted through the incorporation of mitigation measures into operation of the SURTASS LFA sonar including the designation of the LFA mitigation zone.

2.5.1 MITIGATION MEASURES UNDER THE 2007 TO 2012 FINAL RULE

The objectives of these mitigation measures are to avoid injury to marine mammals and sea turtles near the SURTASS LFA sonar source array, and to protect recreational and commercial divers in the marine environment, involving both geographic restrictions and operational measures.

These measures include:

- Geographic Restrictions to ensure that the sound field:
  - Is below 180 dB re 1 µPa (rms) received level within 22 km (12 nmi) of any coastline and in the offshore biologically important areas that exist outside 22-km (12-nmi) from any coastline during the biologically important season for that particular area; and
  - Does not exceed 145 dB re 1 µPa (rms) received level in the vicinity of known recreational and commercial dive sites.
- Monitoring to prevent injury to marine species by making every effort to detect animals within the LFA mitigation zone before and during transmissions. These monitoring techniques include:
  - Visual monitoring for marine mammals and sea turtles[1] from the SURTASS LFA sonar vessel during daylight hours;
  - Use of the passive (low frequency) SURTASS towed array to listen for sounds generated by marine mammals as an indicator of their presence; and

1 Visually detecting sea turtles is more difficult than visual monitoring for marine mammals. As part of the monitoring mitigation, the waters surrounding the SURTASS LFA vessels will be visually inspected for sea turtles during SURTASS LFA sonar transmissions to as great a distance as possible. In addition the HF/M3 sonar should detect sea turtles before they enter areas of injurious LFA levels. The 180-dB mitigation zone plus the 1-km buffer zone is sufficient distance to protect sea turtles from injury. See Subchapter 4.2 for additional discussion on potential impacts to sea turtles.

  - Use of the high frequency marine mammal monitoring (HF/M3) active sonar to detect/locate/track potentially affected marine animals near the SURTASS LFA sonar vessel and the sound field that is produced by the SURTASS LFA sonar source array. Prior to full-power operations, the HF/M3 sonar power level is ramped up over a period of 5 minutes from the source level of 180 dB re 1 µPa @ 1 m (rms) (SPL) in 10-dB increments until full power (if required) is attained.

- Delay or suspension of LFA transmissions if a contact is detected outside the LFA mitigation zone and it is determined that the animal will pass within the LFA mitigation zone or the contact is within the mitigation zone. SURTASS LFA sonar transmissions can commence/resume 15 minutes after there is no further detection by the HF/M3 sonar and there is no further visual observation of the animal within the LFA mitigation zone.

LFA Mitigation Zone
The LFA mitigation zone covers a volume ensonified to a received level >180 dB re 1 µPa (rms) by the SURTASS LFA sonar transmit array. Based on spherical spreading, this zone will vary between the nominal ranges of 0.75 to 1.0 km (0.40 to 0.54 nmi) from the source array ranging over a depth of approximately 87 to 157 m (285 to 515 ft). (The center of the array is at an approximate depth of 122 m [400 ft]). Under rare conditions (e.g., strong acoustic duct) this range could be somewhat greater than 1 km (0.54 nmi). Knowledge of local environmental conditions (such as sound speed profiles [depth vs. temperature] and sea state) that affect sound propagation is critical to the successful operation of SURTASS LFA sonar and is monitored on a near-real-time basis. Therefore, the SURTASS LFA sonar operators would have foreknowledge of such anomalous acoustic conditions and would mitigate to the LFA mitigation zone even when this was beyond 1 km (0.54 nmi).

These mitigation measures are detailed in the FOEIS/EIS Subchapter 2.3.2 and Chapter 5, FSEIS Chapter 5, and in Chapter 5 of this document. Except as noted below, the contents of FOEIS/EIS Subchapter 2.3.2 and Chapter 5 and FSEIS Chapter 5 remain valid and are incorporated herein by reference.

2.5.2 OPERATIONAL RESTRICTIONS

In the SURTASS LFA 2002 to 2007 Final Rule under the MMPA (NOAA, 2002b), NMFS added an interim operational restriction to preclude the potential for injury to marine mammals from resonance effects by establishing a 1-km (0.54-nmi) buffer shutdown zone outside of the LFA mitigation zone. In the 2007 five-year Rule (2007 to 2012), NMFS once more required that the 1-km (0.54 nmi) buffer zone operational restriction be adhered to. This restriction has proven to be practical under current operations; but the analysis, provided in Subchapter 2.5.1 of the SURTASS LFA Sonar FSEIS (DoN, 2007a) demonstrates that it did not appreciably minimize adverse impacts below 180-dB re 1 µPa (rms) RL. Thus, the removal of this operational restriction would not generate a change of any significance in the percentage of animals potentially affected. However, the Navy will adhere to the 1-km buffer zone if implemented by NMFS in the new Rule. Subchapter 2.5.1 of the FSEIS is incorporated herein by reference.

2.5.3 RESULTS OF MITIGATION MONITORING UNDER THE 2002 AND 2007 RULES

During the 129 missions under nine LOA periods of the 2002 and 2007 Rules, there were 13 visual contacts (plus one non-operational sighting), 4 passive acoustic detections, 138 active (HF/M3) detections, and 207 delays/suspensions of LFA transmissions due to mitigation protocols (DoN, 2007c , 2007f; 2011). These data sets involving marine species are too small to support any meaningful analyses, such as determining whether or not there are any differences in detection during the time when LFA is active and when it is not transmitting.

2.6 ALTERNATIVES

NEPA requires federal agencies to prepare an EIS that discusses the environmental effects of a reasonable range of alternatives (including the No Action Alternative). Reasonable alternatives are those that will accomplish the purpose and meet the need of the proposed action, and those that are practical and feasible from a technical and economic standpoint.

2.6.1 ALTERNATIVES CONSIDERED IN PREVIOUS ENVIRONMENTAL IMPACT STATEMENTS

There have been two previous NEPA/Executive Order 12114 environmental impact documents for the deployment of SURTASS LFA sonar systems, the initial FOEIS/EIS (DoN, 2001) and the first SEIS (DON, 2007a). The alternatives for these documents are summarized below.

2.6.1.1 SURTASS LFA Sonar FOEIS/EIS Alternatives

In the FOEIS/EIS, alternatives included the No Action Alternative, Alternative 1 (employment with geographic restrictions and monitoring mitigation), and Alternative 2 (unrestricted operation). Alternative 1 was the Navy's preferred alternative in the FOEIS/EIS.

The FOEIS/EIS also considered alternatives to SURTASS LFA sonar, such as other passive acoustic and non-acoustic technologies, as discussed in FOEIS/EIS Subchapters 1.1.2, 1.1.3, and 1.2.1; and Table 1-1 (DoN, 2001). These were also addressed in the NMFS Final Rule (NOAA, 2002b) and the ROD (DoN, 2002). These alternatives were eliminated from detailed study in the FOEIS/EIS in accordance with CEQ Regulation §1502.14(a). These acoustic and non-acoustic detection methods included radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, and biological technologies, and high- or mid-frequency sonar. The FOEIS/EIS concluded that these technologies did not meet the purpose and need of the proposed action to provide Naval forces with reliable long-range detection and, thus, did not provide adequate reaction time to counter potential threats. Furthermore, they were not considered practical and/or feasible for technical and economic reasons. These non-acoustic technologies were reexamined in Subchapter 1.1.4 of this document, and this evaluation reached the same conclusion as the FOEIS/EIS.

In the 2002 and 2003 Opinions (U.S. District Court, Northern District of California [USDC-NDC], 2002 and 2003), the Court found that the Navy’s alternatives analysis was arbitrary and capricious because the second alternative, full deployment with no mitigation or monitoring, was a phantom option. Moreover, the Court found that the Navy should have considered training in areas that presented a reduced risk of impacts to marine life and the marine environment when practicable.

2.6.1.2 SURTASS LFA Sonar FSEIS Alternatives

The 2007 SURTASS LFA Sonar FSEIS alternative analysis addressed the Court’s 26 August 2003 Opinion and Order (USDC-NDC, 2003). The FSEIS provided an analysis of the proposed alternatives for the employment of SURTASS LFA sonar. In addition to the No Action Alternative, four alternatives were analyzed to address the issues raised by the Court and to determine the potential effects of changes to the proposed action. These alternatives incorporate coastline standoff restrictions of 22 and 46 km (12 and 25 nmi), seasonal variations, additional OBIAs, and the possibility of employing shutdown procedures for schools of fish.

These alternatives include:

- No Action Alternative
- Alternative 1—Same as the FOEIS/EIS Alternative 1;
- Alternative 2—Alternative 1 with additional OBIAs;
- Alternative 3—Alternative 1 with extended coastal standoff range to 46 km (25 nmi); and

- Alternative 4—Alternative 1 with additional OBIAs, extended coastal standoff range to 46 km (25 nmi), and shutdown procedures for fish schools.

Alternative 2 was the Navy's preferred alternative.

2.6.2 ALTERNATIVES CONSIDERED

This subchapter provides a description of the proposed alternatives for the employment of SURTASS LFA sonar (Table 2-1); these alternatives are analyzed in Chapter 4 of this document. In addition to the No Action Alternative, analyses are provided for two alternatives. The analyses of these alternatives are intended to take into account the additional analysis contained in this SEIS/SOEIS on the issues of OBIA and coastal standoff ranges. Alternatives 1 and 2 also include the same mitigation measures presented in the 2007 FSEIS Subchapters 2.4, 5.1, 5.2, and 5.3, which are incorporated herein by reference.

Table 2-1. Proposed alternatives and restrictions for employment of SURTASS LFA sonar.

PROPOSED RESTRICTIONS/MONITORING	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2
Dive Sites	NA[2]	≤145 dB	≤145 dB
Coastline Restrictions	NA	<180 dB within 22 km (12 nmi) of coast	<180 dB within 22km (12 nmi) of coast
FSEIS OBIAs	NA	Yes	No
Updated OBIAs	NA	No	Yes
Visual Monitoring	NA	Yes	Yes
Passive Acoustic Monitoring	NA	Yes	Yes
Active Acoustic Monitoring with Ramp-up of HF/M3 Sonar IAW Protocols	NA	Yes	Yes
Delay/Suspension of LFA Transmissions IAW Protocols	NA	Yes	Yes
Reporting	NA	Yes	Yes

The alternatives considered in this SEIS/SOEIS are:

- No Action Alternative;
- Alternative 1—Same as the 2007 FSEIS Preferred Alternative; and
- Alternative 2—Alternative 1 with updated OBIA list.

2 Not applicable.

2.6.3 NO ACTION ALTERNATIVE

Under this alternative, operational deployment of the active component (LFA/CLFA) of SURTASS LFA sonar will not occur. The No Action Alternative is the same as the No Action Alternative presented in Subchapter 2.3.1 of the FOEIS/EIS and Subchapter 2.6.1 of the FSEIS; the contents of both are incorporated herein by reference. Under the No Action Alternative, SURTASS LFA systems would not be deployed and the U.S. Navy's ability to locate and defends against enemy submarines would be greatly impaired. Thus the purpose and need would not be met.

Because the Navy would not conduct SURTASS LFA sonar operations, marine mammals present in the Atlantic, Pacific, and Indian Ocean, and the Mediterranean Sea would not be incidentally harassed by the SURTASS LFA sonar. This alternative would eliminate any potential risk to the environment from the proposed activities. The Navy would not need nor receive an exemption from the MMPA and ESA prohibitions against incidental take that would allow them to conduct the SURTASS LFA operations in compliance with these statutes.

2.6.4 ALTERNATIVE 1

Alternative 1 is the same as Alternative 2 presented in Subchapter 2.6.3 of the FSEIS, which is incorporated herein by reference. This alternative proposes the employment of SURTASS LFA sonar technology with geographical restrictions to include maintaining SURTASS LFA sonar received levels below 180 dB re 1 µPa (rms) within 22 km (12 nmi) of any coastline and within the designated OBIAs (see Table 2-4 of the FSEIS and the Final Rule (50 CFR §216.184(f), 2007) that are outside of 22 km (12 nmi). Restrictions for OBIAs are year-round or seasonal, as dictated by marine animal abundances. SURTASS LFA sonar sound fields will not exceed received levels of 145 dB re 1 µPa (rms) within known recreational and commercial dive sites. Monitoring mitigation includes visual, passive acoustic, and active acoustic (HF/M3 sonar) to prevent injury to marine animals when employing SURTASS LFA sonar by providing methods to detect these animals within the LFA mitigation zone and delay/suspend transmissions accordingly.

Under this alternative, NMFS would incorporate mitigation and monitoring measures and reporting requirements into the MMPA rulemaking and Letters of Authorization.

2.6.5 ALTERNATIVE 2 (THE PREFERRED ALTERNATIVE)

Alternative 2 is the Navy's preferred alternative. This alternative is the same as Alternative 1 but with a comprehensive update of the OBIAs in Alternative 2 of the 2007 FSEIS (DoN, 2007a). OBIAs are discussed previously in this chapter and are analyzed in Chapter 4.

Under this alternative, NMFS would incorporate mitigation and monitoring measures and reporting requirements into the MMPA rulemaking and Letters of Authorization. Accordingly, this NEPA Alternative would satisfy the purpose and need of the NMFS' MMPA action (the issuance of regulations and subsequent LOAs along with required mitigation measures and monitoring), and would enable the Navy to comply with the statutory and regulatory requirements of the MMPA and ESA.

2.7 MONITORING AND RESEARCH

In order to increase knowledge of marine species, the Navy conducted monitoring and research to provide scientific data on the potential effects from SURTASS LFA sonar and other anthropogenic sources.

2.7.1 MONITORING

The DoN is committed to demonstrating environmental stewardship while executing its national defense mission, and is responsible for compliance with a suite of federal environmental and natural resources laws and regulations that apply to the marine environment. For example, the MMPA implementing regulations (50 CFR 216.104(a)(13)) require that an applicant for an MMPA authorization provide NMFS with a monitoring plan that will result in an increased understanding of the species and the impact that the proposed activity will have on those species.

NMFS recommended that the Navy conduct, or continue to conduct, the following types of monitoring/studies, which would be appropriate under the MMPA:

1. Systematically observe SURTASS LFA sonar training exercises for injured or disabled marine mammals;
2. Compare the effectiveness of the three forms of mitigation (visual, passive acoustic, HF/M3 sonar);
3. Conduct research on the responses of deep-diving odontocete whales to LF sonar signals;
4. Conduct research on the habitat preferences of beaked whales;
5. Conduct passive acoustic monitoring using bottom-mounted hydrophones before, during, and after LF sonar operations for the possible silencing of calls of large whales;
6. Continue to evaluate the HF/M3 mitigation sonar; and
7. Continue to evaluate improvements in passive sonar capabilities.

Under previous MMPA authorizations covering SURTASS LFA sonar, the Navy has conducted monitoring/studies pertinent to LFA (Table 2-2). Table 2-2 also addresses the monitoring/studies pertinent to LFA that the Navy is planning under the forthcoming MMPA authorization.

2.7.2 RESEARCH

The Department of the Navy sponsors significant research and monitoring projects for marine living resources to study the potential effects of its activities on marine mammals. These funding levels have increased in recent years to $31M in FY 2009 and $32M in FY 2010 for marine mammal research and monitoring activities at universities, research institutions, federal laboratories, and private companies. Navy-funded research has produced, and is producing, many peer-reviewed articles in professional journals (Table 2-3). Publication in open professional literature with thorough peer review is the benchmark for the quality of the research. This ongoing marine mammal research includes hearing and hearing sensitivity, auditory effects, dive and behavioral response models, noise impacts, beaked whale global distribution, modeling of beaked whale hearing and response, tagging of free-ranging marine animals at-sea, and radar-based detection of marine mammals from ships.

The Navy continues to fund national and international research on the responses of deep-diving odontocetes to sonar signals by independent scientists for whale behavioral response studies (BRSs) with Navy and NOAA funding support for the 2007, 2008, and 2009 BRSs. Findings from the Deep-Diving Odontocetes BRSs will be published in peer-reviewed literature.

BRS-07 took place in the Tongue of the Ocean (TOTO) and at the adjacent Atlantic Undersea Test and Evaluation Center (AUTEC) on Andros Island, Bahamas during August and September 2007. BRS-07 demonstrated the feasibility of the BRS approach and refined protocols. Direct visual observations were made when whales were at the surface, and passive acoustic measurements were recorded during foraging dives. Data was also collected from ten suction cup tags (six on Blainville's beaked whales and four on short-finned pilot whales). A total of 109 hours of data was collected from these tags. A Cruise Report on BRS-07 was prepared (Boyd, 2008a). In summary, playbacks of mid-frequency (MF) sonar and orca sounds were performed on one tagged beaked whale and two tagged pilot whales. The tagged beaked whale responded to both sonar and orca sounds by premature cessation of clicking during foraging dives, with unusually slow and long ascents. The beaked whale was exposed to a slowly increasing MF sonar signal, resulting in a received level at the whale that varied from below ambient noise to 144 dB re 1 µPa (rms). The whale stopped clicking after 9 minutes, when the received level reached 136 dB. Following the two exposures, the beaked whale exhibited sustained and directed avoidance of the area for at least 10 hours.

Table 2-2 Status of Navy-funded monitoring/studies regarding SURTASS LFA sonar.

NMFS Monitoring/Study Topics	Current Monitoring/Study Status	Monitoring/Study Plans Under New MMPA Authorization
Injured/disabled Marine Animals Systematically observe SURTASS LFA sonar training exercises for injured or disabled marine animals	This monitoring study is ongoing based on the mitigation and reporting requirements under the under the 2007 to 2012 Rule. As reported in the annual reports for the first three LOA periods (DoN, 2008, 2009b, 2010), post-operational incidental harassment assessments demonstrated that there were no known marine mammal exposures to RLs at or above 180 dB. These findings are supported by the results from the visual, passive acoustic and active acoustic monitoring efforts discussed in the first three annual reports for the period 16 August 2007 to 15 August 2010 under the 2007 Rule. In addition, a review of recent marine mammal strandings did not indicate any stranding events associated with the times and locations of SURTASS LFA sonar operations (see Chapter 4).	Navy will continue this monitoring/study during the entire 5-year MMPA authorization, including annual reports and review of marine mammal strandings to determine if any may have been associated with the times and locations of SURTASS LFA sonar operations.
Mitigation Effectiveness Compare the effectiveness of the three forms of mitigation (visual, passive acoustic monitoring, HF/M3 sonar)	A summary of mitigation effectiveness was provided in Subchapter 4.1.8 of the Final Comprehensive Report (DoN, 2007c) for the 2002 to 2007 Rule. Under the 2007 to 2012 Rule, the Navy is also required to summarize the effectiveness of the mitigation in a final comprehensive report, which has been described in the Final Comprehensive Report (DoN, 2011). Therefore, data collection and analyses are continuing as part of the reporting requirements of the Long Term Monitoring (LTM) Program.	Navy will continue to provide a summary of mitigation effectiveness in their Final Comprehensive Reports.
Passive Acoustic Monitoring Conduct passive acoustic monitoring using bottom-mounted hydrophones before, during, and after LF sonar operations for the possible silencing of calls of large whales	The Navy has and is continuing to sponsor multi-year studies regarding the acoustic monitoring of marine mammals using fixed passive acoustic monitoring systems in the North Atlantic Ocean (NORLANT). During four of these monitoring/study efforts (Gagnon, 2004, 2005, 2006, 2006a, 2007), no variations in normal behavior patterns for fin, blue, or humpback whales were noted in response to anthropogenic LF sounds. The fifth NORLANT monitoring/study effort was completed in 2007 (Gagnon, 2007). During this period, seismic airguns were the most prevalent anthropogenic noise. The reports for these tasks are classified; unclassified summary reports have been produced. During the period of this report for the third	Navy will continue to sponsor multi-year studies regarding the acoustic monitoring of marine mammals using fixed passive acoustic monitoring systems in the North Atlantic Ocean; and will expand the acoustic monitoring studies to include fixed passive acoustic monitoring systems, and SURTASS in the North Pacific Ocean, as feasible.

Table 2-2 Status of Navy-funded monitoring/studies regarding SURTASS LFA sonar.

NMFS Monitoring/Study Topics	Current Monitoring/Study Status	Monitoring/Study Plans Under New MMPA Authorization
	year LOAs, the collection of cross spectral matrix (CSM) data from the arrays has continued. These data will be used to count fin and humpback whale calls and estimate their population. Observations of CSM data over time can also note the interaction and influence of noise sources (seismic profilers, storms, shipping, fishing activity, naval activities) on large whale behavior.	
Evaluate HF/M3 Continue to evaluate the HF/M3 sonar	The HF/M3 sonar has been upgraded for integration into the installations of Compact Low Frequency Active (CLFA) sonar on the T-AGOS 19 Class vessels. The first installation of the upgraded HF/M3 sonar was onboard the USNS ABLE (T-AGOS 20). The USNS EFFECTIVE (T-AGOS 21), which is currently undergoing initial at sea testing, is also equipped with the upgraded HF/M3 sonar. Evaluation of the HF/M3 sonar is part of the at sea testing and will be documented in the unclassified final comprehensive reports. The USNS VICTORIOUS (T-AGOS 19), which is scheduled to commence initial at sea testing in late FY 2012, will also be equipped with the upgraded HF/M3 sonar. Evaluation of the HF/M3 sonar will be part of the at sea testing and will be documented in the unclassified final comprehensive reports.	Navy will continue to evaluate the HF/M3 sonar, reporting its findings in the unclassified final comprehensive reports.
Improvements in Passive Sonar Continue to evaluate improvements in passive sonar capabilities	Advances in the development of passive acoustic technology include the development of SURTASS Twin-Line (TL-29A), a shallow water variant of the SURTASS system, which provides improved littoral capability. The USNS ABLE (T-AGOS 20), USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23) have the TL-29A twin-line passive arrays. The USNS VICTORIOUS (T-AGOS 19) will also have the TL-29A passive array. The integrated common processor (ICP) has been, or is scheduled to be, installed on the SURTASS LFA/CLFA sonar vessels. The ICP uses enhanced signal processing and automation to get accurate, actionable information on undersea threats to operational decision makers. The capability	Navy will continue to evaluate improvements in passive sonar capabilities that relate to SURTASS performance capabilities which, in turn, could possibly equate to lower LFA transmission requirements.

Table 2-2 Status of Navy-funded monitoring/studies regarding SURTASS LFA sonar.

NMFS Monitoring/Study Topics	Current Monitoring/Study Status	Monitoring/Study Plans Under New MMPA Authorization
	of passive acoustic sensors is also benefiting from increased processing power in computers and by networking, which is incorporating data from a variety of acoustic and non-acoustic sensors, and sources to construct a more complete battlefield picture (Friedman, 2007c).	
Passive Acoustic Monitoring Before, during and after major fleet exercises in which SURTASS LFA sonar is participating	Not applicable.	Navy will, as feasible, use its SURTASS horizontal line arrays to collect marine mammal vocalizations before, during and after major fleet exercises that SURTASS LFA sonar is involved in, with the goal of determining the extent, if any, of changes in the marine mammal vocalizations that could have been caused by SURTASS LFA sonar operations.

Table 2-3. Department of the Navy (DoN) sponsored monitoring and research

Subject	Published Papers
Beaked Whale Habitat Conduct research on characteristics of beaked whales habitat preferences, population structure, physiology, movements, bioacoustics, and behavior	• The U.S. Navy/Office of Naval Research (ONR) has provided funding for research on beaked whales, which has resulted in the following published articles: • Baird, R.W., D.L. Webster, G.S. Schorr, D.J. McSweeney, and J. Barlow. 2008. Diel variation in beaked whale diving behavior. Marine Mammal Science 24(3):630-642. • Baumann-Pickering, S., S.M. Wiggins, E.H. Roth, M.A. Roch, H.-U. Schnitzler, and J.A. Hildebrand. 2010. Echolocation signals of a beaked whale at Palmyra Atoll. Journal of the Acoustical Society of America 127(6):3790-3799. • Claridge, D., and J. Durban. 2007. Distribution, Abundance and Population Structuring of Beaked Whales in the Great Bahama Canyon, Northern Bahamas. • Cranford, T.W., P. Krysl, and J.A. Hildebrand. 2008. Acoustic pathways revealed: simulated sound transmission and reception in Cuvier's beaked whale (Ziphius cavirostris). Bioinspiration & Biomimetics 3(1):016001. 10 pp. • Cranford, T.W., M.F. McKenna, M.S. Soldevilla, S.W. Wiggins, J.A. Goldbogen, R.E. Shadwick, P. Krysl, J.A. St. Leger, and J.A. Hildebrand. 2008. Anatomic geometry of sound transmission and reception in Cuvier's beaked whale (Ziphius cavirostris). The Anatomical Record 291:353–378. • D'Amico, A. R.C. Gisiner, D.R. Ketten, J.A. Hammock, C. Johnson, P.L. Tyack, and J. Mead. 2009. Beaked whale strandings and naval exercises. Aquatic Mammals 35(4):252-272. • DiMarzio, N., D. Moretti, J. Ward, R. Morrissey, S. Jarvis, A.M. Izzi, M. Johnson, P. Tyack, and A. Hansen. 2008. Passive acoustic measurement of dive vocal behavior and group size of Blainville's beaked whale (Mesoplodon densirostris) in the Tongue of the Ocean (TOTO). Canadian Acoustics 36(1):166-173. • Falcone, E.A., G.S. Schorr, A.B. Douglas, J. Calambokidis, E. Henderson, M.F. McKenna, J. Hildebrand, and D. Moretti. 2009. Sighting characteristics and photo-

Table 2-3. Department of the Navy (DoN) sponsored monitoring and research

SUBJECT	PUBLISHED PAPERS
Beaked Whale Habitat	identification of Cuvier's beaked whales (Ziphius cavirostris) near San Clemente Island, California: A key area for beaked whales and the military? Marine Biology 156:2631-2640. • Filadelfo, R., J. Mintz, E. Michlovich, A. D'Amico, P.L. Tyack, and D.R. Ketten. 2009. Correlating military sonar use with beaked whale mass strandings: What do the historical data show? Aquatic Mammals 35(4):435-444. • Finneran, J.F., D.S. Houser, B. Mase-Guthrie, R.Y. Ewing, and R.G. Lingenfelser. 2009. Auditory evoked potentials in a stranded Gervais' beaked whale (Mesoplodon europaeus). Journal of the Acoustical Society of America 126(1):484-490. • Gillespie, D., C. Dunn, J. Gordon, D. Claridge, C. Embling, and I. Boyd. 2009. Field recordings of Gervais' beaked whales Mesoplodon europaeus from the Bahamas. Journal of the Acoustical Society 125(5):3428-3433. • Hooker, S.K., R.W. Baird, and A. Fahlman. 2009. Could beaked whales get the bends? Effect of diving behaviour and physiology on modelled gas exchange for three species: Ziphius cavirostris, Mesoplodon densirostris, and Hyperodon ampullatus. Respiratory Physiology & Neurobiology 167(3):235-246. • Johnson, M., L.S. Hickmott, N. Aguilar Soto, and P.T Madsen. 2008. Echolocation behaviour adapted to prey in foraging Blainville's beaked whale (Mesoplodon densirostris). Proceedings of the Royal Society, B (Biological Sciences) 275:133-139. • Jones, B.A., T.K. Stanton, A.C. Lavery, M.P. Johnson, P.T. Madsen, and P.L. Tyack. 2008. Classification of broadband echoes from prey of a foraging Blainville's beaked whale. Journal of the Acoustical Society of America 123(3):1753-1762. • MacLeod, C. W.F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). Journal of Cetacean Research and Management, 7(3): 271-286. • MacLeod, C. D., and G. Mitchell. 2006. Key areas for beaked whales worldwide. J. Cetacean Res. Manage. 7(3):309-322. • MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L. Balance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). J. Cetacean Res. Manage. 7(3):271-286. • McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations, and movements of Cuvier's (Ziphius cavirostris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawai'i. Marine Mammal Science 23(3):667-687. • Mellinger, D.K. 2008. A neural network for classifying clicks of Blainville's beaked whales (Mesoplodon densirostris). Canadian Acoustics 55(36):55-59. • Moretti, D., T.A. Marques, L. Thomas, N. DiMarzio, A. Dilley, R. Morrissey, E. McCarthy, J. Ward, and S. Jarvis. 2010. A dive counting density estimation method for Blainville's beaked whale (Mesoplodon densirostris) using a bottom-mounted hydrophone field as applied to a Mid-Frequency Active (MFA) sonar operation. Applied Acoustics 71:1036-1042. • Rankin, S. and J. Barlow. 2007. Sounds recorded in the presence of Blainville's beaked whales, Mesoplodon densirostris, near Hawai'i. Journal of the Acoustical Society of America 122(1):42-45. • Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney, R.D. Andrews. 2009. Movements of satellite-tagged Blainville's beaked whales off the island of Hawai'i. Endangered Species Research 10:203-213. • von Benda-Beckmann, A.M., F.P.A. Lam, D.J. Moretti, K. Fulkerson, M.A. Ainslie,

Table 2-3. Department of the Navy (DoN) sponsored monitoring and research

SUBJECT	PUBLISHED PAPERS
Beaked Whales	S.P. van IJsselmuide, J. Theriault, S.P. Beerens. 2010. Detection of Blainville's beaked whales with towed arrays. Applied Acoustics 71:1027-1035. • Ward, J., R. Morrissey, D. Moretti, N. DiMarzio, S. Jarvis, M. Johnson, P. Tyack, and C. White. 2008. Passive acoustic detection and localization of Mesoplodon densirostris (Blainville's beaked whale) vocalizations using distributed bottom-mounted hydrophones in conjunction with a digital tag (Dtag) recording. Canadian Acoustics 36(1):60-66. • Zimmer, W.M.X., J. Harwood, P.L. Tyack, M.P. Johnson, and P.T. Madsen. 2008. Passive acoustic detection of deep-diving beaked whales. Journal of the Acoustical Society of America 124(5):2823-2832. Other funded research that included beaked whale species: • Ferguson, M. C., J. Barlow, B., S. B. Reilly, and T. Gerrodette. 2006. Predicting Cuvier's (Ziphius cavirostris) and Mesoplodon beaked whale population density from habitat characteristics in the Eastern Tropical Pacific Ocean. JCRM 7(3):287-299. • Filadelfo, R., Y.K. Pinelis, S. Davis, R. Chase, J. Mintz, J. Wolfanger, P.L. Tyack, D.R. Ketten, and A. D'Amico. 2009. Correlating whale strandings with navy exercises off southern California. Aquatic Mammals 35(4):445-451. • Redfern, J.V., M.C. Ferguson, E.A. Becker, K.D. Hyrenbach, C. Good, J. Barlow, K. Kaschner, M.F. Baumgartner, K.A. Forney, L.T. Ballance, P. Fauchald, P. Halpin, T. Hamazaki, A.J. Pershing, S.S. Qian, A. Read, S.B. Reilly, L. Torres, and F. Werner. 2006. Techniques for cetacean–habitat modeling. MEPS 310:271-295.

BRS-08 was conducted in the TOTO adjacent to AUTEC in August and -September 2008. The primary objectives and accomplishments were to: 1) Increase sample size of MF sonar signal playbacks and controls from that achieved in BRS-07 (the sample size was increased, but not as much as hoped); 2) Measure received levels of sonar sound that produce a behavioral response during playbacks (done); 3) Investigate variation in responses in relation to context and species (done—four species investigated); 4) Include at least one killer whale playback to examine whether response of beaked whales might be explained by confusion between sonar signals and killer whale calls (not achieved primarily due to a greater than predicted number of inclement weather days); and 5) Compare responses to MF sonar signals versus more spread spectrum signal with similar overall bandwidth, duration and timing (achieved in some species). A Cruise Report on BRS-08 was prepared (Boyd, 2008b). In summary, a statistical analysis of dive parameters was performed comparing three animal exposure dives to baseline dives. Most dive data were available for 33 dives from six individuals; all were baseline except for three dives of the two individuals exposed to underwater acoustic playback. After accounting for the effects of differences among individuals and sex of the two playback and four baseline whales, foraging and ascent behaviors were significantly affected by the playbacks. The playbacks resulted in a reduction in attempts to capture prey (judged by the number of beaked whale buzzes), shorter foraging durations (judged by the production of clicks), reduced ascent rate, and increased ascent duration compared to the baseline foraging dives recorded from this species in the same location without playback. Dive variables that represented events in advance of playbacks (descent rate, duration and interval before the dive) did not differ between baseline and playback dives, but those occurring during or after playbacks (duration of clicking, number of buzzes, ascent rate, duration of ascent and interval after the dive) were affected.

SOCAL-10 (Southern California) was the first phase of a multi-year research effort (2010 to 2014), notionally referred to as SOCAL-BRS, which is designed to contribute to emerging understanding of marine mammal behavior and changes in behavior as a function of sound exposure. It is in some ways an extension of previous Navy-sponsored BRS efforts in the Bahamas and Mediterranean Sea in 2007 through 2009, but is being constructively integrated with several related, ongoing, successful field efforts (e.g., population surveys of Navy range areas and satellite tagging before active sonar operations) already ongoing in southern California. The research is continuing as SOCAL-BRS (2010 to 2015) to study diving, foraging, and vocal behavior in various marine mammals and their response to controlled underwater sound exposures. The initial phase off southern California was successfully completed during the summer of 2010. In summary, a total of 63 tags of six different types were deployed on 44 individual animals of at least eight species. Nearly 400 hours of tag data were obtained from the diving and acoustic tags (with weeks of positional data for satellite-tagged animals). Twenty controlled exposure experiment (CEE) sequences (18 involving sound transmissions) were conducted on 28 individuals of five marine mammal species using two different sound types (military mid-frequency active [MFA] sonar-type signals and pseudo-random noise [PRN]). Three of the five species were exposed to MFA signals, commonly used in ASW operational training exercises. Results indicated observable responses to sonar/noise sounds in some conditions and species (notably Cuvier's beaked whale and blue whales in deep feeding/travel mode). These animal responses point to a more complex, species- and/or context-specific type of response than a simple dose-response function based solely on received sound amplitude level.

SOCAL-11 was the second field season of the SOCAL-BRS multi-year effort (2010 to 2014). SOCAL-11 was an interdisciplinary study of basic behavior and responses to controlled sound exposures in a variety of marine mammal species, building on a number of related efforts. The overall objective was to provide a better scientific basis for estimating risk and minimizing effects of active sonar for the U.S. Navy and regulatory agencies. SOCAL-BRS is part of a larger international collaboration to measure the impacts of noise on marine mammals, using opportunistic and experimental approaches, including CEEs. Specific objectives for SOCAL-11 included: 1) obtaining baseline behavioral data on a range of marine mammal species; 2) conducting CEEs on baleen whales, beaked whales, Risso's dolphins, and sperm whales; 3) testing optimal configuration for subsequent studies, which may include realistic/actual military sources; and 4) obtaining data to support the Navy's SOCAL range monitoring efforts. Preliminary results include: 1) attached 38 tags on 25 blue whales, 7 Risso's dolphins, 2 bottlenose dolphins, and one Cuvier's beaked whale; 2) conducted CEEs on 18 individuals (13 total sequences) including 13 blue whales, 4 Risso's dolphins, and one Cuvier's beaked whale; and 3) completed three focal follow sequences in testing tag-less group-follow protocols, including two with common dolphins and one with bottlenose dolphins.

These research projects may not be specifically related to SURTASS LFA sonar operations; however, they are crucial to the overall knowledge base on marine mammals and the potential effects from underwater anthropogenic noise. The Navy is also sponsoring research to determine marine mammal abundances and densities for all Navy ranges and other operational areas.

The Navy notes that research and evaluation is being carried out on various monitoring and mitigation methods, including passive acoustic monitoring (PAM). The results from this research could be applicable to SURTASS LFA sonar passive acoustic monitoring.

2.7.2.1 Research on Fish

The Navy has funded independent research to examine whether exposure to high-intensity, low frequency sonar, such as SURTASS LFA sonar, will affect fish, a prey species for marine mammals (Popper, et al. 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010). Dr. Arthur Popper (University of Maryland), an internationally recognized fish acoustics expert, investigated the effects of exposure to LFA sonar on hearing, the structure of the ear, and selected non-auditory systems of the rainbow trout (Onchorynchus mykiss) (a hearing non-specialist related to several endangered salmonids) and channel catfish (Ictalurus punctatus) (a hearing specialist) using an element of the standard SURTASS LFA source array (Popper et al., 2005a, 2007; Halvorsen et al., 2006). Hearing sensitivity was measured using auditory brainstem response (ABR), effects on inner ear structure were examined using scanning electron microscopy, effects on non-auditory tissues were analyzed using general pathology and histopathology, and behavior was observed with video monitoring. Additional studies on the immediate effects on inner ear and non-auditory tissues were done with a hybrid sunfish species (Lepomis sp.) (Kane et al., 2010).

Exposure to 193 dB re 1 µPa (rms) RL in the LFA frequency band for 324 seconds resulted in a TTS of 20 dB at 400 Hz in rainbow trout, with less TTS at 100 and 200 Hz (Popper et al, 2007). TTS in catfish ranged from 6 to 12 dB at frequencies from 200 to 1000 Hz (Popper et al., 2005a). Both species recovered from hearing loss in several days. Inner ear sensory tissues appeared unaffected by acoustic exposure. The sunfish showed no threshold shift (Halvorsen et al., 2006). The TTS results for catfish and sunfish are expected to be published within a year.

Gross pathology of the three fish species indicated no damage to non-auditory tissues, including the swim bladder. Histopathology was done on all major body tissues (brain, swim bladder, heart, liver, gonads, blood, etc.) and no differences were found among sound-exposed, control, or baseline fish (Kane et al., 2010). There was no fish mortality attributable to sound exposure, even up to four days post-exposure. Each species showed initial movement responses at sound onsets and changed position relative to the sound source during exposures. The sound levels (up to 193 dB re 1 µPa [rms] RL) used in these experiments approached those that fish would encounter very close to an active SURTASS LFA sonar source array (within approximately 200 m [656 ft]). However, the exposure during the experiments was very likely more substantial than any a fish would encounter in that the fish were exposed to multiple replicates of very intense sounds, whereas any fishes in the wild would encounter sounds from a moving source, and successive emissions from the source would decrease in intensity as the distance between the ship and exposed fish increased.

The conclusion from the SURTASS LFA sonar study demonstrated that LFA exposure to 193 dB re 1 µPa (rms) RL had no real adverse effects on the fish tested. These results support the conclusion in the FSEIS that the potential for a fish or schools of fish to be injured (thus impacting fish stocks) by exposure to SURTASS LFA sonar signals above 193 dB re 1 µPa (rms) RL (within approximately 200 m [656 ft] of the SURTASS LFA sonar operational array) is considered negligible.

THIS PAGE IS INTENTIONALLY LEFT BLANK

3.0 AFFECTED ENVIRONMENT

This chapter provides a generalized overview of the environments that could potentially be affected by Navy employment of the SURTASS LFA sonar system, including:

- **Marine Acoustic Environment**, including ambient noise in the oceans, physical environmental factors affecting acoustic propagation, and ocean acoustic regimes (Subchapter 3.1);
- **Marine Organisms,** including marine mammals and threatened and endangered species (Subchapter 3.2); and
- **Socioeconomic Conditions**, including commercial and recreational fishing, other recreational activities, research and development, and coastal zone management consistency (Subchapter 3.3).

To assist the reader in understanding the underwater sound units used when referencing sound levels in this chapter and document, the following definitions and suggested references are provided. Additionally, further background information on the basics of underwater sound may be found in Appendix B of the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001), which may be obtained online (http://www.surtass-lfa-eis.com/Download/index.htm).

REFERENCES TO UNDERWATER SOUND LEVELS
• **References to underwater sound pressure level (SPL) in this SEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa at 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).** • **In this SEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).** • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for, or sums, the energy of all of the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for all of the details. As discussed in Appendix C, SPE does not have a straightforward, identified unit. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001 and 2007a).**

3.1 MARINE ENVIRONMENT

Except as noted below, there have been no significant changes to the knowledge or understanding in the marine environment, acoustic propagation, or propagation modeling. The information in Subchapters 3.1 (Marine Environment) in the FOEIS/EIS and the Final SEIS (DoN, 2001; 2007a) remains valid, and their contents are incorporated herein by reference.

Sound energy unlike light and other stimuli travels very efficiently through water (Richardson et al., 1995). Electromagnetic, thermal, light, and other forms of energy are severely attenuated in water at a much greater rate than sound (Au and Hastings, 2008). This makes sound, or acoustics, the medium of choice for sensing the ocean environment for both marine organisms and humans. Marine animals use underwater sound as the most effective method to perform their life cycle functions such as communications, navigation, obstacle avoidance, predator avoidance, and prey detection by the use of both active echolocation and passive listening (Au and Hastings, 2008). Dolphins, and other toothed whales, utilize echoes from sounds that they produce (echolocation) to locate prey and navigate (NRC, 2000a). Humans use acoustics to detect underwater objects, such as submarines or sunken vessels, to conduct depth measurements, and for communications.

The ability to use sound as an effective sensing medium in the ocean is dependent on the level of background noise (ambient noise) as it is related to the signal, or sound, being received, the physical factors of the ocean that affect the speed at which sound travels through water, and the rate at which sound energy is lost. Sound power or intensity loss by the acoustic signal is a result of spreading and absorption. This is referred to as propagation or transmission loss. Water temperature, salinity, and depth/pressure are all factors that affect the density of the water and, therefore, the speed of sound through the water, and thus the water's propagation characteristics.

3.1.1 AMBIENT NOISE

Subchapter 3.1.1 of the FOEIS/EIS (DoN, 2001) provided a summary and discussion of LF ambient noise within the ocean as it relates to the frequency at which SURTASS LFA sonar would operate (i.e., between 100 and 500 Hz). Ambient noise is the typical or persistent background noise that is present in an environment. Ambient noise is broadband in all frequencies and directional both horizontally and vertically, meaning that it does not come at equal sound levels from all directions. For more detailed information on oceanic ambient (or background) noise, Urick (1983), Richardson et al. (1995), and Au and Hastings (2008) provide an excellent and a more comprehensive discussion than can be presented herein.

Ambient noise has both natural and anthropogenic (man-made) components. Many of these sources are comparable in frequency to SURTASS LFA sonar. Distant shipping noise has been reported by Urick (1983) to be from 50 to 500 Hz and by Richardson et al. (1995) to be between 20 and 300 Hz. Biological noise can also be a major contributor of LF noise in the ocean. Several species of baleen whales, toothed whales, and seals are known to produce underwater sounds between 100 and 500 Hz.

3.1.1.1 Natural Sources of Ambient Noise

Natural sources include breaking waves and surf, wind, precipitation, ice, earthquakes, and biological noises. Wind and waves are common and interrelated sources of ambient noise in all of the world's oceans. All other factors being equal, ambient noise levels tend to increase with increasing wind speed and wave height (Richardson et al., 1995). Noise generated by surface wave activity and biological sounds is the primary contributor over the frequency range from 300 Hz to 5 kHz. The wind-generated noise level decreases smoothly with increasing acoustic frequency (i.e., there are no spikes at any given frequency).

At some frequencies, rain and hail will increase ambient noise levels. Significant noise is produced by rainsqualls over a range of frequencies from 500 Hz to 15 kHz. Large storms with heavy precipitation can generate noise at frequencies as low as 100 Hz and significantly affect ambient noise levels at a considerable distance from a storm's center. Lightning strikes associated with storms are loud, explosive events that deliver an average of 100 kilojoules per meter (kJ/m) of energy (Considine, 1995). Hill (1985) estimated the source level for cloud-to-water pulse to be 260.5 dB re 1 µPa (rms) @ 1 m. It has been estimated that over the earth's oceans the frequency of lightning averages about 10 flashes per second, or 314 million strikes per year (Kraght, 1995).

Biological noises are sounds created by animals in the sea and may contribute significantly to ambient noise in many areas of the oceans. Because of the habits, distribution, and acoustic characteristics of these sound producers, certain areas of the oceans are louder than others. Three groups of marine animals are known to produce sounds (Urick, 1983):

- Crustaceans, such as snapping shrimp;
- Fish, such as the drumfish; and
- Marine mammals, including whales, dolphins, and porpoises.

The most widespread, broadband noises from animal sources (in shallow water) are those produced by croakers (representative of a variety of fish classified as drumfish) (100 Hz to 10 kHz) and snapping shrimp (500 Hz to 20 kHz). Sound-producing fishes and crustaceans are restricted almost entirely to bays, reefs, and other coastal waters, although there are some pelagic, sound-producing fish. In oceanic waters, whales and other marine mammals are principal contributors to biological noise.

3.1.1.2 Anthropogenic Component of Ambient Noise

Anthropogenic noises that could affect ambient noise levels arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include:

- Transportation (ship-generated noise);
- Dredging;
- Construction;
- Hydrocarbon and mineral exploration and recovery;
- Geophysical (seismic) surveys;
- Sonars;
- Explosions; and
- Ocean science studies.

The dominate source of anthropogenic sound in the sea stems from the propulsion of ships (Tyack, 2008). At the lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background. Shipping noise centers in the 20 to 200 Hz frequency band and is increasing yearly (Ross, 2005). Ross (1976) estimated that between 1950 and 1975 shipping had caused a rise of 10 dB in ambient ocean noise levels, and he predicted that the level would increase by another 5 dB by the beginning of the 21st century. Andrew et al. (2002) collected ocean ambient sound data from 1994 to 2001 using a receiver on the continental slope off Point Sur, California. These data were compared to measurements made from 1963 to 1965 by an identical receiver. The data demonstrated an increase in ambient noise over the 33-year period of approximately 10 dB in the frequency range of 20 to 80 Hz primarily due to commercial shipping; there were also increases as large as 9 dB in the frequency ranges 100 Hz up to 400 Hz, for which the cause was less obvious (Andrews et al., 2002). McDonald et al. (2006a) compared data sets from 1964 to 1966 and 2003 to 2004 for continuous measurements west of San Nicolas Island, California and found an increase in ambient noise levels of 10 to 12 dB at 30 to 50 Hz.

3.1.2 Environmental Factors Affecting Sound Propagation

Sound propagation in water is influenced by various physical characteristics, including water temperature, depth, salinity, and surface and bottom properties that cause refraction, reflection, absorption, and scattering of sound waves. Except for the discussion of ocean acidification below, there have been no significant changes to the knowledge or understanding of how geology and bottom topography, sedimentation, temperature, salinity, winds and sea state can affect LF sound transmission.

Recent scientific papers and research have reported concerns about the increase in ocean surface acidity and the effects that this will have on ocean noise. Increased levels of carbon dioxide in the atmosphere are raising the dissolved carbon dioxide contents in the oceans, which produces carbonic acid (Hester et al., 2008; Brewer and Hester, 2009; Doney et al., 2009; Ilyina et al., 2010). Because the transmission loss of low frequency sound will decrease with increasing acidity, ocean background noise levels could increase. Several long-term predictive models have been developed (Joseph and Chiu, 2010; Reeder and Chiu, 2010; Udovydchenkov et al., 2010). Over the next 100 years, predicted increases in LF ocean noise from acidification will be less than the present variability (approximately 1 dB) in background noise levels for LF.

3.1.3 Ocean Acoustic Regimes

The oceans are not homogeneous, that is, they do not have the same physical characteristics throughout their four-dimensional structure (the fourth dimension being time or season). Sound speed in water varies with water density. Water density is affected primarily by depth, temperature, and to a lesser degree, by salinity. Thus, the speed of sound in water varies with depth (a plot of sound speed versus water depth is known as a sound speed profile [SSP]). As sound speed changes due to environmental conditions of the water, the sound rays bend, or refract, either toward or away from the surface. Under certain conditions sound rays may become trapped in a duct and create a sound channel (i.e., surface duct or deep sound channel). It is this refraction, coupled with the reflection from the surface and interaction with the bottom that makes it difficult to predict how sound travels in water. There have been no significant changes to the knowledge or understanding concerning the general conditions of sound speed in the oceans. For more details on this topic see Appendix B of the SURTASS LFA FOEIS/EIS (DoN, 2001).

Based on the characteristics of the SSPs for specific areas of the oceans, sound propagation for those areas can be predicted. These predictions are generally grouped by the physical effects that the SSP has on acoustic propagation. Despite the complexity of the ocean environment these effects can be organized into the following three groups, which are referred to as ocean acoustic regimes:

- Deep water convergence zone (CZ);
- Surface duct/sound channels; and
- Shallow water bottom interaction.

3.2 MARINE ORGANISMS

Because the SURTASS LFA sonar system operates in an ocean environment, there is the potential for it to interact with marine species and their environments. Marine species have been screened to determine whether or not they may potentially be affected by LF sounds produced by SURTASS LFA sonar. Those marine species as well as their habitats, and the process by which they could potentially be affected, are discussed in detail in this subchapter.

3.2.1 Species Screening

Marine species must be able to hear LF sound and/or have some organ or tissue capable of changing sound energy into mechanical effects to be affected by LF sound. In order for there to be an effect by LF sound, the organ or tissue must have an acoustic impedance different from water, where impedance is the product of density (kg/m^3 [lb/yd^3]) and sound speed (m/sec [ft/sec]). Thus, many organisms would be unaffected, even if they were in areas of LF sound, because they do not have an organ or tissue with acoustic impedance different from water. These factors immediately limit the types of organisms that could be adversely affected by LF sound. In other words, to be evaluated for potential impact in this

SEIS/SOEIS, the marine species must: 1) occur within the same ocean region and during the same time of year as the SURTASS LFA sonar operation, and 2) possess some sensory mechanism that allows it to perceive the LF sounds, and/or 3) possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. Species that did not meet these criteria were excluded from consideration.

A marine species' potential to be affected by SURTASS LFA sonar is discussed in detail in Subchapter 3.2.1 of the SURTASS LFA Sonar SEIS (DoN, 2007a). Except as noted below, there have been no significant changes to the knowledge or understanding relating to species screening. The information in Subchapter 3.2.1 (Species Screening) in the Final SEIS (DoN, 2007a) remains valid, and the contents are incorporated herein by reference. The screening information is summarized and updated, as necessary, in the remainder of this section.

3.2.1.1 Invertebrates

Many invertebrates can be categorically eliminated from further consideration because: 1) they do not have delicate organs or tissues whose acoustic impedance is significantly different from water; and 2) they have high LF hearing thresholds in the frequency range used by SURTASS LFA sonar. Siphonophores and some other jelly plankton do have air-filled bladders, but because of their size, they do not have a resonance frequency close to the low frequencies used by SURTASS LFA sonar.

Among invertebrates, only cephalopods (octopus and squid) and decapods (lobsters, shrimps, and crabs) are known to sense LF sound (Packard et al., 1990; Budelmann and Williamson, 1994; Lovell et al., 2005; Mooney et al., 2010). Limited data have begun to emerge on the hearing mechanism and potential hearing thresholds on these few invertebrate species. Budelmann and Williamson (1994) demonstrated that the hair cells of cephalopod statocysts are directionally sensitive in a way that is similar to the responses of hair cells on vertebrate vestibular and lateral line systems. Packard et al. (1990) showed that three species of cephalopods were sensitive to particle motion, not pressure, with the lowest thresholds of 2 to 3 x 10^{-3} m/sec^2 at 1 to 2 Hz. This type of hearing mechanism was confirmed by Mooney et al. (2010) who demonstrated that the statocyst of squid acts as an accelerometer through which particle motion of the sound field can be detected. They measured acceleration thresholds of -26 dB re 1 m/sec^2 between 100 and 300 Hz and a pressure threshold of 110 dB re 1 μPa at 200 Hz. Lovell et al. (2005) found a similar sensitivity for prawn, 106 dB re 1 μPa at 100 Hz, noting that this was the lowest frequency at which they tested and animals might be more sensitive at lower frequencies. Thresholds at higher frequencies have been reported, i.e., 134.4 dB re 1 μPa and 139.0 dB re 1 μPa at 1,000 Hz for the oval squid (*Sepioteuthis lessoniana*) and the octopus (*Octopus vulgaris*), respectively (Hu et al., 2009). However, Mooney et al. (2010) suggested that the measurement techniques of Hu et al. (2009) placed the animals close to the air-sea interface and introduced particle motion to which animals were responding rather than the pressure measurements reported. Popper et al. (2003) also reviewed behavioral, physiological, anatomical, and ecological aspects of sound and vibration detection by decapod crustaceans. Many decapods also have an array of hair-like receptors within and upon the body surface that potentially respond to water- or substrate-borne displacements as well as proprioceptive organs that could serve secondarily to perceive vibrations. However, the acoustic sensory system of decapod crustaceans remains under-studied (Popper, et al., 2003).

Popper and Schilt (2008) stated that, like fish, some invertebrate species produce sound, possibly using it for communications, territorial behavior, predator deterrence, and mating. Well known sound producers include lobster (*Panulirus* sp.) (Latha et al., 2005) and the snapping shrimp (*Alpheus heterochaelis*) (Herberholtz and Schmitz, 2001). Snapping shrimp are found worldwide and make up a significant portion of the ambient noise budget between 500 Hz and to 20 kHz.

McCauley et al. (2000) reported that exposure of caged squid to seismic airguns showed behavioral response including inking. Wilson et al. (2007) played back killer whale echolocation clicks to two groups of squid (*Loligo pealeii*) in a tank. With signals of up to 199 to 226 dB, there were no apparent behavioral effects or any acoustic debilitation. Both of these experiments were with caged squid, and it is unclear how unconfined animals would have reacted.

André et al. (2011) exposed four cephalopod species (*Loligo vulgaris, Sepia officinalis, Octopus vulgaris,* and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 Hz at received levels of 157 ± 5 dB re 1 μPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound in a manner incompatible with life. However, scientists have expressed concern that this study contains flaws. The two most egregious errors include the experimental design and lack of controls. First, exposure was produced by an in-air loudspeaker to animals in two different tanks (one 2,000-L fiberglass reinforced plastic tank and one 200-L glass-walled tank), resulting in highly complex and unpredictable sound fields. There was limited description of the experiment set-up, calibration procedures, or sound field measurement techniques, and no reference to the particle motion sound field to which these animals would actually be sensitive. Second, there was a lack of proper controls, with different numbers of animals of each species used in the noise exposure part of the study and no indication if the controls were of the same species as the exposed animals. The paper also implies that the controls were not placed in the same experimental setup as the exposed animals, but rather were captured and then sacrificed immediately. The difference in tissue degradation observed between the experimental and control animals could have resulted from poor tissue fixation techniques, degradation prior to fixation, handling of the animals, feeding regime, water quality, exposure to chemicals in the holding tanks, or differences in how tissue was taken from the animals. Without further details on how the experiment was conducted and statistics on comparing the damage of exposed to control animals, the results and accompanying interpretation are questionable. One final flaw of the study is that it states that "if the relatively low levels and short exposure applied in this study can induce severe acoustic trauma in cephalopods, the effects of similar noise sources on these species in natural conditions over longer time periods may be considerable" (André et al., 2011). However, the authors fail to elaborate that, in fact, there are no anthropogenic sources to which animals might be exposed with characteristics similar to those used in their study. The time sequence of exposure from low-frequency sources in the open ocean would be about once every 10 sec for seismic airguns and once every 10 to 15 min for SURTASS LFA. Ships, such as large tankers, tugs, and barges, which when operated produce continuous, low-frequency sound, would require a cephalopod to be at least within 100 m to receive the sound level used in the study. Therefore, the sound exposures are far longer in duration and higher in energy than any exposure a wild animal would likely ever receive and acoustically very different than a free field sound to which animals would be exposed in the real world.

While data are still very limited, they do suggest that some of the major cephalopods and decapods may not hear well. Given the data on hearing thresholds of cephalopods, SURTASS LFA sonar operations could only have a lasting impact on these animals if they are within a few tens of meters from the source. Therefore, the fraction of the cephalopod and decapod stocks that could possibly be found in the water column near a ship using SURTASS LFA sonar would be negligible. Cephalopods and decapods, therefore, have been eliminated from further consideration because of their distribution in the water column.

3.2.1.2 Vertebrates

Vertebrates offer an acoustic impedance contrast with water and have specialized organs for hearing; hence, they are potentially susceptible to the operation of SURTASS LFA sonar.

Fish

Fish are able to detect sound, although there is remarkable variation in hearing capabilities in different species. While it is not easy to generalize about hearing capabilities due to this diversity, most all fish known to detect sound can at least hear frequencies from below 50 Hz up to 800 Hz, while a large subset of fish can detect sounds to over 1,000 Hz, and another subset can detect sounds to over 2,000 Hz. Of the estimated 29,000 extant fish species (Nelson, 2006) only a small percentage have been studied in terms of audition or sound production (Popper et al., 2003). Of the 100 or more species on which hearing studies have been done, all are able to detect sound. While only a relatively small number of species have been studied, it is apparent that many bony fish (but apparently no sharks and rays) are able to produce vocalizations and use these sounds in various behaviors. Hearing or sound production is documented in well over 240 fish species comprising at least 58 families and 19 orders, although it is likely that with additional study it will be found that many more species produce sounds. Potential SURTASS LFA sonar effects are considered by fish taxonomic order for this analysis, except for the Perciformes, which is analyzed by family, although it must be recognized that even within a taxonomic order or family, different species may have different hearing capabilities or uses of sound. Of the 19 orders of fish currently known with sound production, those that would be found inshore in shallow waters (within 22 km [12 nmi] of the coast) have been eliminated from evaluation because they would not occur where the SURTASS LFA sonar would be operating. The fish orders with known sound production that do occur in pelagic (oceanic) waters where they might encounter SURTASS LFA sonar are Heterodontiformes, Orectolobiformes, Lamniformes, Rajiformes, Anguilliformes, Albutleiformes, Clupeiformes, Salmoniformes, Gadiformes, Pleuronectiformes, Beryciformes, Batrachoidiformes, Scorpaeniformes, Siluriformes, and the Perciformes family’s Pomacentridae, Labridae, Lutjanidae, Serranidae, Sciaenidae, and Scombridae; these fish families also occur pelagically: Haemulidae, Sparidae, Carangidae, Eleotridae, Mullidae, Mugilidae, Gobiidae. These are the fish groups evaluated for potential impacts in this SEIS/SOEIS.

Seabirds

There are more than 270 species of seabirds in five orders, and each order has species that dive to depths exceeding 25 m (82 ft). There are few data on hearing in seabirds and even less on underwater hearing. Studies with bird species have shown that birds are sensitive to LF sounds in air. While it is likely that many diving seabirds can hear underwater LF sound, there is no evidence that seabirds use sound underwater.

There is a considerable amount of knowledge about seabird foraging ecology in terms of foraging habitat, behavior, and strategy. Foraging habitat features include water masses, environmental gradients, fronts, topographical features, and sea ice. Seabird foraging behavior mostly involves taking prey within a half meter of the sea surface. However, some species take prey within 20 m (66 ft) or deeper, feed on dead prey at the surface, or take prey from other birds. Foraging behaviors involve such things as locating physical oceanic features, relying on subsurface predators (marine mammals and large fish) to drive prey to the surface, feeding in flocks, feeding at night, and maximizing surface area surveillance (Ballance et al., 2001). None of these foraging behaviors appear to require the use of underwater sound.

Ballance et al. (2001) states that seabirds spend 90% of their life at sea foraging over hundreds to thousands of kilometers. Some dive to several hundred meters below the sea surface. Ballance et al. (2001) further state, however, that most seabirds take their prey within a half meter of the sea surface and that prey on a global scale is patchier in oceanic waters than shelf and slope waters. There are several factors that reduce the exposure of seabirds to LFA when they are diving. First, the free surface effects (reduction of sound levels at the air-water interface) will effectively reduce the LF sound levels near the surface (within 2 m [6.6 ft]) by 20 to 30 dB. Second, the air bubbles that are created due to the impact will further reduce any potential effects from LFA sound transmissions. Finally, for any possible interaction between a diving seabird and LFA, the animal would need to be at least 2 m (6.6 ft) below the water surface near a transmitting LFA source, even more unlikely given that LFA transmits only 7.5% of the time (active transmission duty cycle based on actual operations). Seabirds are not expected to be impacted by LFA because they are generally shallow divers, spend a small fraction of their time in the water at depths where LFA might affect them, and can rapidly disperse to other areas if disturbed (Croll et al., 1999). However, because as stated above possible interaction between seabirds and LFA would be minimal, the possibility of dispersal due to LFA sound exposure should also be considered minimal. For these reasons, significant impacts to seabirds, including those that may be threatened or endangered, are highly unlikely. Therefore, seabirds have been excluded from further evaluation.

Sea Snakes

There is no available research regarding the potential effects on sea snakes of LF sounds or other anthropogenic underwater noises. Research on hearing ability in snakes is also limited, with current scholarship suggesting that while snakes may perceive LF noises, their hearing threshold is very high at approximately 100 dB in water (this number is extrapolated based on data from terrestrial snakes and corrected for water) (Young, 2003). They possess no external ear and lack many of the interior auditory components that facilitate hearing; but in water the inner ear may receive signals via the lungs, which would work like the swim bladder in fish.

Sea snakes primarily inhabit coastal areas in tropical oceans, notably the Indian Ocean and western Pacific Ocean (Kharin, 2004). Additionally, sea snakes need to surface to breathe and are thus relatively shallow divers, rarely descending deeper than 100 m (328 ft) (Heatwole, 1999).

Sea snakes would not be at any greater risk than fish for potential injury from SURTASS LFA sonar transmissions and would not be subject to behavioral reactions because of their poor sensitivity to LF sound. Because they are predominately shallow diving, coastal creatures, it is unlikely that sea snakes would be exposed to LFA signals at all, much less at levels high enough to affect them adversely. Therefore, sea snakes are excluded from further considerations.

Sea Turtles

There are seven species of marine turtles, six of which are listed as either threatened and/or endangered under the ESA. The flatback turtle (*Natator depressus*) is not listed under the ESA as its distribution is restricted largely to the tropical, continental shelf waters of Australia; Papua New Guinea; and Papua, Indonesia (Limpus, 2007). Since it is likely that all species of sea turtles hear LF sound as adults (Ridgway et al., 1969; O'Hara and Wilcox, 1990), all species of sea turtles (Table 3-1) are considered for evaluation in this document.

Marine Mammals

- **Baleen whales (Mysticetes)**

All 12 species of baleen whales (mysticetes) produce LF sounds. Sounds may be used as contact calls, for courtship displays and possibly for navigation and food finding. Although there are no direct data on auditory thresholds for any mysticete species, anatomical evidence strongly suggests that their inner ears are well adapted for LF hearing. Original work by Ketten (1998) was summarized in the SURTASS LFA FEIS in Figure 1-4 and pages 1-21 through 1-23 (DON, 2001). The resonant properties of the basilar membrane of mysticetes suggest their functional hearing range is 15 Hz to 20 kHz, with good sensitivity from 20 Hz to 2 kHz (Ketten, 1998). Parks et al. (2007) analyzed 18 inner ears from 13 stranded North Atlantic right whales (*Eubalaena glacialis*) to develop a preliminary model of their frequency range of hearing. The thickness/width measurements of the basilar membrane resulted in an estimated hearing range of 10 Hz–22 kHz based on established marine mammal models. Therefore, sound perception and production are assumed to be critical for mysticete survival. For this reason all mysticete species are considered sensitive to LF sound. All 12 species of baleen whales occur within the latitudes of proposed SURTASS LFA sonar operations and as such, all are considered for further evaluation (Table 3-2).

- **Toothed whales (Odontocetes)**

There are at least 72 species of odontocetes (some species classifications are under study and the exact number of beaked whales is not known). Many odontocete species are known to use high-frequency (HF) clicks for echolocation. All odontocete species studied to date hear best in the mid- to high-frequency range, and as a consequence, are less likely to be affected by exposure to LF sounds than mysticetes. Odontocetes also depend upon acoustic perception and sound production for communication, prey

Table 3-1. Sea turtle species considered for further evaluation of the potential effects from exposure to SURTASS LFA sonar.

FAMILY	SPECIES	ESA STATUS
Cheloniidae	Green turtle (*Chelonia mydas)*	Threatened[1]
	Hawksbill turtle (*Eretmochelys imbricata)*	Endangered
	Loggerhead turtle (*Caretta caretta*)	Threatened and Endangered[2]
	Olive ridley turtle (*Lepidochelys olivacea)*	Threatened
	Kemp's ridley turtle (*Lepidochelys kempii)*	Endangered[3]
	Flatback turtle (*Natador depressus*)	
Dermochelyidae	Leatherback turtle (*Dermochelys coriacea)*	Endangered

location, and probably for navigation and orientation as well. Although most odontocete species inhabit ocean areas where SURTASS LFA sonar might operate, at least 14 toothed whale species are found in nearshore or inshore waters where SURTASS LFA will not operate[4] and have been eliminated from further evaluation:

- Narwhal (*Monodon monoceros*)—occurrence principally only in high Arctic waters, where SURTASS LFA sonar will not be operated.
- Coastal Porpoises—Porpoise species, including Burmeister's porpoise *(Phocoena spinipinnis*), vaquita (*P. sinus)*, and finless porpoise (*Neophocaena phocaenoides),* are excluded due to their distribution in nearshore, shallow coastal waters well inside of the 12 nmi shoreward limit where SURTASS LFA sonar would not be operated.
- River Dolphins—Dolphin species, such as the Chinese river dolphin (*Lipotes vexillifer)*, franciscana (*Pontoporia blainvillei*), boto/Amazon River dolphin (*Inia geoffrensis*), and the South Asia river dolphins (Ganges River dolphin [*Platanista gangetica gangetica]* and Indus River dolphin [*Platanista gangetica minor*]), are excluded as their distribution is restricted to riverine waters of Asia and South America. Although occasionally river dolphins may enter coastal waters, they occur well inshore of the areas where SURTASS LFA sonar would be employed.
- Coastal Dolphins—Delphinid species, including the Tucuxi/boto (*Sotalia fluviatilis)*, Irrawaddy dolphin (*Oracella brevirostris),* Australian snubfin dolphin (*Oracella heinsohni*), Indo-Pacific humpbacked dolphin (*Sousa chinensis)*, costero (*Sousa guianensis*), Atlantic humpbacked dolphin (S*ousa teuszii)*, and humpback dolphin (*Sousa plumbea)* all occur in shallow, coastal waters well shoreward of the 12 nmi extent where SURTASS LFA sonar could be employed. Also, these dolphins are not known to hear sounds in the range of the SURTASS LFA sonar system.

---

1 As a species, the green turtle is listed as threatened under the ESA while the Florida and Mexican Pacific coast nesting populations are listed as endangered.

2 Five loggerhead DPS are listed as endangered under the ESA: Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean; while four DPS are listed as threatened: Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean (NOAA and USFWS, 2011).

3 Although as a species the olive ridley is listed as threatened under the ESA, the Pacific nesting population in Mexico is listed as endangered.

4 Generally, SURTASS LFA sonar operations are conducted in waters deeper than 200 m (656 ft). However, with the new CLFA source array and TL-29A Twin Line receive array, operations could be conducted in shallower water, depending upon the operational circumstances.

Table 3-2. Mysticete or baleen whale species considered for further evaluation of the potential effects from exposure to SURTASS LFA sonar.

FAMILY	SPECIES	ESA STATUS
Balaenopteridae	Blue whale (*Balaenoptera musculus)*	Endangered
	Fin whale (*Balaenoptera physalus)*	Endangered
	Sei whale (*Balaenoptera borealis*)	Endangered
	Bryde's whale (*Balaenoptera edeni)*	
	Minke whale (*Balaenoptera acutorostrata)*	
	Humpback whale (*Megaptera novaeangliae*)	Endangered
Balaenidae	Bowhead whale (*Balaena mysticetus*)	Endangered
	North Atlantic right whale (*Eubalaena glacialis*)	Endangered
	North Pacific right whale (*Eubalaena japonica*)	Endangered
	Southern right whale (*Eubalaena australis*)	Endangered (foreign)
Neobalaenidae	Pygmy right whale (*Caperea marginata*)	
Eschrictiidae	Gray whale (*Eschrichtius robustus*)	Endangered—Only Western Pacific population

The remaining 58 species (Table 3-3) of globally occurring odontocetes further analyzed in this document are found in deeper waters away from the coast where SURTASS LFA sonar might operate.

➢ **Seals, sea lions, and walruses (Pinnipeds)**

The suborder Pinnipedia consists of eared seals (family Otariidae), earless or true seals (family Phocidae), and walruses (family Odobenidae). There are 16 species of otariids, including sea lions and fur seals, which are found in temperate to sub-polar waters. All but two of the otariid species (Table 3-4), the Antarctic fur seal (*Arctocephalus gazella),* which is restricted to Antarctic waters where SURTASS LFA sonar will not be operated, and the Japanese sea lion, which is considered by most scientists to be extinct, are analyzed in this document.

Walruses are found discontinuously only in the Northern Hemisphere in Arctic and subarctic waters. The Pacific walrus subspecies is generally found in the Bering Sea of Alaska and north towards the Chukchi Sea, East Siberian Sea, and western Beaufort Sea (Jefferson et al., 2008). The Atlantic walrus subspecies occurs in the eastern Canadian Arctic and Hudson Bay to Greenland, Svalbard, and the Barents and Kara Sea (Jefferson et al., 2008; Kastelein, 2009). An additional isolated population occurs in the Laptev Sea off northern Russia (Jefferson et al., 2008; Kastelein, 2009). Walruses are generally found in shallow, continental shelf waters (up to 80 m [263 ft]) since they feed on benthic invertebrates and rarely are found in deeper waters. Walruses inhabit drifting ice covered regions with numerous leads and polynas (Kastelein, 2009). Due to the restricted polar distribution of all subspecies of the walrus, this species has been excluded from further analysis.

Eight of the 18 species of phocids occur in polar regions of both hemispheres and inland lakes and can, therefore, be excluded from further analysis in this document. These excluded phocid seals include the ringed seal (*Phoca hispida*), Baikal seal (*Pusa sibirica*), Caspian seal (*Pusa caspica*), bearded seal (*Erignathus barbatus*), crabeater seal (*Lobodon carcinophaga*), Ross seal (*Ommatophoca rossii*),

Table 3-3. Odontocete or toothed whale species considered for further evaluation of the potential effects from exposure to SURTASS LFA sonar.

FAMILY	SPECIES	ESA STATUS
Physeteridae	Sperm whale (*Physeter macrocephalus*)	Endangered
Kogiidae	Pygmy sperm whale (*Kogia breviceps*)	
	Dwarf sperm whale (*Kogia sima*)	
Ziphiidae	Baird's beaked whale (*Berardius bairdii)*	
	Arnoux's beaked whale (*Berardius arnuxii)*	
	Shepherd's beaked whale (*Tasmacetus sheperdii*)	
	Cuvier's beaked whale (*Ziphius cavirostris*)	
	Northern bottlenose whale (*Hyperodon ampullatus*)	
	Southern bottlenose whale (*Hyperodon planifrons)*	
	Longman's beaked whale (*Indopacetus pacificus*)	
	Andrew's beaked whale (*Mesoplodon bowdoini*)	
	Blainville's beaked whale (*Mesoplodon densirostris)*	
	Gervais' beaked whale (*Mesoplodon europaeus)*	
	Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens)*	
	Gray's beaked whale (*Mesoplodon grayi)*	
	Hector's beaked whale (*Mesoplodon hectori)*	
	Hubbs beaked whale (*Mesoplodon carhubbsi)*	
	Perrin's beaked whale (*Mesoplodon perrini)*	
	Pygmy beaked whale (*Mesoplodon peruvianus)*	
	Sowerby's beaked whale (*Mesoplodon bidens)*	
	Spade-toothed beaked whale (*Mesoplodon traversii)*	
	Stejneger's beaked whale (*Mesoplodon stejnegeri)*	
	Strap-toothed beaked whale (*Mesoplodon layardii)*	
	True's beaked whale (*Mesoplodon mirus)*	
Monodontidae	Beluga (*Delphinapterus leucas*)	Endangered—Only Cook Inlet stock
Delphinidae	Killer whale (*Orca orcinus*)	Endangered—Only Southern Resident population
	False killer whale (*Pseudorca crassidens*)	Proposed Endangered—Only Insular Hawaiian population
	Pygmy killer whale (*Feresa attenuata*)	
	Melon-headed whale (*Peponocephala electra*)	
	Long-finned pilot whale (*Globicephala melas*)	
	Short-finned pilot whale (*Globicephala macrorhynchus)*	
	Risso's dolphin (*Grampus griseus*)	
	Short-beaked common dolphin (*Delphinus delphis*)	
	Long-beaked common dolphin (*Delphinus capensis)*	

Table 3-3. Odontocete or toothed whale species considered for further evaluation of the potential effects from exposure to SURTASS LFA sonar.

FAMILY	SPECIES	ESA STATUS
Delphinidae (Continued)	Fraser's dolphin (*Lagenodelphis hosei*)	
	Common bottlenose dolphin (*Tursiops truncatus*)	
	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)	
	Pantropical spotted dolphin (*Stenella attenuata*)	
	Striped dolphin (*Stenella coeruleoalba)*	
	Atlantic spotted dolphin (*Stenella frontalis)*	
	Spinner dolphin (*Stenella longirostris)*	
	Clymene dolphin (*Stenella clymene)*	
	Peale's dolphin (*Lagenorhynchus australis*)	
	Dusky dolphin (*Lagenorhynchus obscurus)*	
	Atlantic white-sided dolphin (*Lagenorhynchus acutus)*	
	White-beaked dolphin (*Lagenorhynchus albirostris)*	
	Hourglass dolphin (*Lagenorhynchus cruciger)*	
	Pacific white-sided dolphin (*Lagenorhynchus obliquidens)*	
	Rough-toothed dolphin (*Steno bredanensis*)	
	Northern right whale dolphin (*Lissodelphis borealis*)	
	Southern right whale dolphin (*Lissodelphis peronii)*	
	Commerson's dolphin (*Cephalorhynchus commersonii*)	
	Chilean dolphin (*Cephalorhynchus eutropia)*	
	Heaviside's dolphin (*Cephalorhynchus heavisidii)*	
	Hector's dolphin (*Cephalorhynchus hectori)*	
Phocoenidae	Dall's porpoise (*Phocoenoides dalli*)	
	Harbor porpoise (*Phocoena phocoena*)	
	Spectacled porpoise (*Phocoena dioptrica)*	

leopard seal (*Hydrurga leptonyx*), and Weddell seal (*Leptonychotes weddellii*). The remaining 10 phocid species (Table 3-5), including two endangered monk seal species, merit further evaluation.

- **Ursids and mustelids**

The polar bear (*Ursus maritimus*) is a marine mammal that can be excluded from further analysis since it only occurs in shallow Arctic regions. Two additional species of marine mammals, the sea otter (*Enhydra lutris*) and the marine otter (chungungo) (*Lontra felina*), will not be further considered in this document because they occur almost exclusively in shallow waters less than 12 nmi from shore.

- **Sirenians**

Globally, four sirenian species exist including three manatee species, the West Indian (*Trichechus manatus*), Amazonian (*T. inunguis*), and West African (*T. senegalensis*) manatees, and one dugong species (*Dugong dugon*). The West Indian and West African manatees occur in coastal and inshore tropical to subtropical marine, brackish, and freshwater waters while the Amazonian manatee is restricted solely to the freshwater river habitats of the Amazon River and its tributaries (Jefferson et al., 2008).

Table 3-4. Pinniped species in the Otariidae family considered for further evaluation of the potential effects from exposure to SURTASS LFA sonar.

SPECIES	ESA STATUS
South American fur seal (*Arctocephalus australis*)	
New Zealand fur seal (*Arctocephalus forsteri)*	
Galapagos fur seal (*Arctocephalus galapagoensis)*	
Juan Fernadez fur seal (*Arctocephalus philippi)*	
South African and Australian fur seals (*Arctocephalus pusillus)*	
Guadalupe fur seal (*Arctocephalus townsendi)*	Threatened (foreign)
Subantarctic fur seal (*Arctocephalus tropicalis)*	
Northern fur seal (*Callorhinus ursinus*)	
Steller sea lion (*Eumetopias jubatus*)	Endangered (Western DPS); Threatened (Eastern DPS)[5]
California sea lion (*Zalophus californianus*)	
Galapagos sea lion (*Zalophus wollebaeki)*	
Australian sea lion (*Neophoca cinerea*)	
New Zealand fur seal (*Phocarctos hookeri*)	
South American sea lion (*Otaria flavescens*)	

Table 3-5. Pinniped species in the Phocidae family considered for further evaluation of the potential effects from exposure to SURTASS LFA sonar.

SPECIES	ESA STATUS
Mediterranean monk seal (*Monachus monachus)*	Endangered (foreign)
Hawaiian monk seal (*Monachus schauinslandi*)	Endangered
Northern elephant seal (*Mirounga angustirostris)*	
Southern elephant seal (*Mirounga leonina)*	
Ribbon seal (*Phoca fasciata)*	
Spotted seal (*Phoca largha*)	Threatened (Southern DPS)
Harbor seal (*Phoca vitulina*)	
Gray seal *(Halichoerus grypus)*	
Hooded seal (*Cystophora cristata*)	
Harp seal (*Pagophilus groenlandicus*)	

5 NOAA/NMFS is proposing to remove the "threatened" ESA-listing from the eastern Steller sea lion population after a status review by its biologists found the species is recovering sufficiently.

Although manatees can travel great distances, with occasional sightings of sole individuals of the Florida subspecies of the West Indian manatee (*T. m. latirostris*) having been recorded as far north as Cape Cod, MA (Wynne and Schwartz, 1999; DoN, 2005b). Individuals also very occasionally traveling into waters, but these are considered to be atypical and rare occurrences. Virtually all documented sightings of sirenians have occurred on nearshore and inshore waters, where SURTASS LFA operational restrictions apply (due to the potential for grounding and damaging the source VLA or receive HLA). For these reasons, the manatee species are excluded from further analysis.

Dugongs are widely but discontinuously distributed in the northern Indian and western North Pacific Oceans in coastal and estuarine tropical and subtropical waters that are typically less than 5m (16.4 ft) deep (Jefferson et al., 2008). Although principally coastal dwellers, dugongs have been sighted near reefs up to 80 km (43.2 nmi) from shore in waters up to 23 m (75 ft) deep (Marsh et al., 2002). Although the distance dugongs may potentially travel from shore exceeds the 12 nmi exclusion distance from land in which SURTASS LFA sonar will not operate, the water depth of these more offshore reefs where dugongs uncommonly travel are so shallow that the operation of the sonar is precluded. As a result, the dugong was eliminated from further evaluation.

3.2.2 FISH

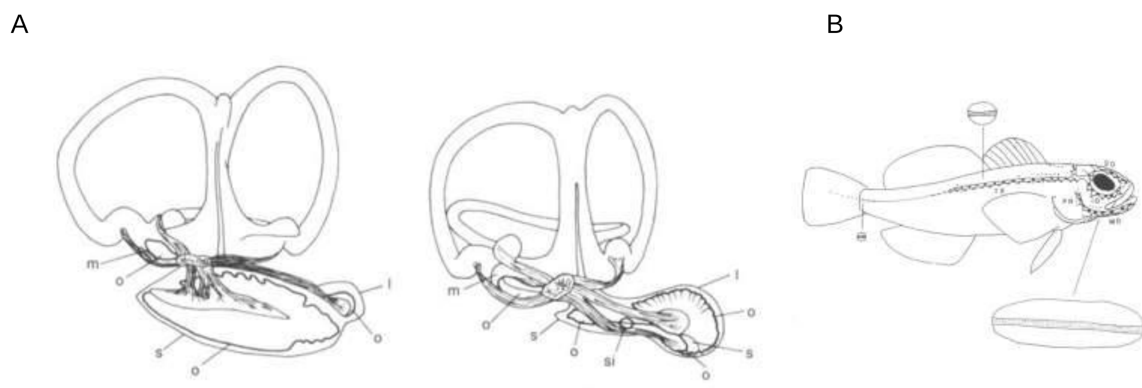
Two taxonomic classes of fish are considered for this SEIS: Chondrichthyes (cartilaginous fish including sharks and rays) and Osteichthyes (bony fish). The bony fish comprise the largest of all vertebrate groups with over 29,000 extant species (Nelson, 2006). The ecological distribution of fish is extraordinarily wide, with different species being adapted to a diverse range of abiotic and biotic conditions.

Pelagic fish live in the water column, while demersal fish live near the bottom and both types of fishes may potentially be exposed to LF sounds. Additionally, many fish species are protected and are commercially important. It is likely that all species of fish can hear, and that many fish species produce and/or use sound for communication (Appendix B). However, data on hearing and/or sound production are not available for many species beyond those shown in the table. For example, there is reason to suggest that a number of deep-sea species that live where there is little or no light, such as myctophids (lanternfish) (Popper, 1980a; Mann and Jarvis, 2004), macrourids (rattails—relatives of cod) (Deng et al., 2009), and deep sea eels (Buran et al., 2005) hear well and/or use sound for communication, but this cannot be confirmed without far more extensive data.

3.2.2.1 Osteichthyes (Bony Fishes)—Hearing Capabilities, Sound Production, and Detection

The octavolateralis system of fish is used to sense sound, vibrations, and other forms of water displacement in the environment, as well as to detect angular acceleration and changes in the fish's position relative to gravity (Popper et al., 2003; Popper and Schilt, 2008). The major components of the octavolateralis system are the inner ear and the lateral line (Figure 3-1). The basic functional unit in the octavolateralis system is the sensory hair cell, a highly specialized cell that is stimulated by mechanical energy (e.g., sound, motion) and converts that energy to an electrical signal that is compatible with the nervous system of the animal. The sensory cell found in the octavolateralis system of fish and elasmobranchs is the same sensory cell found in the ears of terrestrial vertebrates, including in humans (Coffin et al., 2004). Both the ear and the lateral line send their signals to the brain in separate neuronal pathways. However, at some levels the two systems are likely to interact to enable the fish to detect and analyze a wide range of biologically relevant signals (Coombs et al., 1989).

The lateral line is divided into two parts: the canal system and the free neuromasts. Each neuromast is a grouping of sensory hair cells that are positioned so that they can detect and respond to water motion around the fish. The canal neuromasts are spaced evenly along the bottom of canals that are located on the head and extending along the body (in most, but not all, species) (Figure 3-1). The free neuromasts are distributed over the surface of the body. The specific arrangement of the lateral line canals and the free neuromasts vary with different species (Coombs et al., 1992; Webb et al., 2008). The pattern of the



The octavolateralis system of fish includes the inner ear (A) and the lateral line system (B). (A) Medial view of the inner ear of a zander (*Stizostedion lucioperca*) on the left and an ide (*Levciscus idus*) on the right (From Popper and Fay, 1973). (Internal structures not labeled.) Anterior (front of the animal) is to the left and dorsal (top of the animal) is to the top. (B) Enlargement of the canal and surface neuromasts on the body of the mottled sculpin (*Cottus bairdii*), showing the dorsal surface of neuromasts found on the mandible, trunk, and a superficial neuromast; stippling represents hair cells. (From Coombs et al., 1989).

Figure 3-1. Octavolateralis system of fish including the inner ear and lateral line system (Coombs et al., 1989).

lateral line canal suggests that the receptors are laid out to provide a long baseline that enables the fish to extract information about the direction of the sound source relative to the animal. The latest data suggest that the free neuromasts detect water movement (e.g., currents), whereas the receptors of the lateral line canals detect hydrodynamic signals. By comparing the responses of different hair cells along such a baseline, fish should be able to use the receptors to locate the source of vibrations (Montgomery et al., 1995; Coombs and Montgomery, 1999; Webb et al., 2008). Moreover, the lateral line appears to be most responsive to relative movement between the fish and surrounding water (its free neuromasts are sensitive to particle velocity; its canal neuromasts are sensitive to particle acceleration).

The ear and the lateral line overlap in the frequency range to which they respond. The lateral line appears to be most responsive to signals ranging from below 1 Hz to between 150 and 200 Hz (Coombs et al., 1992; Webb et al., 2008), while the ear responds to frequencies from about 20 Hz to several thousand Hz in some species (Popper and Fay, 1993; Popper et al., 2003; Popper and Schilt, 2008).[6] The specific frequency response characteristics of the ear and lateral line varies among different species and is probably related, at least in part, to the life style of the particular species.

The inner ear in fish is located in the cranial (brain) cavity of the head just behind the eye. Unlike terrestrial vertebrates, there are no external openings or markings to indicate the location of the ear in the head. The ear in fish is generally similar in structure and function to the ears of other vertebrates. It consists of three semicircular canals that are used for detection of angular movements of the head, and three otolithic organs that respond to both sound and changes in body position (Schellart and Popper, 1992; Popper et al., 2003; Ladich and Popper, 2004; Popper and Schilt, 2008). The sensory regions of the semicircular canals and otolith organs contain many sensory hair cells (Figure 3-2). In the otolith organs, the ciliary bundles, which project upward from the top surface of the sensory hair cells, contact a

6 As discussed below, some fish species are now known to detect sounds well below 20 Hz and others sounds that are in the ultrasound range.

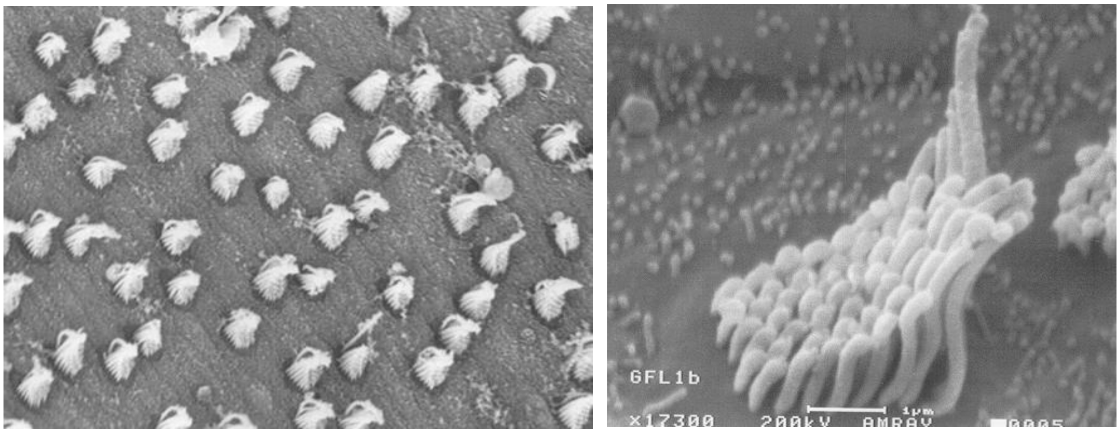


Figure 3-2. Scanning electron micrographs of the ciliary bundles of hair cells from a goldfish (*Carassius auratus*) lagena (unpublished photographs by M.E. Smith). The hair cell on the right is magnified (17,300x) from the general area shown on the left. The scale bar represents 1 µm).

dense structure called an otolith (or ear stone). It is the relative motion between the otolith and the sensory cells that results in stimulation of the cells and responses to sound or body motion. The precise size and shape of the ear varies in different fish species (Popper and Coombs, 1982; Schellart and Popper, 1992; Popper et al., 2003; Ladich and Popper, 2004; Popper and Schilt, 2008).

Hearing is better understood for bony fish than for cartilaginous fish like sharks and jawless fish (class Agnatha) (Popper and Fay, 1993; Ladich and Popper, 2004). Bony fish with specializations that enhance their hearing sensitivity have been referred to as hearing “specialists”, whereas, those that do not possess such capabilities are called “nonspecialists” (or “generalists”). However, in a recent review, Popper and Fay (2009a) have argued that the terms hearing “generalist” and “specialist” should be dropped, since there is so much overlap in hearing capabilities and mechanisms among different species. Instead, Popper and Fay (2009a) suggest that different hearing capabilities should be treated on a “continuum” of capabilities.

Popper and Fay (1993) suggested that in the bony fish species possessing specializations that enhance their hearing sensitivity, one or more of the otolith organs may respond to sound pressure as well as to acoustic particle motion. The response to sound pressure is thought to be mediated by mechanical coupling between the swim bladder (the gas-filled chamber in the abdominal cavity that enables a fish to maintain neutral buoyancy) or other gas bubbles and the inner ear. With this coupling, the motion of the gas-filled structure, as it expands and contracts in a pressure field, is brought to the ear. In fish species without any hearing specializations, however, the lack of a swim bladder, or its lack of coupling to the ear, probably results in most of the energy in the signal from the swim bladder attenuating before it gets to the ear. As a consequence, these fish detect little of the pressure component of the sound (Popper and Fay, 1993).

The vast majority of fish studied to date appear to have no specializations to enhance their hearing sensitivity (Schellart and Popper, 1992; Popper et al., 2003; Popper and Schilt, 2008), and only a few species known to possess hearing specializations inhabit the marine environment (although lack of knowledge about the marine fish with hearing specializations may be due more to limited data on many marine species, rather than on there being few species with specializations in this environment). Some of the better known marine fishes with hearing specializations are found among the Orders Beryciformes (especially the Holocentridae family, which includes soldierfish and squirrelfish) (Coombs and Popper, 1979), and Clupeiformes (which includes herring and shad) (Mann et al., 1997, 2001). Even though there are species with hearing specializations in each of these taxonomic groups, most of these groups also contain numerous species with no hearing specializations. In the family Holocentridae, for example, there is a genus, *Myripristis*, with hearing specializations and a genus, *Adioryx,* with no hearing specializations (Coombs and Popper, 1979).

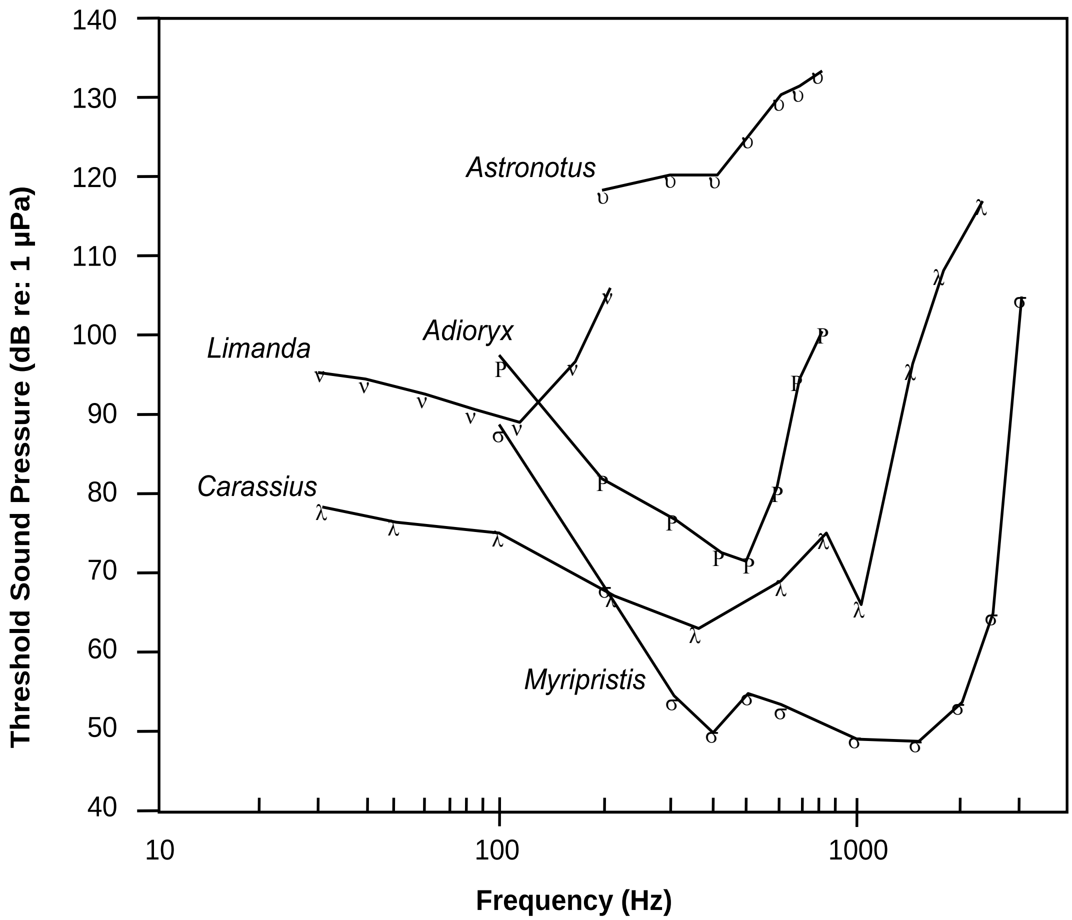
Audiograms (measures of hearing sensitivity) have been determined for over 50 fish (mostly fresh water) and several elasmobranch species (Fay, 1988a; Casper et al., 2003; Casper and Mann, 2006) (Figures 3-3 and 3-4). An audiogram plots auditory thresholds (minimum detectable levels) at different frequencies and depicts the hearing sensitivity of the species. It is difficult to interpret audiograms because it is not known whether sound pressure or particle motion is the appropriate stimulus and whether background noise determines threshold. The general pattern that is emerging indicates that the those species with hearing specializations detect sound pressure with greater sensitivity over a wider bandwidth (to 3 kHz or above) than those species with no hearing specializations. Also, the limited behavioral data available suggest that frequency and intensity discrimination performance may not be as acute in those species with no hearing specializations (Fay, 1988a).

Popper and Fay (1993) point out that threshold values are expressed as sound pressure levels because that quantity is easily measured, although this value is strictly correct only for the fish that respond in proportion to sound pressure. It is uncertain if the thresholds for the oscar and lemon sole should be expressed in terms of sound pressure or particle motion amplitude. In comparing best hearing thresholds, fishes with hearing specializations are similar to most other vertebrates, when thresholds determined in water and air are expressed in units of acoustic intensity (i.e., $Watts/cm^2$) (Popper and Fay, 1993) (Figure 3-4).

Those fish species with hearing specializations whose best hearing is below about 1,000 Hz appear well adapted to this particular range of frequencies, possibly because of the characteristics of the signals they produce and use for communication, or the dominant frequencies that are found in the general underwater acoustic environment to which fish listen (Schellart and Popper, 1992; Popper and Fay, 1997, 1999; Popper et al., 2003). The region of best hearing in the majority of fish for which there are data is from 100 to 200 Hz up to 800 Hz. Most species, however, are able to detect sounds to below 100 Hz, and often there is good detection in the LF range of sounds. It is likely that as data are accumulated for additional species, investigators will find that more species are able to detect low frequency sounds fairly well.

There is a growing literature to suggest that at least some fish species can detect infrasound, often defined as sounds below about 30 Hz, using the ear. This has been demonstrated in Atlantic salmon (*Salmo salar*) (Knudsen et al., 1992); Atlantic cod (*Gadus morhua*) (Sand and Karlsen, 1986); the plaice (*Pleuronectes platessa*) (Karlsen, 1992a), a flatfish lacking a swim bladder; and a perch (*Perca fluvitalis)* (Karlsen, 1992b). All species had a threshold at 0.1 Hz is about $4 * 10^{-5} ms^{-2}$ (Karlsen, 1992a), which corresponds to the particle motion thresholds previously determined for this species between 30 and 150 Hz (Chapman and Sand, 1974). Most recently, infrasound detection was also demonstrated in Atlantic eel, *Anguilla anguilla* (Sand et al., 2000). In all cases studied so far, however, detection only seems to occur when the fish is within a few body lengths of the sound source, and not when the fish are further away.

Many species of fish produce sounds for communication. Myrberg (1981) states that members of more than 50 fish families produce some kind of sound using special muscles or other structures that have evolved for this role, or by grinding teeth, rasping spines and fin rays, burping, expelling gas, or gulping air. Sounds are often produced by fish when they are alarmed or presented with noxious stimuli (Myrberg, 1981; Zelick et al., 1999; Bass and Ladich, 2008). Some of these sounds may involve the use of the swim bladder as an underwater resonator. Sounds produced by vibrating the swim bladder may be at a higher frequency (400 Hz) than the sounds produced by moving body parts against one another. The swim



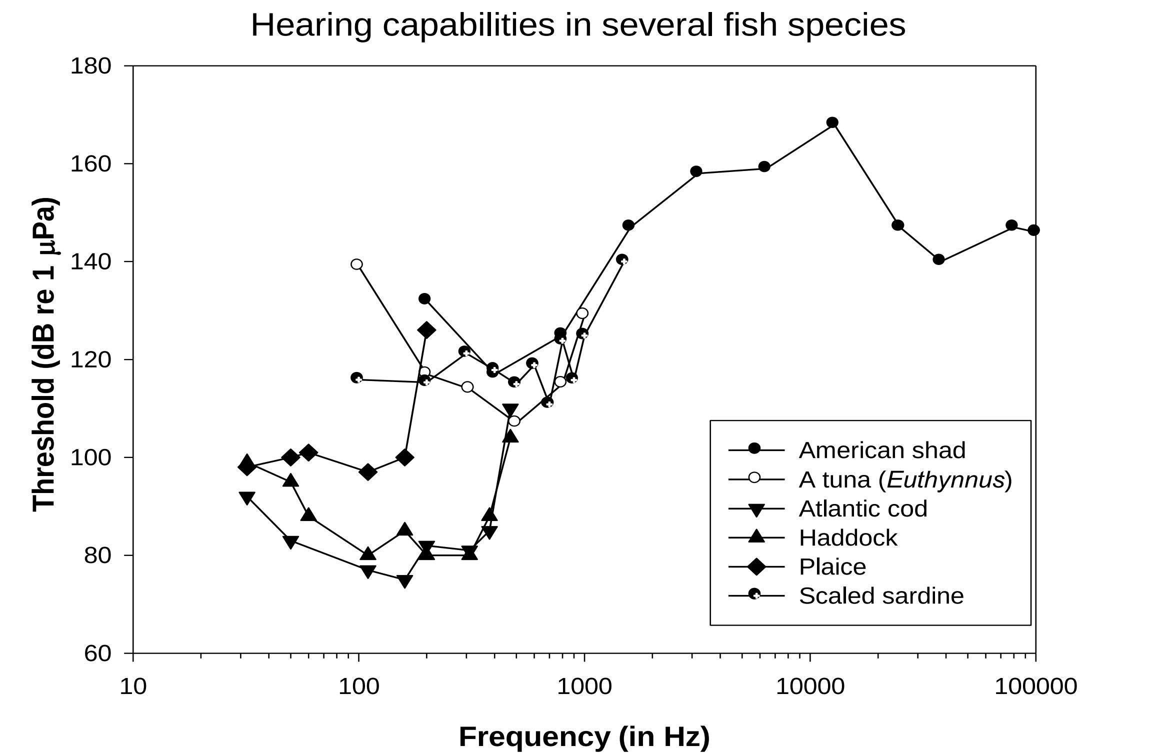
Two fish species with hearing specializations—*Carassius auratus* (goldfish) (Fay, 1969) and *Myripristis kuntee* (squirrelfish) (Coombs and Popper, 1979); two fishes with no hearing specializations but possessing a swimbladder—*Adioryx xantherythrus* (another squirrelfish) (Coombs and Popper, 1979) and *Astronotus ocellatus* (the Oscar) (Yan and Popper, 1992); and a fish with no hearing specializations or a swimbladder— *Limanda limanda* (lemon sole) (Chapman and Sand, 1974).

Figure 3-3. Behavioral audiograms for selected freshwater fish species.

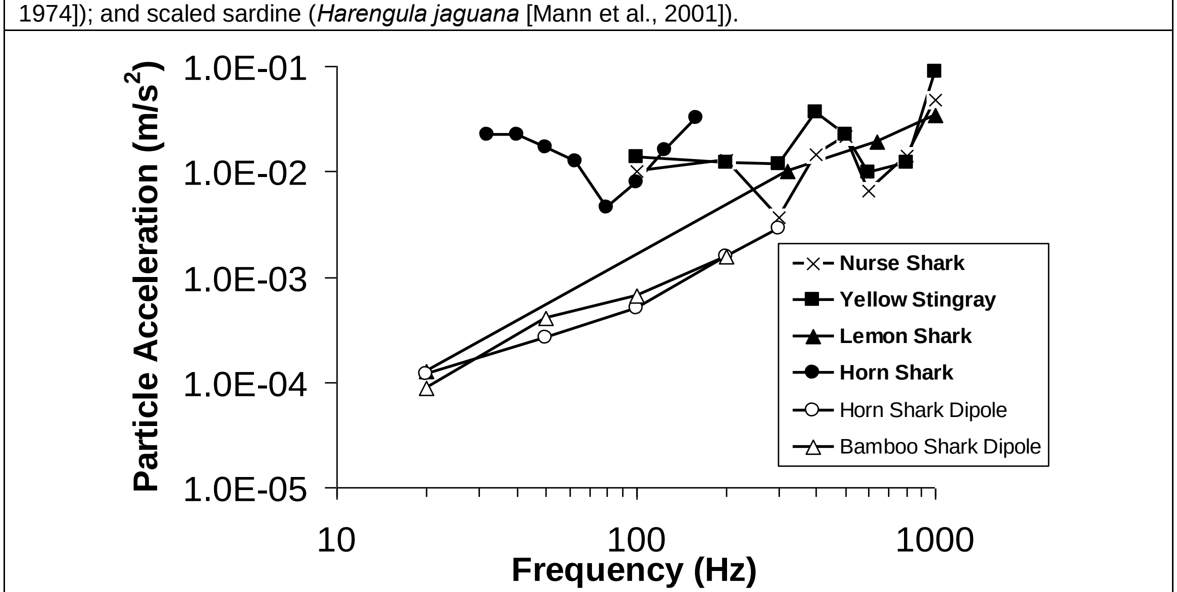
bladder drumming muscles are correspondingly specialized for rapid contractions (Zelick et al., 1999; Bass and Ladich, 2008). Sounds are known to be used in reproductive behavior by a number of fish species, and the current data lead to the suggestion that males are the most active producers. Sound activity often accompanies aggressive behavior in fish, usually peaking during the reproductive season. Those benthic fish species that are territorial in nature often produce sounds regardless of season but particularly during periods of high-level aggression (Myrberg, 1981).

3.2.2.2 Chondrichthyes (Cartilagenous Fish)—Hearing Capabilities, Sound Production, and Detection

Sharks are also of interest because of their low frequency sound detection ability, a capability that is particularly important for detecting sounds produced by potential prey (Nelson and Gruber, 1963; Myrberg et al., 1976; Nelson and Johnson, 1976; Myrberg, 1978). Hearing data have been obtained on very few shark species, and it is not yet clear whether sharks and rays respond to sound pressure or to particle



Data for select marine species: American shad (*Alosa sapidissima* [Mann et al., 2001]); tuna (*Euthynnus affinis*) [Iverson, 1967]), Atlantic cod (*Gadus morhua* [Chapman and Hawkins, 1973]); haddock (*Melanogrammus aeglefinus* [Chapman, 1973]); plaice (*Pleuronectes platessa* [Chapman and Sand, 1974]); and scaled sardine (*Harengula jaguana* [Mann et al., 2001]).



Nurse shark, *Ginglymostoma cirratum*, and yellow stingray, *Urobatis jamaicensis*, are modified from Casper and Mann (2006), with thresholds determined using auditory evoked potentials (AEP). Data for the lemon shark, *Negaprion brevirostris*, was by Banner (1967) and that for the horn shark, *Heterodontus francisi*, (black circle, monopole) from Kelly and Nelson (1975). The lemon shark and horn shark data were obtained using classical conditioning methods in which the animals were trained to respond behaviorally when they heard a sound; the data for these two species was measured in terms of particle displacement and then converted to particle accelerations (Figure from Casper and Mann, 2007).

Figure 3-4. Behavioral audiograms for selected marine fish species.

velocity (or displacement), or to both. The function of the lateral line system of sharks is likely, as in other fish, to detect and respond to low frequency hydrodynamic stimuli (Au and Hastings, 2008). In general, sharks appear to only detect frequencies that are in a range that is similar to that of fish classified as hearing generalists, and hearing sensitivity (the lowest sound levels detectable) is probably poorer than hearing generalist fishes (Banner, 1967; Nelson, 1967; Kelly and Nelson, 1975; Casper et al., 2003).

Olla (1962) observed that hammerhead sharks detect sounds below 750 Hz, with best sensitivity from 250 to 275 Hz, Kritzler and Wood (1961) reported that the bull shark responded to signals at frequencies between 100 and 1,400 Hz, with best hearing from 400 to 600 Hz. Lemon sharks responded to sounds from 10 to 640 Hz, with the greatest sensitivity at 40 Hz, but the lowest frequency may not accurately represent the lower limit of lemon shark hearing due to limitations in the test tank (tank acoustics) used in the experiments (Nelson, 1967). Moreover, lemon sharks may have responded at higher frequencies, but sounds of sufficiently high intensity could not be produced to elicit attraction responses (Nelson, 1967). Banner (1972) reported that lemon sharks he studied responded to sounds varying from 10 to 1,000 Hz. In a conditioning experiment with horn sharks, Kelly and Nelson (1975) discovered the sharks responded to frequencies of 20 to 160 Hz and that the lowest particle motion threshold was at 60 Hz.

The most recent studies of several elasmobranch species show hearing ranges that are comparable to those of earlier studies but were measured in terms of particle motion, the stimulus parameter that is most likely the most important to animals without a swim bladder, such as elasmobranchs (Casper et al., 2003; Casper and Mann, 2006 and 2007), and unlike that done in earlier studies (Van den Berg and Schuijf, 1983). Casper et al. (2003) showed that the little skate, *Raja erinacea* is able to detect sounds from 100 to over 800 Hz, with best hearing up to and possibly slightly greater than 500 Hz. Similar thresholds and hearing range have been reported for the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*) (Casper and Mann, 2006) and the horn shark *Heterodontus francisci* and the white-spotted bamboo shark *Chiloscyllium plagiosum* (Casper and Mann, 2007) (Figure 3-4).

Researchers doing field studies on shark behavior found that several species appear to exhibit withdrawal responses to broadband noise (500 to 4,000 Hz, although it is not likely that sharks heard the higher frequencies in this sound since there is no evidence that their hearing range ever gets much above 1,000 Hz). The oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*) withdrew from an underwater speaker playing low frequency sounds (Myrberg et al., 1978; Klimley and Myrberg, 1979). Lemon sharks exhibited withdrawal responses to broadband noise that was raised 18 dB, at an onset rate of 96 dB/sec, and to a peak amplitude of 123 dB RL from a continuous level, just masking broadband noise (Klimley and Myrberg, 1979). Myrberg et al. (1978) reported that a silky shark withdrew 10 m (33 ft) from a speaker broadcasting a 150-600 Hz sound with a sudden onset and a peak sound pressure level of 154 dB SL. These sharks avoided a pulsed LF attractive sound when its sound level was abruptly increased by more than 20 dB. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. Myrberg (1978) has also reported withdrawal response from the pelagic whitetip shark (*Carcharhinus longimanus*) during limited testing.

The effects of pulse intermittency and pulse-rate variability on the attraction of five species of reef sharks to low frequency pulsed sounds were studied at Eniwetok Atoll, Marshall Islands in 1971 (Nelson and Johnson, 1972). The species tested were gray reef, blacktip reef, silvertip, lemon, and reef white tip. Nelson and Johnson (1972) concluded from these tests that the attractive value of 25 to 500 Hz pulsed sounds is enhanced by intermittent presentation, and that such intermittency contributes more to attractiveness than does pulse-rate variability. All tested sharks exhibited habituation to the sounds during the course of the experiment.

One caveat regarding the data collected on shark hearing is that the majority of the earlier work (1960s to 1970s) was based on studies of single animals, which means the data do not reflect inter-animal variability in sensitivity and bandwidth within a single species, something widely known to occur in all vertebrate groups due to age, health, and other differences (Hill, 2005; Houser and Finneran, 2006a).

While the thresholds reported for sharks give an indication of the sounds they can detect, it would be of great value to replicate these analyses using modern methods for monitoring hearing in multiple animals of the same species.

A second issue with earlier shark hearing research (but much less so with the recent studies) is that hearing was measured in terms of sound pressure levels. However, we now know that elasmobranchs very likely detect particle motion rather than sound pressure (Casper and Mann, 2007), and so interpretation of thresholds and even bandwidth from earlier studies must be assessed in terms of this knowledge. Sharks do not have the hearing specialization of a swim bladder linked to the inner ear. Swim bladders' response to sound pressure may enhance hearing sensitivity (Au and Hastings, 2008). Regardless of whether elasmobranchs detect sound pressure or particle motion, it is certainly clear that elasmobranchs do not detect sounds much above 1,000 Hz, and it is possible that the usable upper limit of their hearing is not much higher than 500 Hz.

3.2.2.3 Threatened and Endangered Fish Species

The following marine and anadromous fish species have been listed as threatened (T) or endangered (E) under the ESA, often for specific geographic locations known as distinct population segment (DPS) or evolutionary significant unit (ESU):

- Atlantic salmon (*Salmo salar)* (E, Gulf of Maine DPS): Maine coastal rivers and northwestern Atlantic Ocean from Gulf of Maine to Labrador, Canada;
- Coho salmon (*Oncorhynchus kisutch*) (E, one ESU; T, three ESUs): North Pacific Ocean basin;
- Chinook salmon (*Oncorhynchus tshawytscha*) (E; two ESUs; T; seven ESUs): North Pacific Ocean basin;
- Sockeye salmon (*Oncorhynchus nerka*) (E, one ESU; T, one ESU): North Pacific Ocean basin;
- Chum salmon (*Oncorhynchus keta) (T, two ESUs):* North Pacific Ocean basin*;*
- Steelhead trout (*Oncorhynchus mykiss*) (T, 11 DPSs): inland and coastal waters of North Pacific Ocean;
- Shortnose sturgeon (*Acipenser brevirostrum*) (E): nearshore waters and coastal rivers of U.S. northwestern Atlantic Ocean;
- Gulf sturgeon (*Acipenser oxyrinchus desotoi*) (T): coastal waters of U.S. Gulf of Mexico from Mississippi River to Tampa Bay;
- Green sturgeon (*Acipenser medirostris)* (T; Southern DPS): Coastal rivers of California;
- Smalltooth sawfish (*Pristis pectinata)* (E, U.S. DPS): primarily nearshore and inshore Florida but may be also found in shelf waters of southeastern U.S.;
- *Largetooth sawfish* (*Pristis perotteti*) (E): shallow near-shore estuarine and lagoonal areas of the Gulf of Mexico;
- Totoaba (*Cynoscion macdonaldi*) (E, foreign): Gulf of California;
- Bocaccio (*Sebastes paucispinis*) (E; Puget Sound/Georgia Basin DPS): inshore waters of Puget Sound and the Georgia Basin;
- Canary rockfish (*Sebastes pinniger)* (T; Puget Sound/Georgia Basin DPS): inshore waters of Puget Sound and the Georgia Basin;
- Yelloweye rockfish (*Sebastes ruberrimus*) (T; Puget Sound/Georgia Basin DPS): inshore waters of Puget Sound and the Georgia Basin; and
- Pacific euchalon/smelt (*Thaleichthys pacificus)* (T): Northeastern Pacific Ocean.

Anadromous fish species, such as salmon and trout, live in the ocean as juveniles and adults but return to the freshwater streams or lakes of their birth to spawn as adults; all of the Pacific salmon species and a number of Atlantic salmon die after spawning. Many of these ESA-listed species, such as the sturgeons, are found only in nearshore waters of the marine environment and also migrate into freshwater rivers and streams. While principally found in nearshore waters, large adult smalltooth sawfish have been captured in continental shelf and deeper waters off the southeastern U.S. (DoN, 2007d).

3.2.3 SEA TURTLES

Seven species of living marine turtles are distributed circumglobally in the Atlantic, Pacific, and Indian Oceans and throughout the Caribbean and Mediterranean Seas. The distributions of these species span tropical and temperate waters and, in the case of the leatherback turtle (*Dermochelys coriacea*), extends northward to the subarctic and as far south as New Zealand and the Southern Ocean. All sea turtles are protected under Appendix I of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES), which prohibits international trade to and from signatory countries. Six of the seven sea turtle species are listed under the ESA as threatened and/or endangered (Table 3-1). The seventh sea turtle species, the flatback turtle (*Natator depressus*), is not listed under the ESA as its distribution is restricted to coastal waters off Australia, Papua New Guinea, and Guinea. In addition, the International Union for the Conservation of Nature and Natural Resources (IUCN) considers the Kemp's ridley and hawksbill turtles to be critically endangered, the loggerhead and green turtles to be endangered, the olive ridley to be vulnerable, and the flatback turtle to be data deficient (IUCN, 2010).

3.2.3.1 Natural History and Behavior

Sea turtles are marine reptiles well adapted for life in the sea. Their streamlined bodies and flipper-like limbs make them strong swimmers, able to navigate across oceans. Marine turtles inhabit the world's oceans except the Arctic and Antarctic and range from the northern and southern reaches of the Atlantic and Pacific Oceans to the tropics and into the Mediterranean Sea. Sea turtles go ashore to lay their eggs on beaches and isolated shores and eat a wide-ranging diet, from sea grasses to jellyfish, algae, clams, crabs, and sponges (Spotila, 2004). In addition, sea turtles are the only reptiles that exhibit long-distance migrations that rival those of terrestrial and avian vertebrates. Data accumulated from several decades of mark-recapture and telemetry studies demonstrate that adult sea turtle migrations are resource-driven, with migrants traveling hundreds to thousands of kilometers between established feeding and breeding areas at regular or seasonal intervals (Plotkin, 2003).

Sea turtles show a wide range of diving ability. Marine turtles are capable of making deep, repetitive dives to search for food and can remain submerged for long periods of time, such as when resting on the ocean bottom. On average, most sea turtles spend as little as 3 to 6% of their time at the surface—often just long enough to take a breath of air—although some sea turtles spend as much as 19 to 26% of their time at the surface engaged in basking, feeding, orientation, and mating (Lutcavage and Lutz, 1997). The leatherback turtle, the deepest diving turtle, has been recorded diving to a maximum water depth of 1,230 m (4,035 ft) (Hays et al., 2004), while the green turtle typically only dives no deeper than 20 m (65.6 ft) (Hays et al. 2000). Olive ridley turtles are exceptional in their ability to remain underwater for very long stretches of time, with turtles tagged in waters >20°C by McMahon et al. (2007) remaining underwater for up to 3 hrs and 30 min. This is unlike the overwintering behavior of loggerhead turtles, during which the longest dive of any marine vertebrate was recorded. A tagged loggerhead dove for 6.8 hrs during winter when low (<15°C) water temperatures result in reduced metabolic rates that allow these animals to remain submerged for extensive periods on the sea floor (Hochscheid et al., 2005).

The biology and distribution of sea turtles is intimately tied to the temperature of their environment (Coles and Musick, 2000). Like other reptiles, sea turtles are ectothermic[7], with no physiological regulation of their body temperature. However, marine turtles are unusual among reptiles because their large body size allows adults to use insulation and blood flow to maintain body temperature above that of the

7 An ectotherm is an animal that obtains most of its body heat from the surrounding environment, does not have the physiologic means to regulate its internal temperature, and maintains its body temperature within a fairly narrow temperature range by behavioral means (e.g., basking or burrowing in sediments).

surrounding water. Most sea turtles become lethargic at temperatures below 10°C and above 40°C (Spotila et al., 1997). The normal range of sea surface temperatures (SST) in which sea turtles predominantly occur is from 13.3° to 28°C (Coles and Musick, 2000); these preferred water temperature ranges vary across age classes and species as well as seasons. In general, the body temperature of inactive green, loggerhead, and olive ridley turtles is 1 to 2°C higher than the temperature of the surrounding water, and when active, their body temperature is 2 to 3°C higher than the water. The body temperature of leatherbacks is also 1 to 2°C higher than ambient tropical waters while their body temperature in cold temperate/subarctic waters is much warmer than the ambient waters due to their large body size and thermoregulatory capabilities (Spotila et al., 1997; Wallace et al., 2005). Leatherback turtles can remain active even in very cold water, down to at least 0.4°C (33°F) (James et al., 2006).

Despite some thermoregulatory and behavioral adaptations that sea turtles have evolved, green, loggerhead, and Kemp's ridley turtles are susceptible to a phenomenon called "cold stunning." Cold stunning occurs in late fall through early winter, when water temperatures suddenly drop to 7 to 10°C (45 to 50°F). In late fall, a small percentage of primarily juvenile turtles remain in the nearshore waters and embayments, where they have spent the summer feeding. As the water temperatures precipitously drop, the young turtles become "stunned" by the suddenly much cooler waters. Cold stunned turtles become lethargic and more buoyant, floating on the surface, and often cease eating (Milton and Lutz, 2003). Death often ensues when most sea turtle species are exposed to water temperatures below 5° to 6°C since the animals can no longer swim or dive (Milton and Lutz, 2003). Cold stunning is a major cause of sea turtle stranding along the New England, Florida, and Gulf of Mexico coasts and along the shores of Western Europe in late fall and early winter (Spotila et al., 1997; Spotila, 2004). Alternatively, in some geographic regions (such as the Mediterranean and Florida), some green and loggerhead turtles escape cold temperature conditions by resting on the seabed or burying themselves in the bottom sediments to brumate (Ogren and McVea, 1995; Hochscheid et al., 2005) or by conducting very long dives, sometimes of more than five hours in duration (Hochscheid et al., 2005; Hawkes et al., 2007).

One strategy to avoid cold water temperatures is for animals to migrate to warmer waters. Sea turtles migrate, sometimes extremely long distances, from foraging grounds to shallow-water nesting grounds to mate, nest, and lay their eggs. Depending on the species, sea turtles reach sexual maturity at five to 15 years (leatherback) to 35 years (green turtle) of age (Spotila, 2004). After the nesting season, turtles migrate back to the foraging grounds. In most species of sea turtles, mature females do not nest every year, remaining instead at the foraging grounds in non-nesting years (Wynne and Schwartz, 1999).

Following an 8- to 10-week incubation period, sea turtle eggs hatch. Hatchlings dig their way out of the nest to typically emerge at night. The hatchlings enter the water and swim rapidly in a "swimming frenzy" (Wyneken, 1997) until they reach the open ocean, where many species spend the "lost years" living and feeding in floating *Sargassum*. Juvenile sea turtles share feeding grounds with adults or, in some cases, migrate to developmental feeding grounds (Wynne and Schwartz, 1999). Bolten (2003) has described this life history pattern as a Type 2 pattern, characterized by early development in the oceanic zone followed by later development in the neritic zone[8]. In contrast, some species, such as the leatherback and olive ridley (east Pacific populations), spend their entire lives in a pelagic existence, coming inshore only to mate and nest and are described as a Type 3 life history pattern, characterized by both developmental and adult stages occurring completely in the oceanic zone (Bolten, 2003).

3.2.3.2 Species Descriptions of Potentially Affected Sea Turtles

Population sizes or abundances of sea turtles are generally derived worldwide from estimates of breeding females as they return to shore to nest, when they are more visible and easily counted. Unless otherwise

---

8 The neritic zone is the marine environmental zone that is closest to shore and that extends from the low-tide mark to the edge of the continental shelf or to a water depth of about 200 m (656 ft).

noted, sea turtle abundances are counts of nesting females. Although these abundances represent underestimations of the sea turtle populations as they do not include counts of male or juvenile turtles, they are the best abundance data available.

- **Green turtle (*Chelonia mydas*)**

There is still considerable controversy regarding the taxonomic status of the east Pacific green turtle, or black turtle, and whether it is a separate species or subspecies from the green turtle. Recent reviews of available data, including morphological, phylogenetic, geographic, and genetic information, have left researchers to conclude that while it is possible that the east Pacific green turtle populations are undergoing speciation, not enough evidence exists at this time to warrant species or subspecies status (Parham and Zug, 1996; Bowen and Karl, 2000). Therefore, for the purposes of this analysis, the black turtle will be considered as eastern Pacific populations of the green turtle, *C. mydas.*

The green turtle is protected under CITES and is listed as endangered by the IUCN. The breeding colonies of Florida and Mexico's Pacific coast are listed as endangered under the ESA while the species is listed as threatened in the rest of the Pacific and Atlantic Oceans. Critical habitat for the green turtle has been designated in the coastal waters surrounding Culebra Island, Puerto Rico from the mean high water line seaward 5.6 km (3 nmi) (NOAA, 1998). Green turtles nest in about 80 countries around the world. The NMFS and USFWS (2007) estimate that between 108,761 to 150,521 female turtles nest per year at the 46 worldwide sites for which data were collected. Raine Island, off eastern Australia is reputed to be the largest nesting concentration of female green turtles in the world, even though no reliable abundance estimates of nesting females are available (NMFS and USFWS, 2007). The most recent estimate of nesting females at Raine Island is 25,000 females, but in some years this number is estimated to reach 80,000 (NMFS and USFWS, 2007). The largest rookery in the Atlantic Ocean is located at Tortuguero, Costa Rica, where 17,402 to 37,290 females are estimated to nest each year (NMFS and USFWS, 2007).

Green turtles are widespread throughout tropical and subtropical waters of the Atlantic, Pacific, and Indian Oceans but have been recorded as far north as the temperate waters of Cape Cod and Georges Bank in the northwestern Atlantic Ocean (Lazell, 1980; DoN, 2005b). These turtles inhabit the neritic zone, typically occurring in nearshore and inshore waters where they forage primarily on sea grasses and algae (Mortimer, 1982). Green turtles primarily occur in coastal regions as juveniles and adults but make long pelagic migrations, swimming thousands of kilometers across the open ocean, between foraging and nesting grounds (Bjorndal, 1997; Pritchard, 1997). Green turtles typically make shallow dive to no more than 30 m (Hochscheid et al., 1999; Hays et al., 2000) with a maximum recorded dive to 110 m (65.6 ft) in the Pacific Ocean (Berkson, 1967). Most dives of green turtles are typically 9 to 23 min in duration with a maximum dive having been recorded at 66 min (Brill et al., 1995).

- **Hawksbill turtle *(Eretmochelys imbricate)***

The hawksbill turtle is listed as critically endangered under the IUCN, endangered throughout its range under the ESA, and is protected by CITES. Critical habitat for the hawksbill turtle has been established in the Caribbean Sea coastal waters surrounding Mona and Monito Islands, Puerto Rico from the mean high water line seaward 5.6 km (3 nmi) (NOAA, 1998). Although there is a lack of data to determine good population estimates, the best estimate of the number of annual nesting females worldwide is 21,212 to 28,138 turtles, which represents about 83 nesting areas (NMFS and USFWS, 2007a). The largest nesting populations in the Pacific Ocean occurs in eastern Australia with some 6,500 females nesting per year, in the Atlantic Ocean Yucatan Peninsula, Mexico and Cuba have 534 to 891 and 400 to 833 females nesting, respectively, and in the Indian Ocean, about 2,000 females nest in western Australia and 1,000 nest in Madagascar annually (NMFS and USFWS, 2007a). Although very few hawksbills nest in U.S. waters, nesting does occur on four Puerto Rico locations (120 to 200 female turtles annually), U.S. Virgin

Islands (56 to 222 females annually), Hawaii (5 to 10 females annually), and fewer than 10 females annually in the north Pacific U.S. territories (Spotila, 2004; NMFS and USFWS, 2007a).

Hawksbill turtles occur in coastal tropical and subtropical waters in the Atlantic, Pacific, and Indian Oceans (NMFS and USFWS, 1998a), and are especially in often encountered in shallow lagoons and coral reefs. The largest populations live in the Caribbean Sea, the Seychelles, Indonesia, and Australia. There are no hawksbills in the Mediterranean Sea (Spotila, 2004). In the western Atlantic, they range from Brazil to Massachusetts, but are considered rare north of Virginia (Wynne and Schwartz, 1999). They tend to remain in shallow water of 20 to 50 m (66 to 164 ft) but make the longest routine dives of all sea turtles, with routine dives ranging from 34 to 74 min (Starbird et al., 1999).

Hawksbills were once thought to be non-migratory residents of reefs adjacent to their nesting beaches, but recent tagging, telemetry, and genetic studies confirm that hawksbills migrate hundreds to thousands of kilometers between feeding and nesting grounds (Plotkin, 2003). While the migratory habits of hawksbills are still largely unknown, it appears that, like many of the hard-shelled turtles, hawksbill turtle hatchlings spend their "lost years" associated with Sargassum mats in the open ocean, driven there by the prevailing currents. Then, at about three years of age, they swim toward shore and settle on a suitable foraging site. Juveniles remain at these sites until they are reproductively mature, then females migrate back to their natal No apparent patterns have emerged to explain why some females migrate short distances, while others bypass reefs close to their nesting beaches and migrate greater distances (Plotkin, 2003; Spotila, 2004).

- **Loggerhead turtle (*Caretta caretta*)**

The loggerhead turtle is listed as endangered under the IUCN and is protected under CITES. Five loggerhead distinct population segments (DPS) are listed as endangered under the ESA (Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean) while four DPS are listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean) (NOAA and USFWS, 2011). No critical habitat has been designated under the ESA for the loggerhead turtle. Although Spotila (2004) estimated that 44,560 adult female loggerheads nest annually worldwide, this is likely an underestimate. One of the three major loggerhead populations occurs in southeastern U.S. and northern Gulf of Mexico waters, where 32,000 to 56,000 adult female turtles are estimated to occur (Ehrhart et al., 2003). Formerly the largest worldwide nesting aggregation, the number of females nesting annually in eastern Australia has substantially declined to less than 500, while the only nesting in the North Pacific Ocean, occurs in Japan where more than 4,000 females have been documented nesting recently (NMFS and USFWS, 2007b). The largest nesting aggregation of loggerheads in the Indian Ocean occurs in Masirah, Oman where 20,000 to 40,000 females nest annually (Baldwin et al., 2003).

Loggerhead turtles are found in coastal and pelagic habitats of temperate, tropical, and subtropical waters of the Atlantic, Pacific, and Indian Oceans, as well as the Mediterranean Sea (Dodd, 1988). Habitat usage varies with loggerhead lifestage. Loggerheads are highly migratory, capable of traveling hundreds to thousands of kilometers between feeding and nesting grounds. In the western North Atlantic Ocean, the largest loggerhead turtle nesting aggregations are found along the southeastern U.S. coast, particularly the coast of eastern Florida (Dodd and Byles, 2003). Another area of high loggerhead nesting occurs in the northwestern Indian Ocean on Masirah Island, Oman, where along with peninsular Florida, as many as 10,000 females nest per year (Conant et al., 2009). Many of the southeast U.S. nesting turtles travel to foraging habitats in waters of the northeastern U.S. and Canada but some remain to feed in the waters of the southeastern U.S. Most of the southeast U.S. nesting turtles overwinter in the shallow waters of the Bahamas, Cuba, Hispaniola, and the southeastern U.S. (Dodd and Byles, 2003). Along the South American coast, nesting of loggerheads only occurs in significant numbers in Brazil (Conant et al., 2009). Very few loggerheads forage along the European or African coasts of the Atlantic Ocean and nesting only occurs in the Cape Verde Islands and along the coast of West Africa (Spotila, 2004; Conant et al., 2009).

Although loggerheads are widely distributed in the Mediterranean Sea and forage there, 45% migrate between the Atlantic Ocean and Mediterranean Sea, and nesting only occurs in the eastern Mediterranean (Margaritoulis et al., 2003). Indian Ocean loggerheads occupy foraging grounds along the coasts of southern Africa, Madagascar, Yemen, and Oman, and in the Arabian Gulf, as well as along Western Australia into Indonesian waters. Tagging data have shown that nesting turtles from the dense nesting aggregations along the Oman coast use the waters of the Arabian Peninsula for foraging and seasonal migrational movements (Conant et al., 2009). In the Pacific, loggerheads nest only in a limited number of sites in Japan and eastern Australia, New Caledonia, Vanuatu, and Tokelau, while foraging occurs in the Gulf of California and along Baja California, and in waters of Peru and Chile (Kamazaki, 2003; Limpus and Limpus, 2003; Conant et al., 2009). Hatchlings from nests in Japan (including the Ryukyu Archipelago) make the 10,000 km (5,400 nmi) migration to Mexican developmental and foraging habitat, using the Kuroshio and North Pacific Currents as transport, until returning to the western Pacific as large juveniles (Bowen et al., 1995). Post-hatchling loggerheads from eastern Australia are thought to also make the extensive trans-Pacific migration to the waters of Chile and Peru to forage (Boyle et al., 2009).

Polovina et al. (2003) found that loggerhead turtles spent about 40% of their time at the water surface and 70% of their dives were to no more than 5 m. Even as larger juveniles and adults, loggerheads' routine dives are only nine to 22 m (30 to 72 ft), but adult female loggerheads have recorded dives to 233 m (764 ft), lasting 15 to 30 min (Lutcavage and Lutz, 1997).

- **Olive ridley turtle (*Lepidochelys olivacea*)**

Although the olive ridley turtle is the most abundant sea turtle worldwide, it has declined or disappeared from many of its historic nesting areas. The global population is protected by CITES, classified as vulnerable under the IUCN, and listed as threatened under the ESA everywhere except the Mexican Pacific coast breeding stocks, which are listed as endangered. No critical habitat has been designated for the olive ridley turtle. Accurate abundance estimates are difficult to obtain, as most olive ridley females nest in mass aggregations of hundreds to thousands of turtles, called arribadas[9], making counts of individual turtles difficult. In addition, solitary-nesting females are often too spread out to ensure accurate data collection. Chaloupka et al. (2004) reported abundances for 1999 and 2000, respectively, of 2 and 1.1 million nesting females for two (Ostional, Costa Rica and Escobilla, Mexico) of the major olive ridley nesting populations in the eastern Pacific stock. From data collected at sea, Eguchi et al. (2007) estimated the juvenile and adult olive ridley population in the eastern tropical Pacific Ocean (area encompasses major arribada beaches in Mexico and Central America) as 1.39 million turtles.

Olive ridleys are found in the tropical to warm-temperate Pacific and Indian oceans, but are uncommon in the western Pacific and eastern Indian Ocean. They can also be found in the Atlantic along the west coast of Africa and northeastern coast of South America. Individuals are rarely sighted further into the Caribbean than Trinidad and the West Indies (NMFS, 1995; Plotkin 2003; Spotila, 2004). Unlike their other hard-shelled counterparts, olive ridleys favor an oceanic existence, rarely coming inshore except to nest. Even during the breeding season, males will often remain in the open ocean, intercepting females on their way to the nesting beaches. Copulating pairs have been seen at distances over 1,000 km (540 nmi) from the nearest nesting beach. Olive ridleys are highly migratory and spend most of their non-breeding life cycle in the oceanic zone. Their migratory paths vary annually and no apparent migration corridors exist. Instead, they appear to wander over vast stretches of ocean in search of food, possibly using water temperature as an environmental cue and seeking oceanographic features, such as thermal fronts and convergence zones, to locate suitable feeding areas (Plotkin, 2003; Spotila, 2004).

9 An arribada is a Spanish term for the mass, synchronous nesting events characteristic to olive and Kemp's ridley turtles. During a period of 1 to 10 days, large numbers (100 to 10,000) of female ridley turtles come ashore at night to nest; arribada events can reoccur over 30 day intervals (Hamann et al., 2003).

Olive ridley turtles are capable of deep dives, having been recorded diving to 290 m (951 ft), although routine feeding dives of 80 to 110 m (262 to 361 ft) are most common (Bjorndal, 1997; Lutcavage and Lutz, 1997). Polovina et al., 2003 reported that olive ridley turtles only remained at the surface for 20% of the time, with about 75% of their dives to 100 m and 10% of total dive time spent at depths of 150 m. Inter-nesting females make routine dives of 54.3 min while breeding and post-breeding males apparently make shorter duration dives of 28.6 and 20.5 min, respectively (Lutcavage and Lutz, 1997).

Little is known about the early life stages of the olive ridley turtle. Based on data from the Kemp's ridley sea turtle (discussed below), it is thought that olive ridleys mature in 11 to 16 years at a size of 56 to 78 cm (22 to 31 in) (NMFS, 1995; Spotila, 2004). As stated previously, olive ridleys nest in mass aggregations, called *arribadas*, with thousands of females emerging from the water to nest on a given stretch of beach at the same time, often in daytime. This nesting technique is thought to be a strategy that evolved to overwhelm predators by providing safety in numbers (Spotila, 2004). Major arribada nesting beaches include Ostional (500,000 females) and Nancite (100,000) on Costa Rica's Pacific coast, La Escobilla (450,000) in Pacific Mexico, and Gahirmatha (135,000) in India. Minor *arribada* beaches are found in Nicaragua (12,000 to 25,000 females), India (2,000 to 10,000), Mexico (2,000), and Panama (2,000). Solitary nesting occurs on the beaches of 32 countries (Spotila, 2004).

- **Kemp's ridley turtle *(Lepidochelys kempii)***

The Kemp's ridley turtle is the rarest sea turtle worldwide and has the most restricted distribution. The Kemp's ridley is classified as critically endangered under the IUCN, as endangered throughout their range under the ESA, and are protected by CITES. No critical habitat has been designated for the Kemp's ridley turtle. When its primary nesting beach was first discovered in 1947, approximately 40,000 female Kemp's ridleys were nesting in an arribada at Rancho Nuevo in Tamaulipas, Mexico (NMFS and USFWS, 2007c). Due to hunting of adults and eggs, these numbers were reduced to an estimated 2,000 females by the mid-1960s. By 1985, only 234 females nested at Rancho Nuevo (NMFS and USFWS, 2007c). In 1977, tentative steps toward protection and recovery began with a bi-national recovery plan was established between the United States and Mexico to protect Kemp's ridley turtles both on the beach and in the water. Available data from 2006 indicate an abundance of 7,000 to 8,000 nesting females (NMFS and USFWS, 2007c).

Kemp's ridley turtles are found primarily in the neritic zone of the Gulf of Mexico and western Atlantic. Tagging and telemetry studies have shown that the Kemp's ridley is a neritic migrant that swims along the U.S. and Mexican coasts, nearshore in continental shelf waters and embayments, with narrow migratory corridors extending along the entire U.S. and Mexican gulf coasts (Byles and Plotkin, 1994; Marquez-M., 1994; Plotkin, 2003). Adult females make relatively short annual migrations from their feeding grounds in the western Atlantic and Gulf of Mexico to their principal nesting beach at Rancho Nuevo. Unique among sea turtles, adult males are non-migratory, remaining resident in coastal waters near Rancho Nuevo year-round. In contrast, juvenile Kemp's ridleys make longer migrations from their winter feeding grounds in the Gulf of Mexico and Florida north along the U.S. East Coast—some as far as Cape Cod Bay, Massachusetts—to their summer feeding grounds in coastal waters and embayments. In the fall, these turtles retrace their path south back to warmer wintering grounds. As described previously, some juvenile ridleys stay in northern waters too long, are caught in the cold water, become cold-stunned, and may die (Wynne and Schwartz, 1999; Plotkin, 2003; Spotila, 2004). Kemp's ridley turtles, like olive ridleys nest participate in arribada nesting. The major arribada nesting site for the Kemp's ridley is at Rancho Nuevo; however, solitary nesting has been recorded at 10 beaches along 193 km (120 miles) of Mexican shoreline in Tamaulipas and another 32 km (20 miles) in Veracruz, Mexico.

Unlike their olive ridley cousins, Kemp's ridleys make shallow dives (<50 m; 164 ft) of short duration (12 to 18 min) (Lutcavage and Lutz, 1997). Few data are available on Kemp's ridley diving but routine dives have durations ranging from 16.7 to 33.7 min (Mendonca and Pritchard, 1986; Renaud, 1995).

➢ **Flatback turtle (*Natador depressus*)**

The flatback turtle is listed under Appendix 1 of CITES, is considered data deficient by the IUCN, and is not listed under the ESA. Since this species is currently listed as data deficient by the IUCN, the IUCN is unable to correctly assess the species' status. No estimate of the overall flatback turtle population size is available. Whiting et al. (2009) estimated an annual abundance of 3,250 flatback turtles at Cape Domett, Western Australia, and Sutherland and Sutherland (2003) estimated that 4,234 flatback female turtles came ashore at one the largest flatback rookeries on Crab Island, Australia during the austral winter in 1997. These abundances are the only estimates available for two of the four flatback genetic stocks in Australia.

Flatback turtles have the most restricted distributional range of all sea turtle species. Flatbacks occur principally in habitats with soft sediments throughout the continental shelf waters of northern Australia (including the waters off Western Australia, Northern Territory, and Queensland), Papua New Guinea, and Papua, Indonesia and are not found elsewhere in the world (Limpus, 2007). Flatback turtles do not have a pelagic or oceanic lifestage, which is thought to be the cause for this species remaining endemic to Australia and parts of southern Indonesia (Walker and Parmenter, 1990). Nesting only occurs along the coast of northern Australia. Once thought to be non-migratory, tagged flatback turtles have been recorded moving up to 1,300 km (702 nmi) between nesting beaches in northern Australia to foraging areas in Indonesia (southern Irian Jaya) (Limpus et al., 1983). Nesting occurs year-round at some beaches but only seasonally at other rookeries.

Very little is known about the diving or swimming behavior of the flatback turtle. Sperling (2007, 2008) found that flatback turtles spend about 10% of their time at or near the water's surface; dive as deep as 30 m (98 ft); and dive for long periods of time, with a mean dive duration of 50 min and a maximum of 98 min. Sperling (2008) also discovered two apparent distinct dive types for flatback turtles that had not been described for other turtle species, which accounted for 2 to 5% of the dives the tagged turtles made during the study.

➢ **Leatherback turtle (*Dermochelys coriacea*)**

The leatherback turtle is the largest turtle in the world and one of the largest living reptiles. It is listed as critically endangered under the IUCN, endangered throughout its range under the ESA, and is protected under CITES. Critical habitat for the leatherback turtle has been designated in the Caribbean Sea waters adjacent to Sandy Point Beach, St. Croix, U.S. Virgin Islands; as well as in the northeast Pacific Ocean waters along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour and from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour, which together comprise an area ~108,558 km^2 (41,914 $miles^2$) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 m (262 ft) (NOAA, 1979 and 2012). .As of 2004, roughly 35,800 adult female leatherbacks were estimated in the world, but fewer than 1,000 in the eastern Pacific (Spotila, 2004). Spotila et al. (2000) reported the possible extirpation of leatherbacks from key nesting beaches in the eastern Pacific. The most recent worldwide population estimate of leatherback turtles is 34,000 to 94,000 (NMFS and USFWS, 2007d). Most turtle authorities consider the leatherback to be the most endangered of all sea turtles due to the rapid decline in global population during the last 15 years (Ferraroli et al., 2004).

Leatherbacks are the most pelagic and most widely distributed of any sea turtle and can be found circumglobally in temperate and tropical oceans, ranging as far north as the waters off Newfoundland and as far south as New Zealand and the Southern Ocean (NMFS, 1995; Spotila, 2004). Highly migratory, they make yearly long-distance excursions from their nesting beaches to their feeding grounds, following their primary food source, jellyfish. In the western Atlantic, leatherbacks travel north in the spring, following the Gulf Stream and feeding opportunistically on the spring blooms of jellyfish they find en route. These turtles continue northward, arriving in waters corresponding to the continental slope by April, and finally, continuing on to continental shelf and coastal waters off New England and Atlantic Canada where they remain through October. In the fall, some leatherbacks head south essentially retracing the offshore route from which they came, while others cross the Atlantic to Great Britain and migrate south along the eastern Atlantic (James et al., 2005). Similarly, populations that nest in the eastern Atlantic and Indian oceans make annual transoceanic migrations between breeding grounds and feeding grounds (Spotila, 2004). During their migratory phases, leatherbacks rarely stop swimming, and individuals have been documented to swim greater than 13,000 km (7,015 nmi) per year (Eckert, 1998; Eckert, 1999).

Leatherback nesting beaches are found around the world, with the largest nesting colony in South America along the coast of French Guiana (Ferraroli et al., 2004). Here, roughly 6,000 adult females nest on beaches from Trinidad to French Guiana each year. The second largest nesting colony is in Gabon, West Africa with 4,300 females per year (Spotila, 2004). The eastern Pacific coast of Mexico, particularly Michoacan, Guerrero, and Oaxaca, were once the largest nesting grounds in the Pacific. Today, however, sea turtles do not nest there regularly (NMFS and USFWS, 1998b). The largest colony of eastern Pacific leatherbacks nests in Guanacaste, Costa Rica, where up to 435 females have been recorded in a given year. Western Pacific colonies in Irian Jaya, Papua New Guinea and the Solomon Islands document 1,052 females per year. And the Andaman and Nicobar islands off Thailand in the Indian Ocean see about 1,000 nesting females per year. Small colonies of leatherbacks nest in U.S. waters, primarily on St. Croix in the U.S. Virgin Islands and in Puerto Rico and Florida (Spotila, 2004).

Studies of leatherback turtle movements in the Pacific Ocean indicate that that there may be important migratory corridors and habitats used by the species in the Pacific Ocean (Morreale et al., 1996; Eckert, 1998; 1999). Recent work by Shillinger et al. (2008) confirmed the existence of a persistent migration corridor for leatherbacks spanning from the Pacific coast of Central America across the equator and into the South Pacific. This migratory heading was strongly influenced by ocean currents. Across the Pacific, leatherbacks from Papua New Guinea swim northeast and travel to Monterey Bay, California, where they feed on jellyfish in the upwelling waters (Spotila, 2004).

Leatherback turtles make the deepest dives—the deepest dive recorded was to 1,230 m (4,035 ft) (Hays et al., 2004). Dives of 4 to 78 m (13 to 256 ft) and 78 to 252 m (256 to 827 ft) of longer duration (28 to 48 min) characterize the migratory phases of the leatherback, while shallower dives (<50 m [164 ft]) of shorter duration (<12 min) were typical on the feeding grounds (James et al., 2005). Leatherbacks have been recorded diving for as long as 70 to 80 min, but most dives are no more than 40 min (Sale et al., 2006).

3.2.3.3 Sea Turtle Hearing Capabilities

There are only very limited data on sea turtle sound production and hearing. A few data are available about the mechanism of sound detection by sea turtles, including the pathway by which sound gets to the inner ear and the structure and function of the inner ear (Bartol et al., 1999; Bartol and Musick, 2003; Bartol, 2008; Ketten, 2008). Additional assumptions have been made about sea turtle hearing based on research on terrestrial species. Based on the structure of the inner ear, there is some evidence to suggest that marine turtles primarily hear low frequency sounds, and this hypothesis is supported by the limited amount of physiological data on turtle hearing (e.g., Ketten and Bartol, 2006; Bartol, 2008). A description of the ear and hearing mechanisms can be found in Bartol and Musick (2003) (see also Ketten, 2008). The few studies completed on the auditory capabilities of sea turtles suggest that they could be capable of hearing LF sounds, particularly as adults. These investigations examined adult green, loggerhead, and Kemp's ridley sea turtles (Ridgway et al., 1969; Mrosovsky, 1972; O'Hara and Wilcox, 1990; Bartol et al., 1999). There have been no published studies to date of olive ridley, hawksbill, or leatherback sea turtles (Ridgway et al., 1969; O'Hara and Wilcox, 1990; Bartol et al., 1999).

Ridgway et al. (1969) used airborne and direct mechanical stimulation to measure the cochlear response in three juvenile green sea turtles in air. The study concluded that the maximum sensitivity for one animal was 300 Hz, and for another 400 Hz. At 400 Hz, the turtle's hearing threshold was about 64 dB (re: 20 µPa). At 70 Hz, it was about 70 dB (re: 20 µPa). Sensitivity decreased rapidly in the lower and higher frequencies. From 30 to 80 Hz, the rate of sensitivity declined approximately 35 dB. However, these studies were done in air, up to a maximum of 1 kHz, and thresholds were not meaningful since they only measured responses of the ear; moreover, they were not calibrated in terms of pressure levels.

Perhaps the most important recent work comes from Saryoa Bartol and her colleagues. Bartol et al. (1999) measured the hearing of juvenile loggerhead sea turtles using auditory evoked potentials to LF tone bursts; they found the range of hearing via auditory evoked potentials[10,11] (AEP) to be from at least 250 to 750 Hz. The lowest frequency tested was 250 Hz and the highest was 1,000 Hz.

However, a recent unpublished ONR-funded study provides the underwater hearing range and hearing sensitivity for loggerhead, green, and Kemp’s ridley turtles of different ages (Figure 3-5) (Ketten and Bartol, 2006). The investigators found that all three turtle species detected sounds to as low as 100 Hz (the lower limit of hearing tested but not necessarily the lowest frequency that the animals could hear) while maximum hearing was to 900 Hz. These data support the earlier results of in-air studies cited above. Interestingly, the widest hearing range (to 900 Hz) was in the hatchling loggerheads, the smallest animals tested. There is some evidence from this study that older animals did not detect higher frequencies as well as the hatchlings, a loss that is found in many terrestrial animals and marine mammals as they age. In older animals, the authors found that two year old loggerheads responded (with AEP responses) to sounds from 100 to 700 Hz, while three year old animals responded to sounds from 100 to 400 Hz. Similar age/size range changes were encountered in green sea turtles (Figure 3-5). The juvenile Kemp’s ridley had the narrowest hearing range, from 100 to 500 Hz, with best hearing from 100 to 200 Hz.

Although yet to be published in the peer-review scientific literature, these data are important since they indicate that marine turtles, as suggested by the earlier data, best detect low frequency sounds. There are several caveats on the Ketten and Bartol (2006) data, however. First, as with all AEP-derived data, these data do not necessarily represent the full hearing range or hearing sensitivity of the animals, as would be obtained in behavioral tests where animals are “asked” to respond to a sound and where the complete nervous system is used to process signals. Second, the data on changes with age suggest that results for older and larger animals may be rather different than the younger animals and this may have important consequences for detection, or non-detection, of anthropogenic sounds. Third, while the AEP data are of importance, more comprehensive data on turtle hearing, such as ability to detect signals in the presence of noise and ability to detect signal direction, are of great importance in understanding the behavioral effects of sound on turtles.

One critical question to ask is whether there are sufficient anthropogenic sounds in the normal environment of sea turtles to suggest that hearing might be masked. While there are no masking studies

---

10 Auditory evoked potentials (AEP) are often referred to with the less accurate term “auditory brainstem response” or ABR.

11 AEP is a method in which recordings are made, non-invasively, of the brain response to sound. It is widely used to rapidly assess hearing in new-born humans, and is now being used extensively in studies of animal hearing, including fish, turtles, and marine mammals. The advantages of AEP are that the animal does not have to be trained to make a response (which can take days or weeks) and it can be done on an animal that is not able to move. It is also very rapid and results can be obtained within a few minutes of exposure to noise. The disadvantages are primarily that the AEP only reflects the signal that is in the ear and brain and does not reflect effects of signal processing in the brain that may result in detection of lower signal levels than apparent from measures of AEP. In other words, in a behavioral study the investigator measures the hearing response of animals that have used their brains to process and analyze sounds, and therefore potentially extract more of the signal even in the presence of noise. With AEP, the measure is strictly of the sound that is detectable by the ear, without any of the sophisticated processing provided by the nervous system of any vertebrate. At the same time, AEP does give an excellent indication of basic hearing loss, and is an ideal method to quickly determine if there is hearing loss right after sound exposure when results are compared with those from controls that were not exposed to loud sounds.

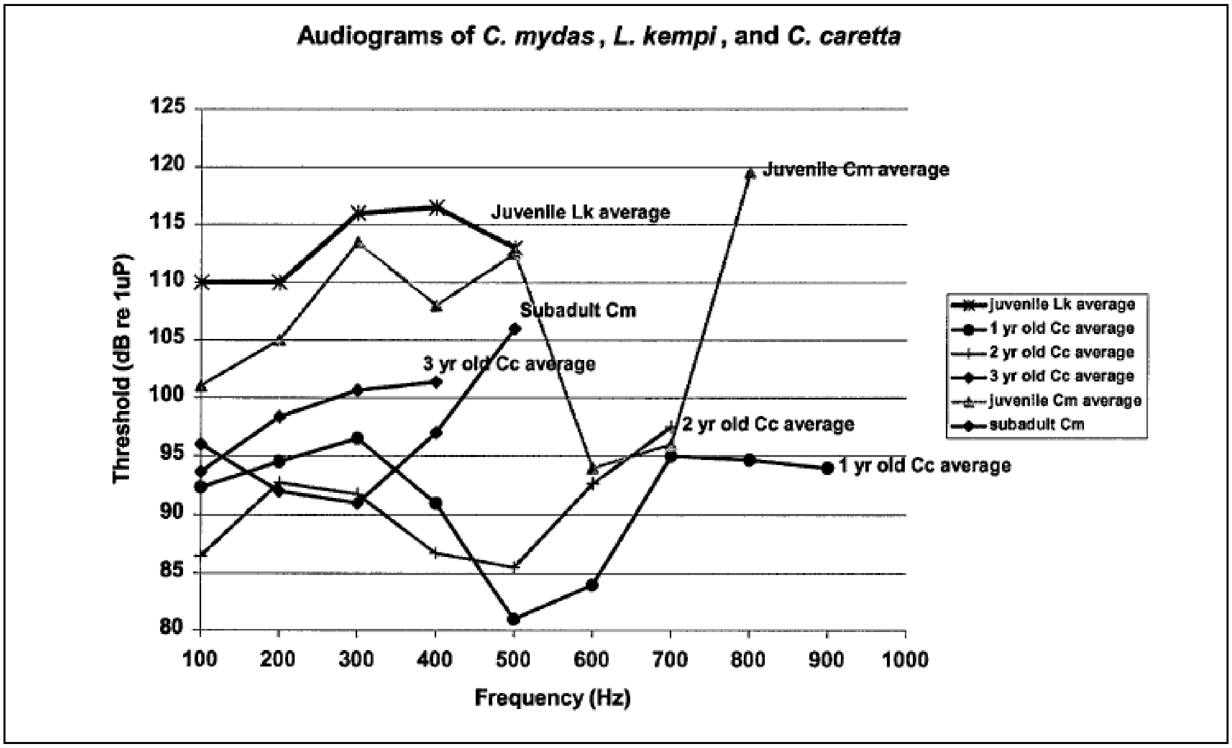


Figure 3-5. Auditory evoked potential audiograms of juvenile Kemp's ridley (Lk), juvenile and subadult green (Cm), and hatchling and juvenile loggerhead (Cc) turtles (Ketten and Bartol, 2006).

on marine turtles, an indirect study looked at the potential for masking by examining sounds in an area known to be inhabited by turtles. These underwater sound recordings were made in one of the major coastal foraging areas for juvenile sea turtles (mostly loggerhead, Kemp's ridley and green sea turtles) in the Peconic Bay Estuary system in Long Island, NY (Samuel et al., 2005). The recording season of the underwater environment coincided with the sea turtle activity season in an inshore area where there is considerable boating and recreational activity, especially during the July to September timeframe. During this time period, RLs at the data collection hydrophone system in the 200 to 700 Hz band ranged from 83 dB (night) up to 113 dB (weekend day). Therefore, during much of the season when sea turtles are actively foraging in New York waters, they are undoubtedly exposed to these levels of noise, most of which is anthropogenic in origin. However, there were no data collected on any behavioral changes in the sea turtles as a consequence of anthropogenic noise or otherwise during this study and so it cannot be stated whether this level of ambient sound would have any physiological and/or behavioral impacts on the turtles.

3.2.3.4 Sea Turtle Sound Production and Acoustic Communication

Very little is known about sound production or use of sound in communication by marine turtles (reviewed in Giles et al., 2009; also see Giles 2005). There is evidence that some species produce sounds when they come onto a beach to mate, but there apparently is no clear evidence for the biological importance of such sounds. More importantly, there are no data on underwater sound production by marine turtles, or use of sound by marine turtles to communicate. The most germane data comes from a recent study of the long-necked freshwater turtle, *Chelodina oblonga* (Giles et al., 2009), and it is not clear if the results of this study have relevance to marine species.

In the study, Giles et al. (2009) found that *Chelodina* produces at least 17 different sounds, and concludes that this species uses sound to communicate since the range of visibility in their aquatic habitats is very limited. The investigators found that call length ranged from less than a tenth of a second to several seconds. All calls contained broad band energy, some starting at 100 Hz and some going to 3.5 kHz. The authors noted some energy in clicks to over 20 kHz (the upper limit of their recording equipment).

Interestingly, this range of frequencies does not overlap well with the hearing range of most turtles studied to date, all of which appear not to hear sounds above about 900 Hz (Bartol, 1999; Ketten and Bartol, 2006). However, there are no hearing data on *Chelodina* and it is possible that this species, which lives in shallow water, would adapt to hearing higher frequency sounds due to the limitations on transmission of lower frequencies in shallow waters (Rogers and Cox, 1988). This would be similar to evolution of higher frequency hearing in freshwater fishes living in shallow water (Popper et al., 2003).

One reason for the ability of Giles et al. (2009) to get data on *Chelodina* is that it lives in shallow freshwater areas. Comparable data are needed on truly marine turtles, and it is not clear that the data from *Chelodina* may give guidance on sound production in marine species. However, these data provide the first quantitative information on sound production in any turtle in an aquatic environment, and suggest that marine species might have evolved use of sounds for communication.

3.2.4 MARINE MAMMALS—CETACEANS

The most abundant order of marine mammals found in the world's oceans is cetaceans (whales, dolphins, and porpoises). Cetaceans spend their entire lives in the aquatic environment and never return to land purposefully. This group varies in distribution and is found in widely diverse variety of aquatic habitats from freshwater rivers to deep ocean waters. Cetaceans are ecologically diverse and range in size from approximately 1 to 33 m (3.3 to 108 ft) in length (Ballance, 2009).

Cetaceans include over 80 species that are classified in two suborders: baleen or mysticete whales and toothed or odontocete whales (also including dolphins and porpoises) (Balance, 2009). Mysticetes are distinguished by their large body size and specialized baleen feeding structures, which are keratinous plates that replace teeth and are used to filter zooplankton (e.g., krill) and small fishes from seawater. In contrast, odontocetes have teeth for feeding and exhibit greater foraging diversity. Both cetacean groups are capable of emitting sound, but only odontocetes emit sound signals, called echolocation, used for locating prey and objects as well as navigating.

The status of cetacean populations is impacted by their biological characteristics and interaction with anthropogenic activity. Many cetacean populations have been reduced by commercial whaling exploitation, incidental mortality, and habitat destruction over the last centuries. The reduction in some cetacean populations has led to the risk of extinction. The ESA, along with the international organizations of CITES and the IUCN, designate a protected status when species at risk of extinction, generally based on natural or manmade factors affecting the continued existence of species. In addition, in the U.S., all marine mammals are protected by the MMPA.

Hearing and sound production is highly developed in all studied cetacean species. Cetaceans rely heavily on sound and hearing for communication and sensing their environment (Norris, 1969; Watkins and Wartzok, 1985; Frankel, 2009). Of all mammals, cetaceans have the broadest acoustic range and the only fully specialized ears adapted for underwater hearing. Little information, however, is available for individual hearing capabilities in most cetacean species (Ketten, 1994 and 2000).

Sound production in cetaceans varies throughout a wide range of frequencies, sound types, and sound levels. The seasonal and geographic variation among cetacean species may also factor into the diversity of cetacean vocalizations. While all functions of sound production are not completely understood, vocalizations are likely used for echolocation, communication, navigation, sensing of the environment, prey location, and orientation in some species (Ellison et al., 1987; George et al., 1989; Tyack and Clark, 2000; Clark and Ellison, 2004; Frankel, 2009).

3.2.4.1 Mysticete Species

The mysticetes that potentially could be affected by SURTASS LFA sonar include four families containing 12 species (Table 3-2). Mysticetes can be distinguished by their large baleen plates and paired blowholes. Baleen whales include the largest animal ever to live on Earth, the blue whale, which can grow to over 30 m (100 ft) in length and 170 tons (154,221 kg) in weight (Bannister, 2009). The status of many mysticete species is considered to be imperiled throughout their worldwide ranges.

All mysticetes produce low frequency sounds, although no direct measurements of auditory (hearing) thresholds have been made for the majority of species as most tests for auditory measurements are impractical in such large animals (Clark, 1990; Richardson et al., 1995; Edds-Walton, 1997; Tyack, 2000; Evans and Raga, 2001). A few species' vocalizations are known to be communication signals but the function of other mysticete low-frequency sounds are not fully understood but likely are used for functions such as orientation, navigation, or detection of predators and prey. Several mysticete species, including the humpback, fin, bowhead, and blue whales, sing or emit repetitous patterned signals or vocalizations (Frankel, 2009). Based on a study of the morphology of cetacean auditory mechanisms, Ketten (1994) hypothesized that mysticete hearing is in the low to infrasonic range. It is generally believed that baleen whales have frequencies of best hearing where their calls have the greatest energy—below 5,000 Hz (Ketten, 2000).

Balaenopteridae (Rorquals)

The family Balaenopteridae contains six whales in two genera: *Balaenoptera* and *Megaptera.* The genus *Balaenoptera* includes the blue, fin, Bryde's, sei, and minke whale species. The genus *Megaptera* includes only one species, the humpback whale. Balaenopterids are also known as "rorquals" because of the large ventral folds or pleats of skin along their throat region that distend when feeding (Bannister, 2009).

- **Blue whale (*Balaenoptera musculus*)**

The blue whale is currently listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered (Antarctic), vulnerable (North Atlantic), and lower risk/conservation dependent (North Pacific) by the IUCN. The global population is estimated between 8,000 to 9,000 individuals (Jefferson et al., 2008), while 1,368 blue whales are estimated to occur in the eastern North Pacific (Carretta et al., 2009), 1,700 blue whales are estimated for the Southern Ocean (Branch et al., 2007), and 424 whales are estimated for the Madagascar Plateau region in the austral summer (Best et al., 2003).

Blue whales are distributed in subpolar to tropical continental shelf and deeper waters of all oceans and migrate between higher latitudes in summer and lower latitudes in winter (Jefferson et al., 2008; Sears and Perrin, 2009). Blue whales in the North Atlantic migrate as far north as Jan Mayen Island and Spitsbergen, Norway, in the summer but during the winter, they may migrate as far south as Florida or Bermuda (Jefferson et al., 2008). In the North Pacific, blue whales can be found as far north as the Gulf of Alaska but are mostly observed in California waters in the summer and Mexican and Central American waters in the winter (Jefferson et al., 2008; Sears and Perrin, 2009). Blue whales are also commonly found in the Southern Ocean (Jefferson et al., 2008).

The swimming and diving behavior of blue whales has been relatively well characterized. The average surface speed for a blue whale is 4.5 km/hr (2.4 kts) but can reach a maximum speed of 45 km/hr (18.9 kts) (Mate et al., 1999; Sears and Perrin, 2009). General dive times range from 4 to 15 min with average depths of 140 m (460 ft) (Croll et al., 2001a; Sears and Perrin, 2009). The longest dive recorded was 36 min (Sears and Perrin, 2009).

There is no direct measurement of the hearing sensitivity of blue whales (Ketten, 2000; Thewissen, 2002). In one of the few studies to date, no change in blue whale vocalization pattern or movements relative to an LFA sound source was observed for RLs of 70 to 85 dB (Aburto et al., 1997). Croll et al. (2001b) studied the effects of anthropogenic low-frequency noise on the foraging ecology of blue and fin whales off San Nicolas Island, California and observed no responses or change in foraging behavior that could be attributed to the low-frequency sounds.

Blue whales produce a variety of LF vocalizations ranging from 10 to 200 Hz (Edds, 1982; Thompson and Friedl, 1982; Alling and Payne, 1990; Clark and Fristrup, 1997; Rivers, 1997; Stafford et al., 1998, 1999a, 1999b, 2001; Frankel, 2009). These low frequency calls may be used as communicative signals (McDonald et al., 1995). Short sequences of rapid FM calls below 90 Hz are associated with animals in social groups (Moore et al., 1999; Mellinger and Clark, 2003). The most typical blue whale vocalizations are infrasonic sounds in the 15 or 17 to 20 Hz range (Sears and Perrin, 2009). The seasonality and structure of the vocalizations suggest that these are male song displays for attracting females and/or competing with other males. At SLs ranging 180 to 190 dB re 1 µPa @ 1 m, blue whale vocalizations are among the loudest made by any animal (Cummings and Thompson, 1971; Aroyan et al., 2000).

Blue whales produce long, patterned hierarchically organized sequences of vocalizations that are characterized as songs. Blue whales produce songs throughout most of the year with a peak period of singing overlapping with the general period of functional breeding. Blue whales also produce a variety of transient sound (i.e., they do not occur in predictable patterns or have much interdependence of probability) in the 30 to 100 Hz band (sometimes referred to as “D” calls). These usually sweep down in frequency or are inflected (up-over-down), occur throughout the year, and are assumed to be associated with socializing when animals are in close proximity (Mellinger and Clark, 2003; Clark and Ellison, 2004).

The call characteristics of blue whales vary geographically and seasonally (Stafford et al., 2001). It has been suggested that song characteristics could indicate population structure (McDonald et al., 2006b). In temperate waters, intense bouts of long, patterned sounds are common from fall through spring, but these also occur to a lesser extent during the summer in high-latitude feeding areas.

- **Fin whale (*Balaenoptera physalus*)**

The fin whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and classified as endangered by the IUCN. The global population estimate is roughly 140,000 whales (Jefferson et al., 2008). In the western North Atlantic, there is an estimated 2,269 whales (Waring et al., 2009), while the population estimated for the central and eastern North Atlantic is 30,000 (IWC, 2009). The eastern North Pacific has an estimated 2,636 whales, and Hawaii has an estimated 174 fin whales (Carretta et al., 2009). The IWC (2009) estimates that 3,200 fin whales exist in West Greenland.

Fin whales are widely distributed in all oceans of the world. They are primarily found in temperate and cool waters. Fin whales migrate seasonally between higher latitudes for foraging and lower latitudes for mating and calving (Jefferson et al., 2008). Specific breeding areas are unknown and mating is assumed to occur in pelagic waters, presumably some time during the winter when the whales are in mid-latitudes. Foraging grounds tend to be near coastal upwelling areas and data indicate that some whales remain year round at high latitudes (Clark and Charif, 1998).

Swimming speeds average between 9.2 and 14.8 km/hr (5 to 8 kts) (Aguilar, 2009). Fin whales dive for a mean duration of 4.2 min at depths averaging 60 m (197 ft) (Croll et al., 2001a; Panigada et al., 2004). Maximum dive depths have been recorded deeper than 360 m (1,181 ft) (Charif et al., 2002). Fin whales forage at dive depths between 100 and 200 m (328 to 656 ft), with foraging dives lasting from 3 to 10 min (Aguilar, 2009).

There is no direct measurement of fin whale hearing sensitivity (Ketten, 2000; Thewissen, 2002). Fin whales produce a variety of LF sounds that range from 10 to 200 Hz (Watkins, 1981; Watkins et al., 1987;

Edds, 1988; Thompson et al., 1992). Short sequences of rapid FM calls from 20 to 70 Hz are associated with animals in social groups (Watkins, 1981; Edds, 1988; McDonald et al., 1995). The most common fin whale vocalization is what is referred to as the "20-Hz signal", which is a low frequency (18 to 35 Hz) loud and long (0.5 to 1.5 sec) patterned sequence signal (Patterson and Hamilton, 1964; Watkins et al., 1987; Clark et al., 2002). The pulse patterns of the 20-Hz signal vary geographically and with seasons (Clark et al., 2002; Croll et al., 2002). Regional differences in vocalization production and structure have been found between the Gulf of California and several Atlantic and Pacific Ocean regions. The 20-Hz signal is common from fall through spring in most regions, but also occurs to a lesser extent during the summer in high-latitude feeding areas (Clark and Charif, 1998; Clark et al., 2002). In the Atlantic region, 20-Hz signals are produced regularly throughout the year. Atlantic fin whales also produce higher frequency downsweeps ranging from 100 to 30 Hz (Frankel, 2009). Estimated SLs of the 20-Hz signal are as high as 180 to 190 dB re 1 µPa @ 1 m (Patterson and Hamilton, 1964; Watkins et al., 1987; Thompson et al., 1992; McDonald et al., 1995; Charif et al., 2002; Croll et al., 2002). Croll et al. (2002) verified the earlier conclusion of Watkins et al. (1987) that the 20-Hz vocalizations are only produced by male fin whales and likely are male breeding displays.

Croll et al. (2001b) studied the effects of anthropogenic low-frequency sound with RLs greater than 120 dB on the foraging ecology and vocalizations of blue and fin whales off San Nicolas Island, California. No obvious responses of either whale species was detected that could be attributable to the anthropogenic low-frequency sounds produced by SURTASS LFA sonar (Croll et al. 2001b).

- **Sei whale (*Balaenoptera borealis*)**

The sei whale is currently listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered by the IUCN. The global population for the sei whale is estimated to be 80,000 whales (Jefferson et al., 2008). The population estimate in Nova Scotian waters is 207 whales (Waring et al., 2009), while the population of the central North Atlantic is estimated as 10,000 whales (Horwood, 2009). In the eastern North Pacific, an estimated 46 whales occur and 77 sei whales are estimated to occur in Hawaiian waters (Carretta et al., 2009).

Sei whales are primarily found in temperate zones of the world's oceans. Like other members of the family Balaenopteridae, sei whales are assumed to migrate to subpolar higher latitudes where they feed during the late spring through early fall, followed by movements to lower latitudes where they breed and calve during the fall through winter (Jefferson et al., 2008). In the North Atlantic, sei whales are located off Nova Scotia and Labrador during the summer and as far south as Florida during the winter (Leatherwood and Reeves, 1983). In the North Pacific, they range from the Gulf of Alaska to California in the east and from Japan to the Bering Sea in the west. Specific breeding grounds are not known for this species.

Sei whales are fast swimmers, surpassed only by blue whales (Sears and Perrin, 2009). Swim speeds have been recorded at 4.6 km/hr (2.5 kts), with a maximum speed of 25 km/hr (13.5 kts) (Jefferson et al., 2008). Dive times range from 0.75 to 15 min, with a mean duration of 1.5 min (Schilling et al., 1992). Sei whales make shallow foraging dives of 20 to 30 m (65 to 100 ft), followed by a deep dive up to 15 min in duration (Gambell, 1985).

There is no direct measurement of the hearing sensitivity of sei whales (Ketten, 2000; Thewissen, 2002). Sei whale vocalizations are the least studied of all the rorquals. Rankin and Barlow (2007) recorded sei whale vocalizations in Hawaii and reported that all vocalizations were downsweeps, ranging from on average from 100.3 to 446 Hz for "high frequency" calls and from 39.4 to 21.0 Hz for "low frequency" calls. In another study, McDonald et al. (2005) recorded sei whales in Antarctica with an average frequency of 433 Hz.

- **Bryde's whale (*Balaenoptera edeni*)**

The Bryde's whale is currently protected under CITES and classified as a data deficient species by the IUCN. There are no global estimates for Bryde's whale. In the western North Pacific, the population of Bryde's whales is estimated by the IWC (2009) as 20,501 whales, while 10,000 whales are estimated in the eastern tropical Pacific (Jefferson et al., 2008). In Hawaiian waters, 493 Bryde's whales have been estimated (Carretta et al., 2009), and in the waters of the Gulf of Mexico, only 15 Bryde's whales are estimated to occur (Waring et al., 2009).

Bryde's whales occur roughly between 40°N and 40°S throughout tropical and warm temperate (>16.3°C [61.3°F]) waters of the Atlantic, Pacific, and Indian Oceans year round (Omura, 1959; Kato and Perrin, 2009). Bryde's whales occur in some semi-enclosed waters such as the Gulf of California, Gulf of Mexico, and East China Sea (Kato and Perrin, 2009). Bryde's whales migrate seasonally toward the lower latitudes near the equator in winter and to high latitudes in summer (Kato and Perrin, 2009). There is some evidence that Bryde's whales remain resident in areas off South Africa and California throughout the year, migrating only short distances (Best, 1960; Tershy, 1992). Bryde's whales are known to breed off South Africa (Best, 1960 and 1975). Foraging grounds are not well known for this species.

Bryde's whales are relatively fast swimming whales. The maximum swim speed reached by a Bryde's whale was recorded at 20 to 25 km/hr (10.8 to 13.5 kts), with average swim speeds reported between 2 and 7 km/hr (1.1 and 3.8 kts) (Kato and Perrin, 2009). Bryde's whales can dive to a water depth of about 300 m but dive durations are not well known (Kato and Perrin, 2009).

There is no direct measurement of the hearing sensitivity of Bryde's whales (Ketten, 2000). Bryde's whales are known to produce a variety of LF sounds ranging from 20 to 900 Hz, with the higher frequencies being produced between calf-cow pairs (Cummings, 1985; Edds et al., 1993). Oleson et al. (2003) reported call types with a fundamental frequency below 60 Hz. These lower frequency call types have been recorded from Bryde's whales in the Caribbean, eastern tropical Pacific, and off the coast of New Zealand. Calves produce discrete pulses at 700 to 900 Hz (Edds et al., 1993). SLs range between 152 and 174 dB re 1 µPa @ 1 m (Frankel, 2009). Although the function of Bryde's whale vocalizations is not known, communication is the assumed purpose.

- **Minke whale (*Balaenoptera acutorostrata*)**

The minke whale is protected under CITES and classified by the IUCN as a least concern (lower risk) species. Populations are estimated at 180,000 in the Northern Hemisphere (Jefferson et al., 2008). Regional stock assessments report approximately 3,312 animals off the Canadian east coast and 806 animals of the coasts of California, Oregon, and Washington (Waring et al., 2009; Carretta et al., 2009). Three stocks of minke whales are recognized in the North Pacific by the International Whaling Commission (IWC). The first stock is the Sea of Japan/East China Sea stock, the second is the western Pacific stock, west of 180°W longitude, and the third is referred to as the "remainder" stock which consists of whales east of 180°W longitude. The NMFS reports that in this remainder area, minke whales are common in the Bering Sea, the Chukchi Sea, and in the Gulf of Alaska, but they are not considered abundant in any other part of the eastern Pacific Ocean. Minke whales are generally found over continental shelf waters; and in the far north, they are believed to be migratory, but appear to have home ranges in the inland waters of Washington and central California (Dorsey et al., 1990). Similar to other balaenopterids, minke whales migrate during late spring through early fall to higher latitudes where they feed, and to lower latitudes where they breed during the fall and winter. Lockyer (1981) recorded average swimming speeds of 6.1 km/hr (3.3 kts). Maximum dive duration in minke whales is 15 min, with an average dive time of 6 to 12 min.

There is no direct measurement of the hearing sensitivity of minke whales (Ketten, 2000; Thewissen, 2002). Minke whales produce a variety of sounds, primarily moans, clicks, downsweeps, ratchets, thump trains, and grunts in the 80 Hz to 20 kHz range (Winn and Perkins, 1976; Thompson et al., 1979; Edds-

Walton, 2000; Mellinger and Clark, 2000; Frankel, 2009). The signal features of their vocalizations consistently include low frequency, short-duration downsweeps from 250 to 50 Hz. Thump trains may contain signature information, and most of the energy of thump trains is concentrated in the 100 to 400 Hz band (Winn and Perkins, 1976; Mellinger et al., 2000). Complex vocalizations recorded from Australian minke whales involved pulses ranging between 50 Hz and 9.4 kHz, followed by pulsed tones at 1.8 kHz and tonal calls shifting between 80 and 140 Hz (Gedamke et al., 2001). The minke whale was identified as the elusive source of the North Pacific "boing" sound during a research cruise off Hawaii (Rankin and Barlow, 2005).

Both geographical and seasonal differences have been found among the sounds recorded from minke whales. Sounds recorded in the Northern Hemisphere, include grunts, thumps, and ratchets from 80 to 850 Hz, and pings and clicks from 3.3 to 20 kHz. Most sounds recorded during the winter consist of 10 to 60 sec sequences of short 100 to 300 microsecond LF pulse trains (Winn and Perkins, 1976; Thompson et al., 1979; Mellinger and Clark, 2000), while Edds-Walton (2000) reported LF grunts recorded during the summer. Recordings in mid- to high latitudes in the Ross Sea, Antarctica, have short sounds, sweeping down in frequency from 130 to 60 Hz over 0.2 to 0.3 sec. Similar sounds with a frequency range from 396 to 42 Hz have been recorded in the Saint Lawrence Estuary (Edds-Walton, 2000). The function of the sounds produced by minke whales is unknown, but they are assumed to be used for communication such as maintaining space among individuals (Richardson et al., 1995).

- **Humpback whale (*Megaptera novaeangliae*)**

The humpback whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and classified as a least concern (lower risk) species by the IUCN. The global population of the humpback whale is estimated to be between 35,000 to 40,000 whales (Jefferson et al., 2008). Stevick et al. (2003) estimated the population of North Atlantic humpback whales to be 11,570 while Øien (2009) estimated 1,059 humpbacks occur in Norwegian waters and the Barents Sea. The stock of humpback whales in the Gulf of Maine is estimated as 847 individuals (Waring et al., 2009). In the north Pacific Ocean, there are an estimated 1,391 whales in the California/Oregon/Washington stock while 394 humpback whales are estimated in the western North Pacific stock (Angliss and Allen, 2009; Carretta et al., 2009). Calambokidis et al. (2008) recently estimated the population of humpback whales in the entire North Pacific as 18,302 individuals.

Humpback whales are distributed throughout the world's oceans, and are only absent from high Arctic and some parts of the equatorial region. They are a highly migratory species that can travel over 8,047 km (4,345 nmi) one way, which is the longest known migration of any mammal (Jefferson et al., 2008). The whales travel to high latitudes in the spring for feeding and to the tropics in the winter for calving and breeding. Humpback whales are found in coastal shelf waters when feeding and close to islands and reefs when breeding (Clapham, 2009). Data indicate that not all animals migrate during the fall from summer feeding to winter breeding sites and that some whales remain year round at high latitudes (Christensen et al., 1992; Clapham et al., 1993).

Barco et al. (2002) reported on humpback whale population site fidelity in the waters off the U.S. Mid-Atlantic States. Individual whales have shown a strong fidelity to specific feeding grounds, including the Gulf of Maine, Newfoundland/Labrador, the Gulf of Saint Lawrence, Greenland, Iceland, and Norway. Humpback whales migrate from their feeding grounds to a winter breeding range in the West Indies. The majority of whales engage in this seasonal migration, but some whales have also been observed in the high latitudes during winter (Barco et al., 2002).

Humpback whales have well-defined breeding areas in tropical waters that are usually located near isolated islands. In the North Atlantic, there are breeding areas near the West Indies and Trinidad in the west, and the Cape Verde Islands and off northwest Africa in the east. In the North Pacific, there are breeding grounds around the Mariana Islands, Bonin, Ogasawara, Okinawa, Ryukyu Island, and Taiwan

(Clapham, 2009). In the eastern North Pacific, breeding grounds occur around the Hawaiian Islands, off the tip of Baja California, and off the Revillagigedo Islands (Clapham, 2009).

Humpback whales travel long distances, with mean swim speeds near 4.5 km/hr (2.4 kts) (Gabriele et al., 1996). Dive times recorded off southeast Alaska are near 3 to 4 min in duration (Dolphin, 1987). In the Gulf of California, humpback whale dive times averaged 3.5 min (Strong, 1990). The deepest recorded humpback dive was 240 m (790 ft), with most dives between 60 and 120 m (197 to 394 ft) (Hamilton et al., 1997).

No direct measurements of the hearing sensitivity of humpback whales exist (Ketten, 2000; Thewissen, 2002). Due to this lack of auditory sensitivity information, Houser et al. (2001) developed a mathematical function to describe the frequency sensitivity by integrating position along the humpback basilar membrane with known mammalian data. The results predicted the typical U-shaped audiogram with sensitivity to frequencies from 700 Hz to 10 kHz with maximum sensitivity between 2 to 6 kHz. Humpback whales have been observed reacting to LF industrial noises at estimated RLs of 115 to 124 dB (Malme et al., 1985). They have also been observed to react to conspecific calls at RLs as low as 102 dB (Frankel et al., 1995).

Humpbacks produce a great variety of sounds that fall into three main groups: 1) sounds associated with feeding; 2) sounds made within groups on winter grounds; and 3) songs associated with reproduction. These vocalizations range in frequency from 20 to 10,000 Hz. Feeding groups produce distinct repeated sounds ranging from 20 to 2,000 Hz, with dominant frequencies near 500 Hz (Thompson et al., 1986; Frankel, 2009). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al., 1985; Sharpe and Dill, 1997). Feeding sounds were found to have SLs in excess of 175 dB (Thompson, et al., 1986; Richardson et al., 1995). Social sounds in the winter breeding areas are produced by males and range from 50 Hz to more than 10,000 Hz with most energy below 3,000 Hz (Tyack and Whitehead, 1983; Richardson et al., 1995). These sounds are associated with agonistic behaviors from males competing for dominance and proximity to females. They are known to elicit reactions from animals up to 9 km (4.9 nmi) away (Tyack and Whitehead, 1983).

During the breeding season, males sing long complex songs with frequencies between 25 and 5,000 Hz. Mean SLs are 165 dB (broadband), with a range of 144 to 174 dB (Payne and Payne, 1971; Frankel et al., 1995; Richardson et al., 1995; Tyack and Clark, 2000). The songs vary geographically among humpback populations and appear to have an effective range of approximately 10 to 20 km (5.4 to 10.8 nmi) (Au et al., 2000). Singing males are typically solitary and maintain spacing of 5 to 6 km (2.7 to 3.2 nmi) from one another (Tyack, 1981; Frankel et al., 1995). Songs have been recorded on the wintering ground, along migration routes, and less often on northern feeding grounds (Richardson et al., 1995).

Gabriele and Frankel (2002) reported that underwater acoustic monitoring in Glacier Bay National Park, Alaska, has shown that humpback whales sing more frequently in the late summer and early fall than previously thought. A song is a series of sounds in a predictable order. Humpback songs are typically about 15 min long and are believed to be a mating-related display performed only by males. This study showed that humpback whales frequently sing while they are in Glacier Bay in August through November. Songs were not heard earlier than August, despite the presence of whales, nor later than November, possibly because the whales had started to migrate. It is possible that song is not as prevalent in the spring as it is in the late summer and fall; however, whales still vocalize at this time. The longest song session was recorded in November and lasted almost continuously for 4.5 hours, but most other song sessions were shorter. The songs in Hawaii and Alaska were similar within a single year. The occurrence of songs possibly correlates to seasonal hormonal activity in male humpbacks prior to the migration to the winter grounds.

Balaenidae (Right and Bowhead Whales)

The family Balaenidae is comprised of four species that are classified in two genera. Three species are included in the genus *Eubalaena*: North Atlantic right whale (*Eubalaena glacialis*), North Pacific right whale (*E. japonica*), and southern right whale (*E. australis*), while only one species, the bowhead whale, is included in the genus *Balaena*. These large baleen whales lack a dorsal fin or ridge, move more slowly than other whales, and are found in cold temperate to arctic waters.

- **Bowhead whale (*Balaena mysticetus*)**

Until recently, five stocks of bowhead whales were recognized for management purposes: Spitsbergen, Davis Strait, Hudson Bay, Okhotsk Sea, and Bering-Chukchi-Beaufort Seas (or western Arctic) stocks (Rugh et al., 2003). However, recent genetic, tagging, and population-survey research indicates that the Davis Strait and Hudson Bay stocks should be classified as the same stock (Heide-Jørgensen et al., 2006; Allen and Angliss, 2010). Only the Okhotsk Sea stock of bowhead whales is located in a region where SURTASS LFA sonar operations potentially may be conducted. Currently, bowheads in the Okhotsk Sea stock do not move beyond the confines of the sea, so this stock remains isolated with no intermingling occurring with the western Arctic stock.

Throughout its range, the bowhead whale is listed under the ESA as endangered and under the MMPA as depleted. While all bowhead stocks are listed on the IUCN Red List, the Okhotsk Sea stock is considered endangered (Reilly et al., 2008). The pre-whaling abundance of bowhead whales in the Sea of Okhotsk is unknown, but Mitchell's (1977) estimate of about 6,500 bowheads is the most commonly used estimate. Currently, there is no reliable abundance estimate for bowhead whales in the Sea of Okhotsk, but the population is considered mature but small, with tentative estimates ranging from 150 to 400 bowhead whales (Reilly et al., 2008; NMFS, 2009; Ivashchenko and Clapham, 2010). The IWC has noted that the Okhotsk Sea stock has shown no significant signs of recovery from whaling exploitation (IWC; 2010).

Bowhead whales are distributed in arctic to sub-arctic waters of the northern hemisphere roughly between 55° and 85°N (Jefferson et al., 2008). Bowheads typically occur in or near sea/pack ice, with their seasonal distribution being strongly influenced by the location of pack ice (Moore and Reeves, 1993). Typically, bowheads move southward in autumn and winter with the advancing ice edge and remain near the ice edge, in polynyas[12], or areas of unconsolidated pack ice. Moving northward in spring and summer, bowheads concentrate on feeding in areas of high zooplankton abundance.

Bowhead whales occur year-round in the Sea of Okhotsk but little is known about their winter distribution or whether seasonal movements occur (Braham, 1984). Today, bowhead whales are found only in the northern Sea of Okhotsk, with the following principal regions of occurrence in the northwestern and northeastern sea: Shantar region (including Academy, Tugurskiy, Ulbanskiy, and Nikolay Bays) to the Kashevarova Bank (located between Sakalin and Iona Islands), Shelikhov Bay, and Gizhiginskaya Bay; formerly, bowhead occurrence ranged as far northward as Penzhinskaya Bay (Braham, 1984; Rice, 1998; Rogachev et al., 2008; Ivashchenko and Clapham, 2010). Bowheads have been observed in the northern sea in January and February; winter sightings so far north have lead to the speculation that some bowheads may spend the winter among the ice (Ivashchenko and Clapham, 2010). By summer and into early fall (June through September), most sightings of bowhead whales have occurred in northwestern Okhotsk Sea in the Shantar region (Rogachev et al., 2008; Ivashchenko and Clapham, 2010). Unlike other regions, bowheads occupy areas that are ice-free during summer in the Sea of Okhotsk (Reilly et al., 2008). In the joint Japanese-Russian summer sighting surveys from 1989 through 2002 across the

12 Polynya=a Russian word that means ice clearing and refers to an area of open water that is surrounded by sea or landfast ice.

entire Okhotsk Sea, including the southern sea, Miyashita et al. (2005) report that no bowhead whales were observed.

Dive behavior of bowhead whales varies widely by season, feeding depth, and life history stage (age and reproductive status) but exhibits no diel pattern (Krutzikowsky and Mate, 2000; Thomas et al., 2003; Heide-Jorgensen et al., 2003). Bowheads are excellent divers, capable of remaining submerged for 61 minutes and diving to depths as deep as 416 m (1,365 ft) (Krutzikowsky and Mate, 2000; Heide-Jorgensen et al., 2003). The majority of bowhead dives appear to be shallow and short dives, at depths ≤16 m (53 ft) for a mean duration of 6.9 to 14.1 minutes (Krutzikowsky and Mate, 2000). Heide-Jorgensen et al. (2003) reported that fewer than 15% of all recorded bowhead dives were to depths greater than 152 m and only 5% of the dives lasted more than 24 minutes. Averaging about 1.1 to 5.8 km/hr (0.6 to 3 kts), bowhead whales are fairly slow swimmers (Mate et al., 2000). They can, however, travel vast distances, with one tagged bowhead whale having traveled 3,386 km (1,828 nmi) in 33 days at an overall swim speed of 5 km/hr (2.7 kts) (Mate et al. 2000).

Knowledge of mysticete hearing is very limited. No direct physiological or behavioral measurements of bowhead whale hearing have been made (Ketten, 1997). Norris and Leatherwood (1981) described the unique auditory morphology of the bowhead whale and determined that bowhead whales are adapted to hear frequencies ranging from high infrasonic to low ultrasonic. Mysticete hearing sensitivity is often inferred from behavioral responses to sound and from the vocalization ranges a species uses. Richardson (1995) estimated from observations of behavioral reactions that mysticete whales likely hear sounds predominantly in the 50 to 500 Hz range, while Ketten (2000) reported that baleen whales likely have best hearing in the frequency range where their vocalizations have the greatest energy, below 5 kHz.

Bowhead whales produce a variety of vocalizations that Frankel (2009) classifies in two principal groups: simple low frequency, frequency-modulated (FM) calls, and complex calls. The FM calls, or moans, are always less than 400 Hz, typically have a duration of 2.5 seconds, and are typified by up-and down-swept, constant FM contours (Au and Hastings, 2008; Frankel, 2009). Cummings and Holliday (1987) measured the source level of bowhead moans at a mean of 177 dB re 1 µPa @ 1 m. The complex calls are a combination of pulsed, pulsed-tonal, and high calls; high calls have frequencies >400 Hz and sound like a whine, while the pulsed tonal call is both FM and amplitude modulated (AM), and the pulsed call is often <400 Hz but can range to 1,000 Hz with a mixture of pulsed AM and FM pulses (Frankel, 2009). The pulse modulated call has been described as a gargle type sound with a measured peak source level between 152 to 169 dB re 1 µPa @1 m (Cummings and Holliday, 1987).

Bowheads also emit sequential sounds with repeatable phrases or patterned signals that can be classified as songs; bowhead whales were the second mysticete whale species discovered to produce songs (Au and Hastings, 2008). Bowhead whales sing one to two themes with the songs changing substantially seasonally and annually (Frankel, 2009; Tervo et al., 2009). Bowhead singing has now been recorded in spring, fall, and winter and may be associated with seasonal movements but also courtship behavior (Delarue et al., 2009; Tervo et al., 2009). Previously, recordings have indicated that the same basic song version with considerable individual variability is sung during a year by all bowhead whales in a population or region but more recently, Stafford et al. (2008) and Delarue et al. (2009) have recorded two songs being sung at a given time. Songs are composed of FM and AM components with great variation in tone (Frankel, 2009). Cummings and Holliday (1987) reported that the mean duration of a song was 66.3 seconds, but song bouts, or the repetition of the same song, can last for hours (Delarue et al., 2009). Several purposes for bowhead vocalizations have been suggested including communication and group cohesion. Bowhead whales may also use the reverberation of their calls off surface ice to assess ice conditions (location and smoothness) to avoid collisions with thick ice keels or to locate smooth ice that is thin enough to break through to breathe (George et al., 1989).

- **North Atlantic right whale (*Eubalaena glacialis*)**

The North Atlantic right whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered under the IUCN. The eastern North Atlantic right whale stock has not recovered over the last century and is considered extirpated (Waring et al., 2009). The western North Atlantic stock is extremely endangered with the best abundance estimated for 2008 as 438 individual individuals (NARWC, 2009). Critical habitat for this species is designated under the ESA in two geographic locations off the eastern U.S.: 1) Southeast U.S. coastal waters between southern Georgia and northern Florida; 2) Northeastern U.S. waters of the Great South Channel (and southern Gulf of Maine) and Cape Cod and Massachusetts Bays (NOAA, 1994).

North Atlantic right whales are found in temperate to subpolar waters of the North Atlantic Ocean (Jefferson et al., 2008). They are most commonly found around coastal and continental shelf waters of the western North Atlantic from Florida to Nova Scotia (Kenney, 2009). From late fall to early spring, right whales breed and give birth in temperate shallow areas, and then migrate into higher latitudes where they feed in coastal waters during the late spring and summer. Right whales have been known to occasionally move offshore into deep water, presumably for feeding (Mate et al., 1997). North Atlantic right whales calve between the northeast coast of Florida and southeastern Georgia and forage in the Bay of Fundy (IFAW, 2001; Vanderlaan et al., 2003).

Mate et al. (1997) studied satellite-monitored movements of North Atlantic right whales in the Bay of Fundy. Of the nine whales tracked, six whales left the Bay of Fundy at least once and had an average speed of 3.5 km/hr (1.9 kts), while those that remained in the Bay of Fundy had a swim speed average of 1.1 km/hr (0.6 kts). The three whales that did not leave the Bay of Fundy still traveled more than 2,000 km (1,080 nmi) before returning to their original tagging area. All of these whales were in or near shipping lanes and moved along areas identified as right whale habitat (Mate et al., 1997). Baumgartner and Mate (2003) studied diving behavior of foraging North Atlantic right whales in the lower Bay of Fundy and found that the average foraging dive time was 12.2 min, with a maximum dive of 16.3 min. The average dive depth for foraging dives was 121 m (398 ft), with a maximum depth of 174 m (571 ft). However, the maximum dive depth recorded by North Atlantic right whales was 306 m (1,000 ft) (Mate et al., 1992).

No direct measurements of the hearing sensitivity of right whales exist (Ketten, 2000; Thewissen, 2002). However, thickness or width measurements of the basilar membrane suggest their hearing range is 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2007). North Atlantic right whales produce LF moans with frequencies ranging from 70 to 600 Hz (Vanderlaan et al., 2003). Lower frequency sounds characterized as calls are near 70 Hz. Broadband sounds have been recorded during surface activity and are termed “gunshot slaps” (Clark, 1982; Matthews et al., 2001). Parks and Tyack (2005) describe North Atlantic right whale vocalizations from surface active groups (SAGs) recorded in the Bay of Fundy, Canada. The call-types defined in this study included screams, gunshots, blows, up calls, warbles, and down calls and were from 59 whale sounds measured at ranges between 40 and 200 m (31 to 656 ft), with an average distance of 88 m (289 ft). The SLs for the sounds ranged from 137 to 162 dB for tonal calls and 174 to 192 dB for broadband gunshot sounds.

- **North Pacific right whale (*Eubalaena japonica*)**

The North Pacific right whale is listed as endangered under the ESA, depleted under the MMPA, and protected under CITES. The North Pacific right whale is also classified as endangered under the IUCN. There are no reliable population estimates for the North Pacific right whale, but it is estimated that there are no more than a few hundred North Pacific right whales in the North Pacific Ocean (Angliss and Allen, 2009).

The North Pacific right whale is not a very well known species because there are so few left. This whale population is primarily sighted in the Sea of Okhotsk and the eastern Bering Sea (Jefferson et al., 2008). Passive acoustics and satellite tracking led to the observation of 17 individuals in the eastern Bering Sea in 2004 (Wade et al., 2006). They are often found in continental shelf waters to oceanic waters. Breeding grounds for this species are unknown. From historic records, North Pacific right whales were recorded in offshore waters with a northward migration in the spring and southward migration in autumn (Jefferson et al., 2008). There is no swim speed or dive information available for the North Pacific right whale.

There is no direct measurement of the hearing sensitivity of right whales (Ketten, 2000; Thewissen, 2002). However, thickness measurements of the basilar membrane of North Atlantic right whale suggests a hearing range from 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2007); this same range can be used as a proxy for North Pacific right whales. McDonald and Moore (2002) studied the vocalizations of North Pacific right whales in the eastern Bering Sea using autonomous seafloor-moored recorders. This study described five vocalization categories: up calls, down-up calls, down calls, constant calls, and unclassified vocalizations. The up call was the predominant type of vocalization and typically swept from 90 Hz to 150 Hz. The down-up call swept down in frequency for 10 to 20 Hz before it became a typical up call. The down calls were typically interspersed with up calls. Constant calls were also interspersed with up calls. Constant calls were also subdivided into two categories: single frequency tonal or a frequency waver of up and down, which varied by approximately 10 Hz. The down and constant calls were lower in frequency than the up calls, averaging 118 Hz for the down call and 94 Hz for the constant call (McDonald and Moore, 2002).

➢ **Southern right whale (*Eubalaena australis*)**

The southern right whale is listed as endangered under the ESA, depleted under the MMPA, and protected under CITES. The southern right whale is also classified as a least concern (lower risk) species under the IUCN. The population size is estimated to be around 8,000 whales (Jefferson, et al., 2008).

Southern right whales have a circumpolar distribution in the Southern Hemisphere, predominately found off Argentina, South Africa, and Australia (Kenney, 2009). Major breeding areas include southern Australia, southern South America along the Argentine coast, and along the southern coast of South Africa (Croll et al., 1999). There is no swimming or diving information available for the southern right whale.

There is no direct measurement of the hearing sensitivity of right whales (Ketten, 2000; Thewissen, 2002). However, thickness or width measurements of the basilar membrane suggest their hearing range is 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2007). Southern right whales produce a great variety of sounds, primarily in the 50 to 500 Hz range, but they also exhibit higher frequencies near 1,500 Hz (Payne and Payne, 1971; Cummings et al., 1972). "Up" sounds are tonal frequency-modulated calls from 50 to 200 Hz that last approximately 0.5 to 1.5 sec and are thought to function in long-distance contact (Clark, 1983). Tonal downsweeps are also produced by this species. Sounds are used as contact calls and for communication over distances of up to 10 km (5.3 nmi) (Clark, 1980, 1982, 1983). For example, females produce sequences of sounds that appear to attract males into highly competitive mating groups. Maximum SLs for calls have been estimated at 172 to 187 dB (Cummings, et al. 1972; Clark, 1982).

<u>Neobalaenidae</u>

The family Neobalaenidae includes a single known genus and species, the pygmy right whale (*Caperea marginata)*, which is one of the least known baleen whales and the smallest species of all the mysticetes (Kemper, 2009).

➢ **Pygmy right whale (*Caperea marginata*)**

The pygmy right whale is protected under CITES and classified as least concern (lower risk) under IUCN. There are no available data on abundance estimates for this species. Very little is known about the pygmy right whale, as less than 25 sightings of this species have been recorded (Kemper, 2009).

The pygmy right whale is found in the Southern Hemisphere of the Atlantic, Pacific, and Indian oceans, generally north of the Antarctic Convergence (Jefferson et al., 2008). It has been recorded in coastal and oceanic regions, including areas of southern Africa, South America, Australia, and New Zealand. Pygmy right whales occur in Tasmania throughout the year and during the southern winter off South Africa, particularly between False Bay and Algoa Bay (Leatherwood and Reeves, 1983; Evans, 1987). There is some evidence for an inshore movement in spring and summer, but no long-distance migration has been documented. There is no available literature on locations of breeding areas or mating and calving seasons (Ross et al., 1975; Lockyer, 1984; Baker, 1985). Records show this species swims at a speed of 5.4 to 9.4 km/hr (2.9 to 5.1 kts) and dives up to 4 min (Kemper, 2009). There is no information available on the dive depths of pygmy right whales.

There is no direct measurement of the hearing sensitivity of pygmy right whales (Ketten, 2000; Thewissen, 2002). Sounds produced by one solitary captive juvenile were recorded from 60 to 300 Hz (Dawbin and Cato, 1992). This animal produced short thump-like pulses between 90 and 135 Hz with a downsweep in frequency to 60 Hz. No geographical or seasonal differences in sounds have been documented. Estimated SLs were between 153 and 167 dB (Frankel, 2009).

<u>Eschrichtiidae</u>

The family Eschrichtiidae includes a single known genus and species, the gray whale. A highly distinctive species, the gray whale is known to be the most coastal of all the mysticetes (Jones and Swartz, 2009).

- **Gray whale (*Eschrichtius robustus*)**

The gray whale population is divided into two different stocks. The eastern North Pacific stock of gray whales was listed as endangered under the ESA, but was de-listed in 1994. The western North Pacific stock is extremely small and is still listed as endangered by the ESA. Gray whales are protected under CITES and classified as a least concern (lower risk) species under IUCN. The western North Pacific stock was thought to be extinct, but a small group of less than 100 gray whales still remain (Jefferson et al., 2008). The eastern North Pacific stock of gray whales is estimated to be 18,178 whales along the west coast of the United States (Angliss and Allen, 2009).

Gray whales are confined to the shallow coastal waters of the North Pacific and adjacent seas. They are found as far south as the Baja of California in the eastern North Pacific, and to southern China in the western North Pacific (Jefferson et al., 2008). Every year most of the population makes a large north-south migration from high latitude feeding grounds to low latitude breeding grounds. Most gray whales in the eastern Pacific breed or calve during the winter in lagoons of Baja California (Jones and Swartz, 2009). There is no available information on breeding and calving areas of the western North Pacific gray whale.

Swim speeds during migration average 4.5 to 9 km/hr (2.4 to 4.9 kts) and when pursued may reach about 16 km/hr (8.64 kts) (Jones and Swartz, 2009). Gray whales generally are not long or deep divers. Traveling-dive times are 3 to 5 min with prolonged dives from 7 to 10 min, with a maximum dive time of 26 min, and a maximum dive depth recorded at 170 m (557 ft) (Jones and Swartz, 2009).

There are sparse data on the hearing sensitivity of gray whales. Dahlheim and Ljungblad (1990) suggest that free-ranging gray whales are most sensitive to tones between 800 and 1,500 Hz. Migrating gray whales showed avoidance responses at ranges of several hundred meters to LF playback SLs of 170 to 178 dB when the source was placed within their migration path at about 2 km (1.1 nmi) from shore. However, this response did not occur when the source was moved out of their migration path but occurred when the SL increased to duplicate the animals' RL within their migration corridor (Clark et al., 1999).

Gray whales produce a variety of sounds from about 100 Hz, potentially up to 12 kHz (Jones and Swartz, 2009). The most common sounds recorded during foraging and breeding are knocks and pulses in frequencies from <100 Hz to 2 kHz, with most energy concentrated at 327 to 825 Hz (Richardson et al., 1995). Tonal moans are produced during migration in frequencies ranging between 100 and 200 Hz (Jones and Swartz, 2009). A combination of clicks and grunts has also been recorded from migrating gray whales in frequencies ranging below 100 Hz to above 10 kHz (Frankel, 2009). The seasonal variation in the sound production is correlated with the different ecological functions and behaviors of the gray whale. Whales make the least amount of sound when dispersed on the feeding grounds and are most vocal on the breeding-calving ground. The SLs for these sounds range between 167 and 188 dB (Frankel, 2009).

Moore and Clarke (2002) reviewed information on how offshore oil and gas activities, commercial fishing and vessel traffic, and whale watching and scientific research affected gray whales. The underwater noise sources played during these experiments included helicopter overflights, drill ship operations, drilling and production platforms, a semi-submersible drilling rig, and tripping operations. Malme et al. (1984, 1988) also conducted experiments using air gun arrays and single air guns. The gray whales' responses to the noise playback experiments and air gun shots include changes in swimming speed and changes in direction (away from the sound sources) (Malme et al., 1984). Changes in feeding with a resumption of feeding after exposure, changes in call rates and structure, and changes in surface behavior were also observed (Dahlheim, 1987; Malme et al., 1988; Moore and Clarke, 2002).

3.2.4.2 Odontocete Species

The odontocetes evaluated for this SEIS include six families containing over 54 species (Table 3-3). Odontocetes can be distinguished from mysticetes by the presence of functional teeth and a single blowhole. They range in size from the sperm whale at 16 m (52 ft) and 40,823 kg (45 tons) to the harbor porpoise at 1.4 m (4.8 ft) and 50 kg (110 lbs) (Whitehead, 2009; Bjorge and Tolley, 2009).

Odontocetes have a broad acoustic range, with recent hearing thresholds measuring between 400 Hz and 100 kHz (Finneran et al., 2002). Many odontocetes produce a variety of click and tonal sounds for communication and echolocation purposes (Au, 1993). Odontocetes communicate mainly above 1,000 Hz and echolocation signals as high as 150 kHz (Würsig and Richardson, 2009). Little is known about the details of most sound production and auditory thresholds for many species (Frankel, 2009).

<u>Physeteridae</u>

The family Physeteridae includes a single known genus and species, the sperm whale (*Physeter macrocephalus)*, which is the largest of all the odontocete species (Whitehead, 2009).

- **Sperm whale (*Physeter macrocephalus*)**

The sperm whale is currently endangered under the ESA, depleted under the MMPA, classified by IUCN as vulnerable, and classified as protected under CITES .The global population of sperm whales is unknown, but is estimated to be about 360,000 (Jefferson et al., 2008). Estimates were 4,000 for the eastern tropical Pacific (ETP), 76,000 for the northern Pacific, 14,000 for the northern Atlantic, and 1,665 for the northern Gulf of Mexico (Jefferson et al., 2008; Waring et al., 2009).

Sperm whales are primarily found in deeper (>1000 m [3,280 ft]) ocean waters and distributed in polar, temperate, and tropical zones of the world (Reeves and Whitehead, 1997). They have the largest range of all cetaceans, except killer whales (Rice, 1989), but are commonly found near the equator and in the North Pacific (Whitehead, 2009). The migration patterns of sperm whales are not well understood, as some whales show seasonal north-south migrations, and some whales show no clear seasonal migration, especially in the equatorial areas (Whitehead, 2009). The sperm whale has a prolonged breeding season extending from late winter through early summer. In the Southern Hemisphere, the calving season is between November and March (Simmonds and Hutchinson, 1996), although specific breeding and foraging grounds are not well known for this species.

Swim speeds of sperm whales generally range from 2.6 to 4 km/hr (2.2 kts) (Watkins et al., 2002; Whitehead, 2009). Dive durations range between 18.2 to 65.3 min (Watkins et al., 2002). Sperm whales may be the longest and deepest diving mammals with recorded dives to 1,500 m (4,921 ft) (Davis et al, 2007), but stomach content evidence suggests that sperm whales may dive as deep as 3,200 m (10,498 ft) (Clarke, 1976). Foraging dives typically last about 30 to 40 min and descend to depths from 300 to 1,245 m (984 to 4,085 ft) (Papastavrou, 1989; Wahlberg, 2002).

Recent audiograms measured from a sperm whale calf suggest an auditory range of 2.5 to 60 kHz, with best hearing sensitivity between 5 and 20 kHz (Ridgway and Carder, 2001). Measurements of evoked response data from one stranded sperm whale have shown a lower limit of hearing near 100 Hz (Gordon et al., 1996).

Sperm whales produce broadband clicks with energy from less than 100 Hz to 30 kHz (Watkins and Schevill, 1977; Watkins et al., 1985; Goold and Jones, 1995; Weilgart and Whitehead, 1997; Mohl et al., 2000; Madsen et al., 2002; Thode et al., 2002). Regular click trains and creaks have been recorded from foraging sperm whales and may be produced as a function of echolocation (Whitehead and Weilgart, 1991; Jaquet et al., 2001; Madsen et al., 2002). A series of short clicks, termed “codas,” have been associated with social interactions and are thought to play a role in communication (Watkins and Schevill, 1977; Weilgart and Whitehead, 1993; Pavan et al., 2000). Distinctive coda repertoires have shown evidence of geographical variation among female sperm whales (Weilgart and Whitehead, 1997; Whitehead, 2009). SELs of clicks have been measured between 202 and 236 dB (Madsen and Mohl, 2000; Mohl et al., 2000; Mohl et al., 2003; Thode et al., 2002). Mohl et al. (2000) reported results from recordings of sperm whales at high latitudes with a large-aperture array that were interpreted to show high directionality in their clicks, with maximum recorded SLs greater than 220 dB. Mohl et al. (2003) further described the directionality of the clicks and show that the source levels of clicks differ significantly with aspect angle. This is dependent on the direction that the click is projected and the point where the click is received. The maximum SL for any click in these recordings was 236 dB with other independent events ranging from 226 to 234 dB (Mohl et al., 2003).

Zimmer et al. (2005) discuss the three-dimensional beam pattern of regular sperm whale clicks. Regular clicks have several components including a narrow, high-frequency sonar beam to search for prey, a less-directional backward pulse that provides orientation cues, and a low-frequency component of low directionality that conveys sound to a large part of the surrounding water column with a potential for reception by conspecifics at large ranges. The click travel time was used to estimate the acoustic range of the whale during its dives. In this study, the SL of the high-frequency sonar beam in the click was 229 dB (peak value). The backward pulse had an SL of 200 dB (peak value). The low-frequency component immediately followed the backward pulse and had a long duration, with peak frequencies that are depth dependent to over 500 m (1640 ft). Zimmer et al. (2005) propose that the initial backward pulse is produced by the phonic lips and activates air volumes connected to the phonic lips, which generate the low-frequency component. The two dominant frequencies in the low-frequency component indicate either one resonator with aspect-dependent radiation patterns or two resonators with similar volumes at the surface but different volumes at various depths. Most of the energy of the initial backward-directed pulse reflects forward off the frontal sac into the junk and leaves the junk as a narrow, forward-directed pulse. A fraction of that energy is reflected by the frontal sac back into the spermaceti organ to generate higher-order pulses. This forward-directed pulse is well suited for echolocation.

Kogiidae

The family Kogiidae includes two species, the pygmy (*Kogia breviceps*) and dwarf (*Kogia sima*) sperm whales (McAlpine, 2009).

- **Pygmy sperm whale *(Kogia breviceps)* and Dwarf sperm whale *(Kogia sima)***

Both the pygmy sperm whale and dwarf sperm whale are listed as data deficient under the IUCN. Abundance estimates of the global population sizes for these species are unknown. However, there are estimates for specific geographic regions. Jefferson et al. (2008) stated that there are an estimated 3,000 pygmy sperm whales off the coast of California, and an estimated 11,000 dwarf sperm whales in the ETP. In the Atlantic, there is an estimated 395 pygmy and dwarf sperm whales, and 453 in the Gulf of Mexico (Waring et al., 2009). Pygmy and dwarf sperm whales are distributed worldwide, primarily in temperate to tropical deep waters. They are especially common along continental shelf breaks (Evans, 1987); Jefferson et al., 2008). Dwarf sperm whales seem to prefer warmer water than the pygmy sperm whale (Caldwell and Caldwell, 1989). Breeding areas for both species include waters off Florida (Evans, 1987). There is little evidence that pygmy and dwarf sperm whales have a seasonal migration pattern (McAlpine, 2009).

Swim speeds vary and were found to reach up to 11 km/hr (5.9 kts) (Scott et al., 2001). In the Gulf of California, *Kogia* spp. have been recorded with an average dive time of 8.6 min, whereas dwarf sperm whales in the Gulf of Mexico exhibited a maximum dive time of 43 min (Breese and Tershy, 1993; Willis and Baird, 1998).

There are sparse data on the hearing sensitivity for pygmy sperm whales. An ABR study on a rehabilitating pygmy sperm whale indicated that this species has an underwater hearing range that is most sensitive between 90 and 150 kHz (Carder et al., 1995; Ridgway and Carder, 2001). No hearing measured hearing data are available for the dwarf sperm whale. Recent recordings from captive pygmy sperm whales indicate that they produce sounds between 60 and 200 kHz with peak frequencies at 120 to 130 kHz (Santoro et al., 1989; Carder et al., 1995; Ridgway and Carder, 2001). Echolocation pulses were documented with peak frequencies at 125 to 130 kHz (Ridgway and Carder, 2001). Thomas et al. (1990) recorded an LF swept signal between 1.3 to 1.5 kHz from a captive pygmy sperm whale in Hawaii. Jérémie et al. (2006) reported frequencies ranging from 13 to 33 kHz for dwarf sperm whale clicks with durations of 0.3 to 0.5 sec. No geographical or seasonal differences in sounds have been documented. Estimated source levels were not available.

Ziphiidae (Beaked Whales)

The family Ziphiidae contains 21 species of whales in five genera (Mead, 2009a) (Table 3-3). Ziphiidae are protected under the MMPA. The northern and southern bottlenose whales are the only two species in the Ziphiidae family protected under Appendix I of CITES. All species of beaked whales are considered data deficient by the IUCN except the southern bottlenose whale and Cuvier's beaked whale, which are classified as least concern.

- **Baird's beaked whale *(Berardius bairdii)* and Arnoux's beaked whale *(Berardius arnuxii)***

Both the Baird's and Arnoux's beaked whales are currently classified as data deficient under the IUCN. Abundance estimates of the global population size for either species are unknown. The abundance of both species has been estimated as 5,029 whales off the Pacific coast of Japan, 1,260 whales in the eastern Sea of Japan, and 660 in the southern Sea of Okhotsk (Kasuya, 2009). Baird's beaked whale population numbers are estimated at 1,100 in the eastern North Pacific, including 540 Baird's beaked whales in the waters of Washington, Oregon, and California (Jefferson et al., 2008; Caretta et al., 2009).

Baird's beaked whales occur in the North Pacific, including the Bering and Okhotsk seas (Kasuya, 1986 and 2009). Arnoux's beaked whales are distributed in waters surrounding Antarctica, northern New Zealand, South Africa, and southeast Australian. Both species inhabit deep water and appear to be most abundant at areas of steep topographic relief such as shelf breaks and seamounts (Dohl et al., 1983; Kasuya, 1986; Leatherwood et al., 1988). Baird's beaked whales were documented as having an inshore-offshore movement off California beginning in July and ending in September to October (Dohl et al., 1983). Ohizumi et al. (2003) reported that Baird's beaked whales migrate to the coastal waters of the western North Pacific and the southern Sea of Okhotsk in the summer. No data are available to confirm seasonal migration patterns for Arnoux's beaked whales, and no data are available for breeding and calving grounds of either species.

Few swim speed data are available for any beaked whale species. Baird's beaked whales were recorded diving between 15 and 20 min, with a maximum dive duration of 67 min (Barlow, 1999; Kasuya, 2009). In a recent study, a Baird's beaked whale in the western North Pacific had a maximum dive time of 64.4 min and a maximum depth of 1,777 m (5,830 ft). It was also found that one deep dive (>1,000 m [3,280 ft]) was followed by several intermediate dives (100 to 1,000 m [328 to 3,280 ft]) (Minamikawa et al., 2007). Arnoux's beaked whales have a dive time ranging from 10 to 65 min and a maximum of 70 min when diving from narrow cracks or leads in sea ice near the Antarctic Peninsula (Hobson and Martin, 1996). No dive depths are available for Arnoux's beaked whale.

There is no direct measurement of auditory threshold for the hearing sensitivity of either Baird's or Arnoux's beaked whales (Ketten, 2000; Thewissen, 2002). Baird's beaked whales have been recorded producing HF sounds between 12 and 134 kHz with dominant frequencies between 23 to 24.6 kHz and 35 to 45 kHz (Dawson et al., 1998). Arnoux's beaked whales were recorded off Kemp Land, Antarctica, producing sounds between 1 and 8.7 kHz (Rogers and Brown, 1999). Both species produced a variety of sounds, mainly burst-pulse clicks and FM whistles. The functions of these signal types are unknown. Clicks and click trains were heard sporadically throughout the recorded data, which may suggest that these beaked whales possess echolocation abilities. There is no available data regarding seasonal or geographical variation in the sound production of these species. Estimated SLs are not documented.

- **Shepherd's beaked whale (*Tasmacetus shepherdi*)**

The Shepherd's beaked whale is currently classified as a data deficient species by IUCN. Abundance estimates of this species are not available. Shepherd's beaked whales are distributed in cold temperate to polar seas of the Southern Hemisphere including the waters of Antarctica, Brazil, Galapagos Islands, New Zealand, Argentina, Australia, and the South Sandwich Islands (Mead, 2009b). No data are available to confirm seasonal migration patterns for Shepherd's beaked whales, and there are no known breeding or calving grounds.

No data are available on swim speeds, dive times, or dive depths for Shepherd's beaked whales. There is no direct measurement of auditory threshold for the hearing sensitivity of Shepherd's beaked whales (Ketten, 2000; Thewissen, 2002). No data are available on sound production for this species.

- **Cuvier's beaked whale (*Ziphius cavirostris*)**

Cuvier's beaked whale is currently classified as a least concern (lower risk) species by the IUCN. Global population estimates for this species are unknown. Abundances of Cuvier's beaked whales are estimated for the ETP as 20,000 individuals while 90,000 whales are estimated in the eastern North Pacific (Barlow, 1995). Off the U.S. West Coast (CA/OR/WA), 2,830 Cuvier's have been estimated to occur while 12,728 individuals are estimated for Hawaiian EEZ waters (Caretta et al., 2009). The best abundance estimate for pooled beaked whales in the western North Atlantic is 3,513 individuals while 65 Cuvier's are estimated in the northern Gulf of Mexico (Waring et al., 2009).

Cuvier's beaked whales are widely distributed in oceanic tropical to polar waters of all oceans except the high polar areas (Heyning and Mead, 2009). This species is also found in enclosed seas such as Gulf of Mexico, Gulf of California, Caribbean Sea, Mediterranean Sea, Sea of Japan, and the Sea of Okhotsk (Omura et al., 1955; Jefferson et al., 2008). The Cuvier's beaked whale is the most cosmopolitan of all beaked whale species. The Cuvier's apparently prefers waters over the continental slope. No data on breeding and calving grounds are available.

Swim speeds of Cuvier's beaked whale have been recorded between 5 and 6 km/hr (2.7 and 3.3 kts) (Houston, 1991). Dive durations range between 20 and 87 min with an average dive time near 30 min (Heyning, 1989; Jefferson et al., 1993; Baird et al., 2004). This species is a deep diving species and can reach depths of 1,888 m (6,194 ft) (Heyning and Mead, 2009).

There is no direct measurement of auditory threshold for the hearing sensitivity of Cuvier's beaked whales (Ketten, 2000; Thewissen, 2002). Cuvier's beaked whales were recorded producing HF clicks between 13 and 17 kHz; since these sounds were recorded during diving activity, the clicks were assumed to be associated with echolocation (Frantzis et al., 2002). A more recent study on Cuvier's beaked whale vocalization abilities by Johnson et al. (2004) recorded frequencies of Cuvier's clicks ranging from about 12 to 40 kHz with associated SLs of 200 to 220 dB re 1 µPa @ 1 m (peak-to-peak) (Johnson et al., 2004). Johnson et al. (2004) also found that Cuvier's beaked whales do not vocalize when within 200 m (656 ft) of the surface and only started clicking at an average depth of 475 m (1,558 ft) and stopped clicking on the ascent at an average depth of 850 m (2,789 ft) with click intervals of approximately 0.4 seconds. Zimmer et al. (2005a) also studied the echolocation clicks of Cuvier's beaked whales and recorded a SL of 214 dB re 1 µPa @ 1 m (peak-to-peak). There are no available data regarding seasonal or geographical variation in the sound production of Cuvier's beaked whales.

- **Northern bottlenose whale *(Hyperoodon ampullatus)* and Southern bottlenose whale *(Hyperoodon planifrons)***

The IUCN classifies the status of northern bottlenose whales as data deficient while southern bottlenose whales are currently classified as least concern (lower risk). Both species are also protected under CITES. Abundance estimates of the global populations are unknown. There are an estimated 40,000 northern bottlenose whales in the North Atlantic Ocean, including the Gully, the region southeast of Sable Island, Nova Scotia with an estimated 130 whales, and the Faroe Islands, with over 5,000 northern bottlenose whales estimated (Whitehead et al., 1997). The Scotian Shelf population of northern bottlenose whales was listed as endangered under Canada's Species at Risk Act (SARA). There are an estimated 500,000 southern bottlenose whales south of the Antarctic Convergence, making them the most common beaked whale sighted in Antarctic waters (Jefferson et al., 2008).

The northern bottlenose whale is found only in the cold temperate to subarctic waters of the North Atlantic from New England to southern Greenland and the Strait of Gibraltar to Svalbard (Jefferson et al., 2008). This oceanic species occurs seaward of the continental shelf in waters deeper than 500 m (1,640 ft) (Leatherwood and Reeves, 1983; Jefferson et al., 2008). Northern bottlenose whales are commonly found foraging in the Gully, off the coast of Nova Scotia, Canada (Gowans, 2009). The Scotian Shelf population appears to be non-migratory, unlike other northern bottlenose whale populations. The Labrador population migrates to the southern portion of their range, between New York and the Mediterranean, for the winter months. Calving and breeding grounds are unknown.

Southern bottlenose whales are found south of 20°S, with a circumpolar distribution (Leatherwood and Reeves, 1983; Jefferson et al., 2008). Evidence of seasonal migration shows a northward movement near South Africa in February and southward movement toward the Antarctic in October (Sekiguchi et al., 1993). Calving and breeding grounds are unknown.

General swim speeds for ziphiids average 5 km/hr (2.7 kts) (Kastelein and Gerrits, 1991). Hooker and Baird (1999) documented northern bottlenose whales with regular dives from 120 m (394 ft) to over 800 m (2,625 ft), with a maximum recorded dive depth to 1,453 m (4,770 ft). Dive durations have been recorded close to 70 min. Southern bottlenose whales have been observed diving from 11 to 46 min, with an average duration of 25.3 min (Sekiguchi et al., 1993). Bottlenose whales feed primarily on squid (Gowans, 2009), and the deeper dives of northern bottlenose whales have been associated with foraging behavior (Hooker and Baird, 1999).

There is no direct measurement of hearing sensitivity for bottlenose whales (Ketten, 2000; Thewissen, 2002). Off Nova Scotia, diving northern bottlenose whales produced regular click series (consistent inter-click intervals) at depth with peak frequencies of 6 to 8 kHz and 16 to 20 kHz (Hooker and Whitehead, 1998). Click trains produced during social interactions at the surface ranged in peak intensity from 2 to 4 kHz and 10 to 12 kHz. There is no seasonal or geographical variation documented for the northern bottlenose whale. There are no available data for the sound production of southern bottlenose whales.

- **Longman's beaked whale (*Indopacetus pacificus*)**

Longman's beaked whale, also known as the Indo-Pacific beaked whale, is currently classified as data deficient by IUCN. Global abundance estimates of this species are not available but 760 animals have been estimated in Hawaiian waters (Jefferson et al., 2008).

The distribution of Longman's beaked whale is limited to the Indo-Pacific region (Leatherwood and Reeves, 1983; Jefferson et al., 2008). Recent whale groups sighted in the equatorial Indian and Pacific Oceans off Mexico and Africa have tentatively been identified as Longman's beaked whales (Ballance and Pitman, 1998; Pitman et al., 1998; Pitman, 2009a). No data are available to confirm seasonal migration patterns for Longman's beaked whales. No data on breeding and calving grounds are available.

No data are available on swim speeds or dive depths. Only a small number of dive times have been recorded from this species. Dive duration in the Longman's beaked whale is 11 to 33 min, possibly up to 45 min (Pitman, 2009a). There is no direct measurement of hearing sensitivity for Longman's beaked whales (Ketten, 2000; Thewissen, 2002). No data are available on sound production in this species.

- ***Mesoplodon* species**

Species in the genus *Mesoplodon* are currently classified with a data deficient status by IUCN. The worldwide population sizes for all species of *Mesoplodon* spp. are unknown. However, estimates of 25,300 in the ETP and 250 *Mesoplodon* whales off California have been documented (Wade and Gerrodette, 1993; Barlow, 1995). In addition, minimum population estimates for undifferentiated beaked whales in the western North Atlantic was 3,531 whales (Waring et al, 2009), and an estimate of 1,024 whales was reported in the eastern North Pacific (Carretta et al., 2009).

Mesoplodon whales are distributed in all of the world's oceans except for the cold waters of the Arctic and Antarctic. They are normally found in deep (>2,000 m [6,562 ft]) pelagic water or in continental slope waters. Sowerby's and True's beaked whales are found in the temperate waters of the North Atlantic, and True's is also found in the southern Indian Ocean. Hector's beaked whales, Gray's beaked whales, and Andrew's beaked whales are found in the temperate waters of the Southern Hemisphere. Gervais' beaked whale is found in warm, temperate, and tropical waters of the North Atlantic. Pygmy beaked whales and ginkgo-toothed beaked whales are found in tropical warm waters in the Pacific, and the ginkgo-toothed beaked whale is also found in the tropical waters of the Indian Ocean. Stejneger's beaked whale and Hubb's beaked whale are found in the temperate North Pacific, and the Stejneger's beaked whale can also be found in subarctic waters. Blainville's beaked whales are the most cosmopolitan of the beaked whales and can be found in the Atlantic, Pacific, and Indian oceans in warm temperate and tropical waters (Pitman, 2009b).

Few swim speed data are available for any beaked whale species. Schorr et al. (2009) reported a horizontal swim speed of 0.8 to 1.5 km/hr (0.4 to 0.8 kts) for a Blainville's beaked whales in Hawaii with a maximum rate of 8.1 km/hr. Dives of Blainville's beaked whales average 7.5 min during social interactions at the surface (Baird et al., 2004). Dives over 45 min have been recorded for some species in this genus (Jefferson et al., 1993). Dive depths are variable among species and not well documented. In Hawaii, a Blainville's beaked whale had a maximum dive depth of 1,408 m (4,619 ft), and dive duration from 48 to 68 min (Pitman, 2009b).

Hubb's beaked whale has been recorded producing whistles between 2.6 and 10.7 kHz, and pulsed sounds from 300 Hz to 80 kHz and higher with dominant frequencies from 300 Hz to 2 kHz (Buerki et al., 1989; Lynn and Reiss, 1992). A stranded Gervais' beaked whale had an upper limit for effective hearing at 80 to 90 kHz (Finneran et al., 2009).

In a study of echolocation clicks in Blainville's beaked whales, Johnson et al. (2006) found that the whales make various types of clicks while foraging. The whales have a distinct search click that is in the form of an FM upsweep with a minus 10 dB bandwidth from 26 to 51 kHz (Johnson et al., 2006). They also produce a buzz click that is during the final stage of prey capture, and they have no FM structure with a minus 10 dB bandwidth from 25 to 80 kHz or higher (Johnson et al., 2006).

Studies on Cuvier's beaked whales and Blainville's beaked whales conducted by Johnson et al. (2004) concluded that no vocalizations were detected from any tagged beaked whales when they were within 200 m (656 ft) of the surface. The Blainville's beaked whale started clicking at an average depth of 400 m (1,312 ft), ranging from 200 to 570 m (656 to 1,870 ft), and stopped clicking when they started their ascent at an average depth of 720 m (2,362 ft), with a range of 500 to 790 m (1,640 to 2,591 ft). The intervals between regular clicks were approximately 0.4 second. Trains of clicks often end in a buzz. Both the Cuvier's beaked whale and the Blainville's beaked whale have a somewhat flat spectrum that was accurately sampled between 30 and 48 kHz. There may be a slight decrease in the spectrum above 40 kHz, but the 96 kHz sampling rate was not sufficient to sample the full frequency range of clicks from either of the species (Johnson et al., 2004).

Monodontidae

The family Monodontidae includes the beluga whale*,* also known as the "white whale" (O'Corry-Crowe, 2002).

- **Beluga whale (*Delphinapterus leucas*)**

The beluga is classified as a near threatened species by the IUCN, and the Cook Inlet stock is a listed as endangered under the ESA (Jefferson et al., 2008; NMFS, 2008). Worldwide abundance is estimated near 150,000, with 39,258 in the Beaufort Sea, 3,710 in the eastern Chukchi Sea, 7,986 in the eastern Bering Sea, 18,142 in Norton Sound, 2,877 in Bristol Bay, 375 in Cook Inlet, 28,000 in Baffin Bay, 25,000 in western Hudson Bay, 10,000 in eastern Canada, and over 21,000 in Russian waters, including the Sea of Okhotsk (Jefferson et al., 2008; Angliss and Allen, 2009).

Beluga habitat is found in both shallow and deep water of the north circumpolar region ranging into the subarctic. Belugas inhabit the east and west coasts of Greenland, and their distribution in North America extends from Alaska across the Canadian western arctic to the Hudson Bay (Jefferson et al., 2008). Occasional sightings and strandings occur as far south as the Bay of Fundy in the Atlantic. Belugas tend to summer in large groups in bays, shallow inlets, and estuaries. Possible reasons include warmer water in the shallow areas, and availability of anadromous fish, such as salmon, capelin, and smelt which are highly abundant in those areas during the summer months (O'Corry-Crowe, 2009). In the Pacific, migratory belugas summer in the Okhotsk, Chukchi, Bering, and Beaufort seas, the Anadyr Gulf, and waters off Alaska (Jefferson et al., 2008; Waring et al., 2009). One of the Alaska stocks of beluga whales, the Cook Inlet stock, resides there year-round and is geographically isolated from all other stocks (Hansen and Hubbard, 1999; Rugh et al., 2000). Little is known about the distribution of beluga whales in the winter, but it is believed that the whales migrate in the direction of the advancing ice front and overwinter near "polynyas" (O'Corry-Crowe, 2009).

The beluga is not a fast swimmer, with maximum swim speeds estimated between 16 and 22 km/hr (8.6 and 11.9 kts) and a steady swim rate in the range of 2.5 to 3.3 km/hr (1.3 to 1.8 kts) (Brodie, 1989; O'Corry-Crowe, 2009). Studies on diving capabilities of trained belugas in open ocean conditions by Ridgway et al. (1984) demonstrated a capacity to dive to depths of 647 m (2,123 ft) and remain submerged for up to 15 min. Most dives fall into either of two categories: shallow surface dives or deep dives. Shallow dive durations of belugas are less than 1 min. Deep dives last for 9 to 18 min, and dive depths range between 300 and 600 m (984 and 1,968 ft). In deep waters beyond the continental shelf, belugas may dive in excess of 1,000 m (3,281 ft), remaining submerged for up to 25 min (O'Corry-Crowe, 2009).

Belugas have hearing thresholds approaching 42 dB RL at their most sensitive frequencies (11 to 100 kHz) with overall hearing sensitivity from 40 Hz to 150 kHz (Awbrey et al., 1988; Johnson et al., 1989; Au, 1993; Ridgway et al., 2001). Awbrey et al. (1988) measured hearing thresholds for three captive belugas between 125 Hz and 8 kHz. They found that the average threshold was 65 dB RL at 8 kHz. Below 8 kHz, sensitivity decreased at approximately 11 dB per octave and was 120 dB RL at 125 Hz. A study by Mooney et al. (2008) found that belugas had a more sensitive hearing threshold than previously thought. The studied whale had a hearing threshold below 60 dB re 1 µPa between 32 and 80 kHz and below 70 db at 11.2 and 90 kHz. (Mooney et al., 2008).

Belugas produce tonal calls or whistles in the 260 Hz to 20 kHz range and a variety of call types in the 100 Hz to 16 kHz range. Echolocation clicks extend to 120 kHz (Schevill and Lawrence, 1949; Sjare and Smith 1986; O'Corry-Crowe, 2009). There are 50 different call types, including "groans," "whistles," "buzzes," "trills" and "roars" (O'Corry-Crowe, 2009). Beluga whales are commonly most vocal during milling and social interactions (Karlsen et al., 2002). Predominant echolocation frequencies are bimodal for this species and occur in ranges of 40 to 60 kHz and 100 to 120 kHz at SLs between 206 and 225 dB (Au, 1993; Au et al., 1987). There is supportive evidence of geographical variation from distinctive calls used for individual recognition among beluga whales (Belkovich and Shekotov, 1993).

Delphinidae

- **Killer whale (*Orcinus orca*)**

The killer whale is classified as a data deficient species under the IUCN. On 18 November 2005, the NMFS published a final determination to list the Southern Resident killer whales (*Orcinus orca*) distinct population segment (DPS) as endangered under the ESA, which was effective in 2005 (NOAA, 2005a). Critical habitat has been designated for the Southern Resident killer whales in the inland marine waters of Washington (Puget Sound, Strait of Juan de Fuca, and Haro Strait) (NOAA, 2006c).

Although no current global population estimates are available, Reeves and Leatherwood (1994) estimated the killer whale worldwide abundance near 100,000 individuals. An abundance of 8,500 killer whales was estimated for the waters of the ETP, while 445 and nearly 80,000 killer whales are estimated for northern Norwegian waters and south of the Antarctic Convergence Zone, respectively (Wade and Gerrodette, 1993; Jefferson et al., 2008). In U.S. Atlantic waters, 49 killer whales are estimated to occur in the northern Gulf of Mexico but no abundance could be estimated for the western north Atlantic stock (Waring et al., 2009). In the Eastern North Pacific killer whale stock, as many as 353 Offshore, 86 Southern Resident, 1,123 Alaska Resident, 216 Northern Resident, 249 Alaska Transient, 7 AT1 Transient, and 314 West Coast Transient killer whales have been estimated in these sub-stocks (Angliss and Allen, 2009; Carretta et al., 2009). About 430 killer whales currently are estimated in the Hawaiian stock (Carretta et al., 2009). Resident killer whales occur in large pods with roughly 10 to 60 members. Resident killer whales in the North Pacific consist of the southern, northern, southern Alaska (which includes southeast Alaska and Prince William Sound whales), western Alaska, and western North Pacific groups (NOAA, 2005a).

The killer whale is perhaps the most cosmopolitan of all marine mammals, found in all the world's oceans from about 80°N to 77°S, especially in areas of high productivity and in high latitude coastal areas (Leatherwood and Dahlheim, 1978; Ford, 2009). However, they appear to be more common within 800 km (430 nmi) of major continents in cold-temperate to subpolar waters (Mitchell, 1975).

Swimming speeds usually range between 6 to 10 km/hr (3.2 to 5.4 kts), but they can achieve speeds up to 37 km/hr (20 kts) in short bursts (Lang, 1966; LeDuc, 2009). In southern British Columbia and northwestern Washington State, killer whales spend 70% of their time in the upper 20 m (66 ft) of the water column, but can dive to 100 m (330 ft) or more with a maximum recorded depth of 201 m (660 ft) (Baird et al., 1998). The deepest dive recorded by a killer whale is 265 m (870 ft), reached by a trained individual (Ridgway, 1986). Dive durations range from 1 to 10 min (Norris and Prescott, 1961; Lenfant, 1969; Baird et al., 1998).

Killer whales hear underwater sounds in the range of <500 Hz to 120 kHz (Bain et al., 1993; Szymanski et al., 1999). Their best underwater hearing occurs between 15 and 42 kHz, where the threshold level is near 34 to 36 dB RL (Hall and Johnson, 1972; Szymanski et al., 1999). Killer whales produce sounds as low as 80 Hz and as high as 85 kHz with dominant frequencies at 1 to 20 kHz (Schevill and Watkins, 1966; Diercks et al., 1971, 1973; Evans, 1973; Steiner et al., 1979; Awbrey et al., 1982; Ford and Fisher, 1982; Ford, 1989; Miller and Bain, 2000). An average of 12 different call types (range 7 to 17)—mostly repetitive discrete calls—exist for each pod (Ford, 2009). Pulsed calls and whistles, called dialects, carry information hypothesized as geographic origin, individual identity, pod membership, and activity level. Vocalizations tend to be in the range between 500 Hz and 10 kHz and may be used for group cohesion and identity (Ford, 2009; Frankel, 2009). Whistles and echolocation clicks are also included in killer whale repertoires, but are not a dominant signal type of the vocal repertoire in comparison to pulsed calls (Miller and Bain, 2000). Erbe (2002) recorded received broadband sound pressure levels of orca burst-pulse calls ranging between 105 and 124 dB RL at an estimated distance of 100 m (328 ft).

- **False killer whale (*Pseudorca crassidens*)**

False killer whales are classified as least concern (lower risk) by the IUCN. In November 2010, the insular Hawaiian population of the false killer whale was proposed for listing as endangered under the ESA due to the determination of the population as a DPS (NOAA, 2010). The global population for this species is unknown. Estimates of 39,800 whales have been documented in the ETP (Wade and Gerrodette, 1993). In the northwestern Pacific, an estimate of near 17,000 has been documented (Miyashita, 1993), with 123 false killer whales estimated in the Hawaii Insular population (Carretta et al., 2010). In the Gulf of Mexico, there are an estimated 777 false killer whales (Waring et al., 2009).

False killer whales are found in tropical to warm temperate zones in deep, offshore waters (Stacey et al., 1994; Odell and McClune, 1999; Baird, 2009a). Although typically a pelagic species, they approach close to the shores of oceanic islands and regularly mass strand (Baird, 2009a). False killer whales have a poorly known ecology. Breeding grounds and seasonality in breeding are unknown; however, one population does have a breeding peak in late winter (Jefferson et al., 2008). These whales do not have specific feeding grounds but feed opportunistically (Jefferson et al., 2008). False killer whales have an approximate swim speed of 3 km/hr (1.6 kts), although a maximum swim speed has been documented at 28.8 km/hr (11.9 kts) (Brown et al. 1966; Rohr et al., 2002).

False killer whales hear underwater sounds in the range of less than 1 to 115 kHz (Johnson, 1967; Au, 1993). Their best underwater hearing occurs at 17 kHz, where the threshold level ranges between 39 to 49 dB RL. In a study by Yuen et al. (2005), false killer whales' hearing was measured using both behavioral and AEP audiograms. The behavioral data show that this species is most sensitive between 16 and 24 kHz, with peak sensitivity at 20 kHz. The AEP data show that this species best hearing sensitivity is from 16 to 22.5 kHz, with peak sensitivity at 22.5 kHz. Au et al. (1997) studied the effects of the Acoustic Thermometry of Ocean Climate (ATOC) program on false killer whales. The ATOC source transmitted 75-Hz, 195 dB SL signals. The hearing thresholds for false killer whales were 140.7 dB RL ± 1.2 dB for the 75-Hz pure tone and 139.0 dB RL ±1.1 dB for the ATOC signal.

False killer whales produce a wide variety of sounds from 4 to 130 kHz, with dominant frequencies between 25 to 30 kHz and 95 to 130 kHz (Busnel and Dziedzic, 1968; Kamminga and van Velden, 1987; Thomas and Turl, 1990; Murray et al., 1998). Most signal types vary among whistles, burst-pulse sounds and click trains (Murray et al. 1998). Whistles generally range between 4.7 and 6.1 kHz. False killer whales echolocate highly directional clicks ranging between 20 and 60 kHz and 100 and 130 kHz (Kamminga and van Velden, 1987; Thomas and Turl, 1990). There are no available data regarding seasonal or geographical variation in the sound production of false killer whales. Estimated SL of clicks are near 228 dB (Thomas and Turl, 1990).

- **Pygmy killer whale (*Feresa attenuata*)**

Pygmy killer whales are one of the least known cetacean species. They are classified as data deficient by the IUCN. The global population for this species is unknown. Estimates of 39,000 have been documented in the ETP (Jefferson et al., 2008). An estimated 323 pygmy killer whales were reported in the Gulf of Mexico (Waring et al., 2009).

Pygmy killer whales have been recorded in oceanic tropical and subtropical waters (Caldwell and Caldwell, 1971; Donahue and Perryman, 2009). It is sighted relatively frequently in the ETP, the Hawaiian archipelago and off Japan (Leatherwood et al., 1988; Donahue and Perryman, 2009). No data are available to confirm seasonal migration patterns for pygmy killer whales. No data on breeding and calving grounds are available. General swim speeds for this species are not available, and no dive data are available.

Little information is available on the hearing sensitivity of pygmy killer whales. Recently, AEP-derived audiograms were obtained on two live-stranded pygmy killer whales during rehabilitation. The U-shaped audiograms of these pygmy killer whales showed that best hearing sensitivity occurred at 40 kHz with lowest hearing thresholds having occurred between 20 and 60 kHz (Montie et al., 2011). These stranded animals did not hear well at higher frequencies (90 and 96 dB re 1 µPa at 100 kHz) (Montie et al., 2011). Little is known of the sound production of this species. One document describes pygmy killer whales producing LF “growl” sounds (Pryor et al., 1965).

- **Melon-headed whale (*Peponocephala electra*)**

Melon-headed whales are classified as a lower risk (least concern) species by the IUCN. The global population for this species is unknown. Estimates of 45,000 have been documented in the ETP (Jefferson et al., 2008). An estimate of 2,283 whales was reported for the northern Gulf of Mexico (Waring et al., 2009).

The melon-headed whale occurs in pelagic tropical and subtropical waters (Jefferson and Barros, 1997). Breeding areas and seasonal movements of this species have not been confirmed. Melon-headed whales feed on mesopelagic squid found down to 1,500 m (4,920 ft) deep, so they appear to feed deep in the water column (Jefferson and Barros, 1997). General swim speeds for this species are not available. No data are available on dive depths and dive times of melon-headed whales.

There is no direct measurement of hearing sensitivity for melon-headed whales (Ketten, 2000; Thewissen, 2002). Melon-headed whales produce sounds between 8 and 40 kHz. Individual click bursts have frequency emphases between 20 and 40 kHz. Dominant frequencies of whistles are 8 to 12 kHz, with both upsweeps and downsweeps in frequency modulation (Watkins et al., 1997). There are no available data regarding seasonal or geographical variation in the sound production of this species. Maximum SLs are estimated at 155 dB for whistles and 165 dB re 1 µPa at 1 m for click bursts (Watkins et al., 1997).

- **Long-finned pilot whale (*Globicephala melas*)**

The long-finned pilot whale is classified as data deficient by the IUCN. The global population for the long-finned pilot whale is unknown. An estimated 200,000 exist in the Antarctic Convergence (Jefferson et al., 2008). An estimate of 31,139 long-finned pilot whales was reported for the western North Atlantic and 780,000 in the eastern North Atlantic (Jefferson et al., 2008; Waring et al., 2009).

Long-finned pilot whales occur off shelf edges in deep pelagic waters and in temperate and subpolar zones excluding the North Pacific (Nelson and Lien, 1996). There is a high abundance of long-finned pilot whales in the Mediterranean Sea and evidence of an autumn migration near this area (Croll et al., 1999).

There is also a seasonal migration evident around Newfoundland that may be correlated to a breeding season lasting from May to November (Sergeant, 1962; Nelson and Lien, 1996).

Pilot whales generally have swim speeds ranging between 2 to 12 km/hr (1.1 to 6.5 kts) (Shane, 1995). Long-finned pilot whales have an average speed of 3.3 km/hr (1.8 kts) (Nelson and Lien, 1996) and are considered deep divers (Croll et al., 1999). Dive depths of long-finned pilot whales range from 16 m (52 ft) during the day to 648 m (2,126 ft) during the night (Baird et al., 2002). Dive duration varied between 2 and 13 min.

Although little information is available on the hearing sensitivity of the long-finned pilot whale, a recent study by Pacini et al. (2010) measured the first audiogram of this species. The AEP-derived audiogram of a rehabilitated stranded long-finned pilot whale showed the U-shaped curve common in other mammals. The audiogram results found best hearing between 11.2 and 50 kHz with thresholds below 70 dB, while best hearing sensitivity was found at 40 kHz with a 53.1 dB threshold (Pacini et al., 2010). Pilot whales echolocate with a precision similar to bottlenose dolphins and vocalize with other school members (Olson, 2009). Long-finned pilot whales produce sounds, including double clicks and whistles, with frequencies as low as 500 Hz and as high as 18 kHz, with dominant frequencies between 3.5 and 5.8 kHz (Schevill, 1964; Busnel and Dziedzic, 1966; Taruski, 1979; Steiner, 1981; McLeod, 1986; Rendell et al., 1999). Sound production of long-finned pilot whales is correlated with behavioral state and environmental context (Taruski, 1979; Weilgart and Whitehead, 1990; Frankel, 2009). For example, signal types described as non-wavering whistles are associated with resting long-finned pilot whales. The whistles become more complex in structure as more social interactions take place (Frankel, 2009). There are no available data regarding seasonal or geographical variation in the sound production of the long-finned pilot whale. Estimated source levels were not available.

- **Short-finned pilot whale (*Globicephala macrorhynchus*)**

The short-finned pilot whale is classified as data deficient by the IUCN. A global population estimate for short-finned pilot whales is unknown. Off the U.S. west coast, abundance estimates are approximately 1,000 animals (Jefferson et al., 2008). Estimates of 500,000 have been documented in the ETP, 7,700 have been estimated in Philippine waters, and 60,000 in Japanese waters (Jefferson et al., 2008). Estimates of 716 and 31,139 short-finned pilot whales were reported for the Gulf of Mexico and western North Atlantic, respectively (Waring et al., 2009).

Short-finned pilot whales have a tropical and subtropical distribution (Olson, 2009). There appears to be little seasonal movement of this species. Some short-finned pilot whales stay year round near the California Channel Islands whereas others are found offshore most of the year moving inshore with the movement of squid (Croll et al., 1999). Calving season peaks during the spring and fall in the Southern Hemisphere. No breeding grounds have been confirmed.

Pilot whales generally have swim speeds ranging between 2 to 12 km/hr (1.1 to 6.5 kts) (Shane, 1995). Short-finned pilot whales have swim speeds ranging between 7 and 9 km/hr (3.8 and 4.6 kts) (Norris and Prescott, 1961). Both long- and short-finned pilot whales are considered deep divers, feeding primarily on fish and squid (Croll et al., 1999). A short-finned pilot whale was recorded as diving to 610 m (2,000 ft) (Ridgway, 1986).

No information has been available on short-finned pilot whale hearing until recently. AEPs were used to measure the hearing sensitivity of two short-finned pilot whales (Schlundt et al., 2011). This study tested hearing of one captive and one stranded short-finned pilot whale and found the region of best hearing sensitivity for the captive whale to be between 40 and 56 kHz (thresholds of 78 and 79 dB re 1 µPa, respectively) with the upper limit of functional hearing between 80 and 100 kHz (Schlundt et al., 2011). The only measurable detection threshold for the stranded pilot whale was 108 dB re 1 µPa at 10 kHz, which suggested severe hearing loss above 10 kHz (Schlundt et al., 2011). The hearing range of the captive short-finned pilot whale was similar to other odontocete species, particularly of larger toothed whales. Pilot whales echolocate with a precision similar to bottlenose dolphins and vocalize with other school members (Olson, 2009). Short-finned pilot whales produce sounds as low as 280 Hz and as high as 100 kHz, with dominant frequencies between 2 to 14 kHz and 30 to 60 kHz (Caldwell and Caldwell, 1969; Fish and Turl, 1976; Scheer et al., 1998). The mean frequency of calls produced by short-finned pilot whales is 7,870 Hz, much higher than the mean frequency of calls produced by long-finned pilot whales (Rendell et al., 1999). Echolocation abilities have been demonstrated during click production (Evans, 1973). SLs of clicks have been measured as high as 180 dB (Fish and Turl, 1976; Richardson et al., 1995). There are little available data regarding seasonal or geographical variation in the sound production of the short-finned pilot whale, although there is evidence of group specific call repertoires (Olson, 2009).

- **Risso's dolphin (*Grampus griseus*)**

Risso's dolphins are classified as a least concern (lower risk) species by the IUCN. Although no global population abundance exists for the Risso's dolphin, in the waters of the ETP, Japan, the Philippines, and off Sri Lanka abundances have been estimated at 175,000; 83,000; 950; and 5,550 to 13,000 dolphins, respectively (Jefferson et al., 2008). In the U.S. Pacific Ocean waters, an estimated 11,621 Risso's dolphins occur in the California/Oregon/Washington stock while 2,351 dolphins occur in the Hawaiian stock (Carretta et al., 2009). An abundance of 20,479 Risso's dolphins has been estimated for the western North Atlantic stock and 1,589 Risso's dolphins in the northern Gulf of Mexico stock (Waring et al., 2009).

Risso's dolphin inhabits deep oceanic and continental slope waters from the tropics through the temperate regions (Leatherwood et al., 1980; Jefferson et al., 1993; Baird, 2009b). They occur predominantly at steep shelf-edge habitats, between 400 and 1,000 m (1,300 and 3,281 ft) deep with water temperatures commonly between 15 and 20°C and rarely below 10°C (Baird, 2009b). They are commonly found in the north-central Gulf of Mexico and in the northwestern Atlantic. Seasonal migrations for Japan and the North Atlantic populations have been apparent, although seasonal variation in their movement patterns elsewhere have not been studied (Kasuya, 1971; Mitchell 1975). No data on breeding grounds are available, and Risso's dolphins have been known to calve year round, but peak breeding times differ by habitat. In the North Atlantic, breeding peaks in the summer, while in Japan breeding peaks in summer-fall, and in California, breeding peaks in fall-winter (Jefferson et al., 2008).

Swim speeds from Risso's dolphins were recorded at 2 to 12 km/hr (1.1 to 6.5 kts) off Santa Catalina Island (Shane, 1995). Risso's dolphins feed predominantly on neritic and oceanic squid species, probably primarily feed at night (Baird, 2009b). Dive times up to 30 min have been reported for this species (Jefferson et al. 2008).

Audiograms for Risso's dolphins indicate their hearing RLs equal to or less than approximately 125 dB in frequencies ranging from 1.6 to 110 kHz (Nachtigall et al., 1995). Phillips et al. (2003) reported that Risso's dolphins are capable of hearing frequencies up to 80 kHz. Optimal underwater hearing occurs between 4 and 80 kHz, with hearing threshold levels from 63.6 to 74.3 dB RL. Other audiograms obtained on Risso's dolphin (Au et al., 1997) confirm previous measurements and demonstrate hearing thresholds of 140 dB RL for a 1-second 75 Hz signal (Au et al., 1997; Croll et al., 1999). Au et al. (1997) estimated the effects of the ATOC source on false killer whales and on Risso's dolphins. The ATOC source transmitted 75-Hz, 195 dB SL acoustic signal to study ocean temperatures. The hearing sensitivity was measured for Risso's dolphins and their thresholds were found to be 142.2 dB RL ± 1.7 dB for the 75 Hz pure tone signal and 140.8 dB RL ± 1.1 dB for the ATOC signal (Au et al., 1997).

Risso's dolphins produce sounds as low as 0.1 kHz and as high as 65 kHz. Their dominant frequencies are between 2 to 5 kHz and at 65 kHz (Watkins, 1967; Au, 1993; Croll et al., 1999; Phillips et al., 2003). The maximum peak-to-peak SL, with dominant frequencies at 2 to 5 kHz, is about 120 dB (Au, 1993). In one experiment conducted by Phillips et al. (2003), clicks were found to have a peak frequency of 65 kHz, with 3 dB bandwidths at 72 kHz and durations ranging from 40 to 100 microsec. In a second experiment, Phillips et al. (2003) recorded clicks with peak frequencies up to 50 kHz, with 3 dB bandwidth at 35 kHz with durations ranging from 35 to 75 microsec. SLs were up to 208 dB. The behavioral and acoustical results from these experiments provided evidence that Risso's dolphins use echolocation. Estimated SLs of echolocation clicks can reach up to 216 dB (Phillips et al., 2003). Bark vocalizations consisted of highly variable burst pulses and have a frequency range of 2 to 20 kHz. Buzzes consisted of a short burst pulse of sound around 2 seconds in duration with a frequency range of 2.1 to 22 kHz. Low frequency, narrowband grunt vocalizations ranged between 400 and 800 Hz. Chirp vocalizations were slightly higher in frequency than the grunt vocalizations, ranging in frequency from 2 to 4 kHz. There are no available data regarding seasonal or geographical variation in the sound production of Risso's dolphin.

- **Short-beaked common dolphin (*Delphinus delphis*) and Long-beaked common dolphin (*Delphinus capensis*)**

The two common dolphin species are the short-beaked and long-beaked common dolphin. In addition, a geographic form of the long-beaked common dolphin is recognized—the Indo-Pacific common dolphin (*Delphinus capensis tropicalis*). The short-beaked dolphin is classified as a least concern (lower risk) species, and the long-beaked common dolphin is classified as a data deficient species by the IUCN. The global population for all common dolphin species is unknown. Short-beaked common dolphins are the most abundant species at an estimate of 3,000,000 in the ETP (Jefferson et al., 2008). In the California/Oregon/Washington stock, there are an estimated 392,733 dolphins while an estimated 120,743 short-beaked common dolphins are estimated for the western North Atlantic stock (Carretta et al., 2009; Waring et al., 2009). There are also an estimated 61,000 in the eastern Atlantic, 96,000 in the Black Sea, and 75,000 in the Celtic Sea (Jefferson et al., 2008). There are little data available on abundance estimates of long-beaked common dolphins. The abundance of long-beaked common dolphins in the California/Oregon/Washington waters is 15,335 animals while 15,000 to 20,000 long-beaked dolphins are estimated to occur in South African waters (Jefferson et al., 2008; Carretta et al., 2009).

Short-beaked and long-beaked common dolphins are distributed worldwide in temperate, tropical, and subtropical oceans, primarily along continental shelf and steep bank regions where upwelling occurs (Jefferson et al. 2008; Perrin, 2009). They seem to be most common in the coastal waters of the Pacific Ocean, usually beyond the 200-m (656-ft) isobath and north of 50°N in the Atlantic Ocean (Croll et al., 1999). Long-beaked dolphins, however, seem to prefer shallower, warmer waters that are closer to the coast (Perrin, 2009). They are often found within 180 km (97.2 nmi) of the coast (Jefferson et al., 2008). Long-beaked common dolphins occur around West Africa, from Venezuela to Argentina in the western Atlantic Ocean, from southern California to central Mexico and Peru in the eastern Pacific Ocean, around Korea, southern Japan, and Taiwan in the western Pacific, and around Madagascar and South Africa. Indo-Pacific common dolphins are only known to occur in the northern Indian Ocean and in Southeast Asia. No breeding grounds are known for common dolphins (Croll et al., 1999). Calving peaks during May and June both in the northeastern Atlantic and North Pacific.

Swim speeds for *Delphinus* spp. have been measured at 5.8 km/hr (3.1 kts) with maximum speeds of 16.2 km/hr (8.7 kts); but in other studies, common dolphins have been recorded at swimming up to 37.1 km/hr (20 kts) (Hui, 1987; Croll et al., 1999). Dive depths range between 9 and 200 m (30 and 656 ft), with a majority of dives 9 to 50 m (30 to 164 ft) (Evans, 1994). The deepest dive recorded for these species was 260 m (850 ft) (Evans, 1971). The maximum dive duration has been documented at 5 min (Heyning and Perrin, 1994). The deepest foraging dive recorded was 200 m (656 ft) (Evans, 1994).

Common dolphins produce sounds as low as 0.2 kHz and as high as 150 kHz, with dominant frequencies at 0.5 to 18 kHz and 30 to 60 kHz (Caldwell and Caldwell, 1968; Popper, 1980b; Au, 1993; Moore and Ridgway, 1995). Signal types consist of clicks, squeals, whistles, and creaks (Evans, 1994). Whistles of short-beaked common dolphins range between 7.4 and 13.6 kHz, while the whistles of long-beaked common dolphins ranges from 7.7 to 15.5 kHz (Oswald et al., 2003). Most of the energy of echolocation clicks is concentrated between 15 and 100 kHz (Croll et al., 1999). The maximum peak-to-peak SL of common dolphins is 180 dB. In the North Atlantic, the mean SL was approximately 143 dB with a maximum of 154 dB (Croll et al., 1999). There are no available data regarding seasonal or geographical variation in the sound production of common dolphins.

- **Fraser's dolphin (*Lagenodelphis hosei*)**

Fraser's dolphin is classified as a data deficient species by the IUCN. The global population for this species is unknown. Abundances or densities of Fraser's dolphins only exist for a limited number of regions: in the ETP, the Fraser's abundance has been estimated as 289,300 Fraser's dolphins; in the eastern Sulu Sea the abundance is estimated as 13,518 dolphins; and in Hawaiian waters, the Fraser's abundance is estimated as 16,836 dolphins (Carretta et al., 2009; Dolar, 2009). Although the Fraser's dolphin is known to occur rarely in the U.S. Gulf of Mexico, no current abundance estimate is available for this dolphin in the northern Gulf (Waring et al., 2009).

Fraser's dolphins occur primarily in tropical and subtropical waters (Croll et al., 1999; Dolar, 2009). They are found in the Atlantic, Pacific, and Indian Oceans. This species is an oceanic species that is most commonly found in deep waters (1,500 to 2,000 m [4,921 to 6,562 ft]) usually 15 to 20 km from shore or where deepwater approaches the shore, such as occurs in the Philippines, Taiwan, some Caribbean islands, and the Indonesian-Malay archipelago (Jefferson et al., 2008). Breeding areas and seasonal movements of this species have not been confirmed. However, in Japan, calving appears to peak in the spring and fall. There is some evidence that calving occurs in the summer in South Africa (Dolar, 2009). Swim speeds of Fraser's dolphin have been recorded between 4 and 7 km/hr (2.2 and 3.8 kts) with swim speeds up to 28 km/hr (15 kts) when escaping predators (Croll et al., 1999). Several foraging depths have been recorded. Based on prey composition, it is believed that Fraser's dolphins feed at two depth horizons in the ETP. The shallowest depth in this region is no less than 250 m (820 ft) and the deepest is no less than 500 m (1640 ft). In the Sulu Sea, they appear to feed near the surface to at least 600 m (1,968 ft). In South Africa and in the Caribbean, they were observed feeding near the surface (Dolar et al., 2003). According to Watkins et al. (1994), Fraser's dolphins herd when they feed, swimming rapidly to an area, diving for 15 seconds or more, surfacing and splashing in a coordinated effort to surround the school of fish. Dive durations are not available.

There is no direct measurement of the hearing sensitivity of Fraser's dolphins (Ketten, 2000; Thewissen, 2002). Fraser's dolphins produce sounds ranging from 4.3 to over 40 kHz (Leatherwood et al., 1993; Watkins et al., 1994). Echolocation clicks are described as short broadband sounds without emphasis at frequencies below 40 kHz, while whistles were frequency-modulated tones concentrated between 4.3 and 24 kHz. Whistles have been suggested as communicative signals during social activity (Watkins et al., 1994). There are no available data regarding seasonal or geographical variation in the sound production of Fraser's dolphins. Source levels were not available.

- **Common bottlenose dolphin *(Tursiops truncatus)***

The bottlenose dolphin is classified as least concern (lower risk) by the IUCN. The global population for the bottlenose dolphin is unknown. Estimates of 243,500 have been documented in the ETP, and an estimated 317,000 inhabit the waters of Japan (Jefferson et al., 2008). Off the Pacific coast of the U.S., 3,495 bottlenose dolphins were estimated (Carretta et al., 2009). A total of 7,000 bottlenose dolphins were estimated in the Black Sea and a minimum of 2,000 to 3,000 animals have been estimated for Shark Bay, Australia (Jefferson et al., 2008). The abundance of the western North Atlantic offshore and coastal stocks stock of bottlenose dolphins are 81,588 and 39,977, respectively, with 39,087 bottlenose dolphins found in the northern Gulf of Mexico (Waring et al., 2009).

The bottlenose dolphin is distributed worldwide in temperate to tropical waters. In North America, they inhabit waters with temperatures ranging from 10 to 32°C (50 to 89°F) (Wells and Scott, 2009). They are primarily found in coastal waters, but they also occur in diverse habitats ranging from rivers and protected bays to oceanic islands and the open ocean, over the continental shelf, and along the shelf break (Scott and Chivers, 1990; Sudara and Mahakunlayanakul, 1998; Wells and Scott, 2009). Bottlenose dolphins are found in the Pacific, Atlantic, and Indian oceans. The species' northern range extends to the United Kingdom and northern Europe (Croll et al., 1999). The species' southern range extends as far south as Tierra del Fuego, South Africa, Australia, and New Zealand (Wells and Scott, 2009). Seasonal movements vary between inshore and offshore locations and year-round home ranges (Croll et al., 1999; Wells and Scott, 2009). Calving season is generally year-round with peaks occurring from early spring to early fall (Scott and Chivers, 1990). There are no known breeding grounds.

Sustained swim speeds for bottlenose dolphins range between 4 and 20 km/hr (2.2 and 10.8 kts) and may reach speeds as high as 29.9 km/hr (16.1 kts) (Croll et al., 1999). Dive times range from 38 seconds to 1.2 min but have been known to last as long as 10 min (Mate et al., 1995; Croll et al., 1999). The dive depth of a bottlenose dolphin in Tampa Bay, Florida, was measured at 98 m (322 ft) (Mate et al., 1995). The deepest dive recorded for a bottlenose dolphin is 535 m (1,755 ft) reached by a trained individual (Ridgway, 1986).

Bottlenose dolphins hear underwater sounds in the range of 150 Hz to 135 kHz (Johnson, 1967; Ljungblad et al., 1982). Their best underwater hearing occurs at 15 to 110 kHz, where the threshold level range is 42 to 52 dB RL (Au, 1993). The range of highest sensitivity occurs between 25 and 70 kHz, with peaks in sensitivity at 25 and 50 kHz (Nachtigall et al. 2000). Bottlenose dolphins also have good sound location abilities and are most sensitive when sounds arrive directly towards the head (Richardson et al., 1995).

Bottlenose dolphins produce sounds as low as 0.05 kHz and as high as 150 kHz with dominant frequencies at 0.3 to 14.5 kHz, 25 to 30 kHz, and 95 to 130 kHz (Johnson, 1967; Popper, 1980b; McCowan and Reiss, 1995; Schultz et al., 1995; Croll et al., 1999; Oswald et al., 2003). The maximum SL produced is 228 dB (Croll et al., 1999). Bottlenose dolphins produce a variety of whistles, echolocation clicks and burst-pulse sounds. Echolocation clicks with peak frequencies from 40 to 130 kHz are hypothesized to be used in navigation, foraging, and predator detection (Au, 1993; Houser et al., 1999; Jones and Sayigh, 2002). According to Au (1993), sonar clicks are broadband, ranging in frequency from a few kilohertz to more than 150 kHz, with a 3 dB bandwidth of 30 to 60 kHz (Croll et al., 1999). The echolocation signals usually have a 50 to 100 microsec duration with peak frequencies ranging from 30 to 100 kHz and fractional bandwidths between 10 and 90% of the peak frequency (Houser et al., 1999). Burst-pulses, or squawks, are commonly produced during social interactions. These sounds are broadband vocalizations that consist of rapid sequences of clicks with inter-click intervals less than 5 milliseconds. Burst-pulse sounds are typically used during escalations of aggression (Croll et al., 1999).

Each individual bottlenose dolphin has a fixed, unique FM pattern, or contour whistle called a signature whistle. These signal types have been well studied and are presumably used for recognition, but may have other social contexts (Jones and Sayigh, 2002; Frankel, 2009). Signature whistles have a narrow-band sound with the frequency commonly between 4 and 20 kHz, duration between 0.1 and 3.6 seconds, and an SL of 125 to 140 dB (Croll et al., 1999). Jones and Sayigh (2002) reported geographic variations in behavior and in the rates of vocal production. Whistles and echolocation varied between Southport, North Carolina, the Wilmington-North Carolina Intracoastal Waterway (ICW), the Wilmington, North Carolina, coastline, and Sarasota, Florida. Dolphins at the Southport site whistled more than the dolphins at the Wilmington site, which whistled more than the dolphins at the ICW site, which whistled more than the dolphins at the Sarasota site. Echolocation production was higher at the ICW site than all of the other sites. Dolphins in all three of the North Carolina sites spent more time in large groups than the dolphins at the Sarasota site. Echolocation occurred most often when dolphins were socializing (Jones and Sayigh, 2002).

- **Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)**

Only in the last ten years has this species' taxonomy been clearly differentiated from that of the common bottlenose dolphin. Indo-Pacific bottlenose dolphins are considered data deficient by the IUCN. No global abundance estimates exist for the species and even regional abundance estimates are few, even though it is the most commonly observed marine mammal species in some coastal regions of the world. Estimates of Indo-Pacific bottlenose dolphins include 218 animals in Japanese waters; 1,634 to 1,934 in Australian waters; and 136 to 179 dolphins off Zanzibar, Tanzania (Wang and Yang, 2009).

Indo-Pacific bottlenose dolphins occur in warm temperate to tropical waters of the Indian Ocean and southwestern Pacific Ocean, from South Africa and the Red Sea and Persian Gulf to southern Japan, Indonesia, Malaysia, and central Australia (Jefferson et al., 2008). Considered principally a coastal species, the Indo-Pacific bottlenose dolphin occurs predominantly in continental shelf and insular shelf waters, usually in shallow coastal and inshore waters (Jefferson et al., 2008). However, movements across deep, oceanic waters have been reported (Wang and Yang, 2009).

Swimming speeds range from 0.4 to 1 m/sec (0.8 to 2.2 kts) but bursts of higher speeds can reach 4.4 to 5.3 m/sec (8.6 to 10.3 kts) (Wang and Yang, 2009). Little information is known about the diving ability of the Indo-Pacific bottlenose dolphin, but dive depths and durations are thought be less than 200 m and from 5 to 10 min (Wang and Yang, 2009).

Although much is known about hearing in the common bottlenose dolphin, specific hearing data are not yet available for the Indo-Pacific bottlenose dolphin. These dolphins produce whistle and pulsed call vocalizations. Whistles range in frequency from 7 to 10 kHz (Morisaka et al., 2005). Morisaka et al. (2005) found variations in whistles between populations of Indo-Pacific bottlenose dolphins and determined that ambient noise levels were likely responsible for the whistle variability (Morisaka et al., 2005a).

- **Pantropical spotted dolphin *(Stenella attenuata)***

The pantropical spotted dolphin is one of the most abundant dolphin species in the world. This species is listed as a least concern (lower risk) species by the IUCN. In the ETP, 640,000 northeastern offshore spotted dolphins have been estimated, while an estimated 4,439 occur in the western North Atlantic, and 29,311 dolphins are estimated in the northern Gulf of Mexico (Perrin, 2009a; Waring et al., 2009). In the Hawaiian EEZ, there are an estimated 10,260 pantropical spotted dolphins (Carretta et al., 2009). In the early 1990s, about 438,000 were estimated to occur in Japanese waters (Jefferson et al., 2008).

Pantropical spotted dolphins occur throughout tropical and sub-tropical waters from roughly 40°N to 40°S in the Atlantic, Pacific, and Indian Oceans (Perrin, 2009a). These dolphins typically are oceanic but are found close to shore in areas where deep water approaches the coast, as occurs in Taiwan, Hawaii, and the western coast of Central America (Jefferson et al., 2008). Pantropical spotted dolphins also occur in the Persian Gulf and Red Sea.

Pantropical spotted dolphins have been recorded swimming at speeds of 4 to 19 km/hr (2.2 to 10.3 kts), with bursts up to 22 km/hr 12 kts (Perrin, 2009a). Pantropical spotted dolphins dive to at least 170 m (557.7 ft), with most of their dives to between 50 and 100 m (164 and 328 ft) for 2 to 4 min, and most foraging occurs at night (Stewart, 2009). Pantropical spotted dolphins off Hawaii have been recorded to dive at a maximum depth of 122 m (400 ft) during the day and 213 m (700 ft) during the night (Baird et al., 2001). The average dive duration for the pantropical spotted dolphins is 1.95 min for depths as deep as 100 m (Scott et al., 1993). Dives of up to 3.4 min have been recorded (Perrin, 2009a).

Pantropical spotted dolphins produce whistles with a frequency range of 3.1 to 21.4 kHz (Richardson et al., 1995). They also produce click sounds that are typically bimodal in frequency with peaks at 40 to 60 kHz and 120 to 140 kHz with SLs up to 220 dB re 1 μPa (Schotten et al., 2004). There are no direct hearing measurements for the pantropical spotted dolphin.

- **Striped dolphin (*Stenella coeruleoalba*)**

Striped dolphins are a lower risk (least concern) species classified by the IUCN. Striped dolphins are known to be the most abundant species in the Mediterranean Sea, with an estimated 225,000 individuals (Jefferson et al., 2008; Archer, 2009). In the ETP, there is an estimated 1 million striped dolphins (Jefferson et al., 2008). In the western North Atlantic, there is an estimated 94,462, and in the northern Gulf of Mexico there is an estimated 3,325 (Waring et al., 2009). Off the Pacific coast of the U.S., there are an estimated 17,925, and in the Hawaiian EEZ there is an estimated 10, 385 striped dolphins (Carretta et al., 2009).

Striped dolphins are common in tropical and warm-temperate waters. Their full range is unknown, but they are known to range from the Atlantic coast of northern South America up to the eastern seaboard of North America, with a northern limit following the Gulf Stream. They are found in the eastern North Atlantic, south of the United Kingdom, and are the most frequently observed dolphin in the Mediterranean Sea. Striped dolphins have also been documented off the coast of several countries bordering the Indian Ocean. Striped dolphins are found outside the continental shelf, over the continental shelf, and are associated with convergence zones and waters influenced by upwelling. Temperature ranges for these dolphins are reported at 10 to 26°C but most often between 18° and 22°C.

In the Ligurian Sea, striped dolphins are commonly found along the Ligurian Sea Front, which has water depths of 2,000 to 2,500 m (6,562 to 8,202 ft). It is believed that they have a high abundance in this area due to a high biological productivity, which attracts and sustains their prey. Striped dolphins may be more active at night because the fish and cephalopods that they eat migrate to the surface at night (Gordon et al., 2000).

Average swim speeds of 11 km/hr (5.9 kts) were measured from striped dolphins in the Mediterranean (Archer II and Perrin, 1999). Based on stomach contents, it is predicted that striped dolphins may be diving down 200 to 700 m (656 to 2,297 ft) to feed (Archer, 2009). Dive times are unknown for this species.

The behavioral audiogram developed by Kastelein et al. (2003) shows hearing capabilities from 0.5 to 160 kHz. The best underwater hearing of the species appears to be at from 29 to 123 kHz (Kastelein et al., 2003). Striped dolphins produce whistle vocalizations ranging from 6 to >24 kHz with peak frequencies ranging from 8 to 12.5 kHz (Thomson and Richardson, 1995).

- **Atlantic spotted dolphin *(Stenella frontalis)***

The Atlantic spotted dolphin is classified as a data deficient species by the IUCN. The global abundance of the Atlantic spotted dolphin is unknown. In the western North Atlantic, the population estimated for most of the U.S. Atlantic waters (between Florida and Maryland) is 47,400, and the most current stock estimate for the northern Gulf of Mexico is an estimated 37,611 Atlantic spotted dolphins (Waring et al., 2009).

The Atlantic spotted dolphin is found only in the tropical and warm-temperate waters of the Atlantic Ocean. They are commonly found around the southeastern U.S. and the Gulf coasts, in the Caribbean, and off West Africa. They inhabit waters around the continental shelf and the continental shelf-break. Atlantic spotted dolphins are usually near the 200 m (656 ft) contour, but they occasionally swim closer to shore in order to feed.

In the Gulf of Mexico, Atlantic spotted dolphins were recorded diving 40 to 60 m (131 to 197 ft) deep (Perrin, 2009b). The average dive time was around 6 min, and most, if not all dives were less than 10 min in duration (Perrin, 2009b).

There are no current hearing data on Atlantic spotted dolphins. Atlantic spotted dolphins produce a variety of sounds, including whistles, whistle-squawks, buzzes, burst-pulses, synch pulses, barks, screams, squawks, tail slaps, and echolocation clicks. Like other odontocetes, they produce broadband, short duration echolocation signals. Most of these signals have a bimodal frequency distribution. They project relatively high-amplitude signals with a maximum SL of about 223 dB (Au and Herzing, 2003). Their broadband clicks have peak frequencies between 60 and 120 kHz. Dolphins produce whistles with frequencies generally in the human audible range, below 20 kHz. These whistles often have harmonics which occur at integer multiples of the fundamental and extend beyond the range of human hearing. Atlantic spotted dolphins have also been recorded making burst pulse squeals and squawks, along with bi-modal echolocation clicks with a low-frequency peak between 40 and 50 kHz and a high-frequency peak between 110 and 130 kHz. Many of the vocalizations from Atlantic spotted dolphins have been associated with foraging behavior (Herzing, 1996). There are no available data regarding seasonal variation in the sound production of *Stenella* dolphins, although geographic variation is evident. Peak-to-peak SLs as high as 210 dB have been measured (Au et al., 1998; Au and Herzing, 2003).

- **Spinner dolphin (*Stenella longirostris*)**

Spinner dolphins are classified as a data deficient species by the IUCN. Spinner dolphins are one of the most abundant dolphin species in the world. In the ETP there is an estimated 1,250,000 (Jefferson et al., 2008). In the northern Gulf of Mexico, there are an estimated 1,989 individuals in the stock while in the Pacific there are an estimated 2,805 spinner dolphins in the Hawaiian stock (Carretta et al., 2009; Waring et al., 2009).

Spinner dolphins are pantropical, occurring in tropical and most subtropical oceanic waters from about 40°S to 40°N, except in the Mediterranean Sea (Jefferson et al. 2008). Spinner dolphins are found in coastal regions of Hawaii, the eastern Pacific, Indian Ocean, and off Southeast Asia, usually resting in the shallow waters of bays of oceanic islands and atolls (Perrin, 2009c). The dwarf species occurs only in the shallow waters of Southeast Asia and northern Australia is found in shallower waters in the Gulf of Thailand, Timor Sea, and Arafura Sea (Jefferson et al., 2008; Perrin, 2009c).

Hawaiian spinner dolphins have swim speeds ranging from 2.6 to 6 km/hr (1.4 to 3.2 kts) (Norris et al., 1994). Based on where their prey is located in the water column, spinner dolphins likely dive as deep as 600 m (1,969 ft) (Perrin, 2009c). Dive durations are unknown for this species. Spinner dolphins are known for their aerial behavior, spinning up to seven times during one aerial leap from the water, reaching heights of 3 m (9 ft) above the water surface with an airborne time of 1.25 sec (Fish et al., 2006).

There are no current hearing data on spinner dolphins. The amount and variety of signal types generally increases with increasing social activity, particularly in Hawaiian spinner dolphins (Frankel, 2009). Spinner dolphins produce burst pulse calls, echolocation clicks, whistles, and screams (Norris et al., 1994; Bazua-Duran and Au, 2002). The results of a study on spotted and spinner dolphins conducted by Lammers et al. (2003) revealed that the whistles and burst pulses of the two species span a broader frequency range than is traditionally reported for delphinids. The fundamental frequency contours of whistles occur in the human hearing range, but the harmonics typically reach 50 kHz and beyond. Additionally, the burst pulse signals are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al., 2003).

- **Clymene dolphin (*Stenella clymene*)**

Clymene dolphins are one of the more poorly known dolphin species and are classified as data deficient by the IUCN. Global population estimates are unknown, but there are an estimated 6,086 in the western North Atlantic and an estimated 6,575 in the northern Gulf of Mexico (Waring et al., 2009).

Clymene dolphins are only found in the tropical to warm-temperate waters of the Atlantic Ocean from New Jersey in the northwestern Atlantic Ocean to Brazil and West Africa (Angola) in the South Atlantic Ocean (Jefferson et al., 2008). Most sightings of Clymene dolphins have been in deep, oceanic waters, but they have also been observed close to shore in areas where deep water approaches the coast. Very little is known about their ecology (Jefferson, 2009).

There are no measurements for Clymene dolphin hearing abilities. Clymene dolphins generally produce a higher frequency whistle than other *Stenella* species. The Clymene dolphin whistle frequency was measured ranging from 6.3 to 19.2 kHz (Mullin et al., 1994).

- **Peale's dolphin (*Lagenorhynchus australis*)**

Peale's dolphins are classified at data deficient under the IUCN. Although the only abundance estimate for this species is 200 individuals in southern Chilean waters, the species is considered to be fairly abundant throughout its range (Jefferson et al., 2008). Peale's dolphins inhabit the open coastal waters of Patagonia, Tierra del Fuego, and Chile as well as the deep, protected bays and channels of southern Chile (Goodall, 2009). Peale's dolphins are routinely observed in the waters of the Falkland Islands (Jefferson et al. 2008). The dive sequences Peale's dolphins are usually three short dives followed by one longer dive with dive durations from 3 to 157 seconds, averaging 28 seconds (Goodall, 2009).

Species in this genus produce sounds as low as 0.06 kHz and as high as 325 kHz with dominant frequencies at 0.3 to 5 kHz, 4 to 15 kHz, 6.9 to 19.2 kHz, and 60 to 80 kHz (Popper, 1980b; Richardson et al., 1995). Peale's dolphin vocalizations were recorded in the Chilean channel with broadband clicks at 5 to 12 kHz and narrowband clicks at 1 to 2 kHz bandwidths (Goodall, 2009). Peale's dolphin SLs were recorded at low levels of 80 dB re 1 µPa @ 1 m with a frequency of 1 to 5 kHz and were mostly inaudible at more than 20 m (65.6 ft) away (Croll et al., 1999).

- **Dusky dolphin (*Lagenorhynchus obscurus*)**

The dusky dolphin is listed as data deficient species under the IUCN. No global population estimates are available for this species. Dusky dolphins occur off New Zealand, central and southern South America, southwestern and southern Africa, southern Australia, and several islands in the South Atlantic and southern Indian Oceans (Jefferson et al., 2008; Van Waerebeek and Würsig, 2009). Dusky dolphins occur primarily in neritic waters but have been observed in deep waters when it approaches close to continental or island coasts (Van Waerebeek and Würsig, 2009). Although no well-defined seasonal migration patterns are apparent, this species are known to move over a range of 780 km (421 nmi) (Van Waerebeek and Würsig, 2009). Dusky dolphins off Argentina and New Zealand move inshore-offshore on both a diurnal and a seasonal scale. Calving takes place from November to February (Croll et al., 1999).

Off Argentina, the mean dive time for dusky dolphins was 21 sec, with shorter dives during the day and longer dives at night (Würsig, 1982). Dusky dolphins in New Zealand swim at mean routine speeds between 4.5 and 12.2 km/hr (2.4 and 6.6 kts) (Würsig and Würsig, 1980; Cipriano, 1992).

There are no hearing data available for this species. Dusky dolphins produce bimodal echolocation clicks, with lower frequency clicks from 40 to 50 kHz and high frequency clicks between 80 and 110 kHz (Waerebeek and Würsig, 2009). Au and Würsig (2004) reported echolocation clicks between 30 and 130 kHz, with a maximum SL of 210 dB re 1 µPa @ 1 m.

- **Atlantic white-sided dolphin *(Lagenorhynchus acutus)***

The Atlantic white-sided dolphin is listed as a least concern (lower risk) species under the IUCN. The estimated population in the North Atlantic is 150,000 to 300,000 Atlantic white-sided dolphins (Cipriano, 2009). In the western North Atlantic, there are an estimated 63,368 Atlantic white-sided dolphins (Waring et al., 2009), and in the eastern North Atlantic off the western coast of Scotland, there are an estimated 96,000 Atlantic white-sided dolphins (Jefferson et al., 2008).

Atlantic white-sided dolphins are found only in the cold-temperate waters of the North Atlantic from about 38°N (south of U.S. Cape Cod) and the Brittany coast of France north to southern Greenland, Iceland, and southern Svalbard (Jefferson et al., 2008). They are generally found in continental shelf and slope waters but are also observed in shallow and oceanic waters. Cape Cod is the southern limit to the Atlantic white-sided dolphin, with an eastern limit of Georges Bank and Brittany. It has been noted that there are seasonal shifts in abundance for the Atlantic white-sided dolphin (Jefferson et al., 2008). Calving occurs during the summer months with peaks in June and July (Croll et al., 1999; Jefferson et al., 2008). Atlantic white-sided dolphins are probably not deep divers. A tagged dolphin dove for an average of 38.8 seconds with 76 % of dives lasting less than 1 minute (Mate et al., 1994). This dolphin also swam at an average speed of 5.7 km/hr (3.1 kts) (Mate et al., 1994). The maximum dive time recorded from a tagged animal was 4 min (Cipriano, 2009).

There are no available hearing data on the Atlantic white-sided dolphin. Whistle vocalizations of Atlantic white-sided dolphins have been recorded with a dominant frequency of 6 to 15 kHz (Richardson et al., 1995). The average estimated SL for an Atlantic white-sided dolphin is approximately 154 dB re 1 µPa @ 1 m with a maximum at 164 dB re 1 µPa @ 1 m (Croll et al., 1999).

- **White beaked dolphin (*Lagenorhynchus albirostris)***

The white beaked dolphin is classified as a least concern (lower risk) species under the IUCN. There is no global population estimate for this species. A total of 7,856 white-beaked dolphins are estimated in the North Sea and adjacent waters (Hammond et al., 2002) while 2,003 white-beaked dolphins are estimated in the western North Atlantic (Waring et al., 2009).

White-beaked dolphins are distributed in the temperate and subarctic North Atlantic Ocean and share a similar habitat to that of the Atlantic white-sided dolphin but with a more northern range (Evans, 1987; Reeves and Leatherwood, 1994; Kinze, 2009). Reports of white-beaked dolphins in the Mediterranean Sea are questionable (Jefferson et al., 2008; Kinze, 2009). This species is distributed principally in continental shelf waters of these four high density areas: Labrador Shelf including southwestern Greenland, Iceland, Scotland/North Sea/Irish Sea, Norway coast to White Sea (Kinze, 2009).

Nachtigall et al., (2008) performed AEP measurements on the white beaked dolphin. An adult male was measured to have a hearing threshold near 100 dB at 152 kHz, and 121 dB at 181 kHz (Nachtigall et al., 2008). Clicks produced by white-beaked dolphins resemble those by bottlenose dolphins. They make short, broadband clicks with peak frequencies of about 120 kHz (Rasmussen et al., 2002). They are approximately 10 to 30 ms in duration. Some clicks have a secondary peak of 250 kHz. The maximum sound level was recorded at 219 dB re 1 µPa @ 1 m and was measured at a range of 22 m (72.2 ft) (Rasmussen et al., 2002). The minimum recorded sound level was 189 dB at a distance of 1.5 m (4.9 ft) from the dolphin (Rasmussen et al., 2002).

- **Hourglass dolphin (*Lagenorhynchus cruciger*)**

Hourglass dolphins are listed as least concern/low risk species under the IUCN. There is no global population abundance available, but Kasamatsu and Joyce (1995) estimated the abundance of hourglass dolphins south of the Antarctic Convergence as 144,300 dolphins.

Hourglass dolphins are oceanic and occur in the Southern Hemisphere from 45°S to the pack ice or about 60°S in Antarctic and subantarctic waters that range in temperature from 0.3° to 13.4°C (32.54° to 56.1°F) (Goodall, 2009a). Although an oceanic species, hourglass dolphins have been sighted near islands and over banks and areas where the water is turbulent (Goodall, 2009a). Nothing is known about the migratory movements of this species but they move seasonally into nearshore or subantarctic waters (Goodall, 2009a).

There are no available hearing data for this species. Tougaard and Kyhn (2010) recently recorded echolocation clicks of hourglass dolphins with frequencies ranging from about 100 to 190 kHz, a mean peak frequency of 125 kHz, and signal duration of 150 msec.

- **Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)**

Pacific white-sided dolphins are listed as least concern/low risk species under the IUCN. In the North Pacific Ocean, an abundance of 931,000 to 990,000 Pacific white-sided dolphins has been estimated (Jefferson et al., 2008; Black, 2009). There are an estimated 20,719 Pacific white-sided dolphins in the waters of the U.S. west coast (CA, OR, and WA) and an estimated 26,880 in the Gulf of Alaska (Angliss and Allen, 2009; Carretta et al., 2009). Some animals found in the Gulf of Alaska could also be part of the U.S. west coast stock. In Japanese waters, 30,000 to 50,000 Pacific white-sided dolphins have been estimated to occur (Nishiwaki, 1972).

Pacific white-sided dolphins are mostly pelagic and have a primarily cold temperate distribution across the North Pacific; in the western North Pacific, this species occurs from Taiwan north to the Commander and Kuril Islands while in the eastern North Pacific, it occurs from southern Gulf of California to the Aleutian Islands (Jefferson et al., 2008; Black, 2009). Pacific white-sided dolphins are distributed in continental shelf and slope waters generally within 185 km of shore and often move into coastal and even inshore waters. No breeding grounds are known for this species. From studies of the ecology of their prey, Pacific white-sided dolphins are presumed to dive from 120 to 200 m (393.7 to 656 ft), with most of their foraging dives lasting a mean of 27 sec (Black, 1994). Captive Pacific white-sided dolphins have been recorded swimming as fast as 27.7 km/hr (15.0 kts) for 2 sec intervals (Fish and Hui, 1991) with a mean travel speed of 7.6 km/hr (Black, 1994).

Pacific white-sided dolphins hear in the frequency range of 2 to 125 kHz when the sounds are equal to or softer than 90 dB RL (Tremel et al., 1998). This species is not sensitive to low frequency sounds (i.e., 100 Hz to 1 kHz) (Tremel et al., 1998). Pacific white-sided dolphins produce broad-band clicks that are in the frequency range of 60 to 80 kHz and that have a SL at 180 dB re 1 µPa @ 1 m (Richardson et al., 1995). There are no available data regarding seasonal or geographical variation in the sound production of *Lagenorhynchus* dolphins.

- **Rough-toothed dolphin (*Steno bredanensis*)**

The rough-toothed dolphin is classified as data deficient species by the IUCN. Globally, few population estimates are available for the rough-toothed dolphin except in the ETP, where the stock was estimated at 145,900 individuals (Wade and Gerrodette, 1993), and in the U.S. Gulf of Mexico, where the stock estimate is 2,653 dolphins (Waring et al., 2009), and in Hawaiian waters, where the stock was estimated at 19,904 individuals (Carretta et al., 2009). Occurrence data are insufficient elsewhere to estimate abundances.

Rough-toothed dolphins occur in oceanic tropical and warm-temperate waters around the world and appear to be relatively abundant in certain areas; these dolphins are also found in continental shelf waters in some locations, such as Brazil (Jefferson, 2009a). In the Atlantic Ocean, they are found from the southeastern U.S. to southern Brazil and from the Iberian Peninsula and West Africa to the English Channel and North Sea. Their range also includes the Gulf of Mexico, Caribbean Sea, and the Mediterranean Sea (Jefferson, 2009a). In the Pacific, they inhabit waters from central Japan to northern Australia and from Baja California, Mexico, south to Peru. In the eastern Pacific, they are associated with warm, tropical waters that lack major upwelling (Jefferson, 2009a). Their range includes the southern Gulf of California and the South China Sea. Rough toothed dolphins are also found in the Indian Ocean, from the southern tip of Africa to Australia (Jefferson et al., 2008). Seasonal movements and breeding areas for this species have not been confirmed.

Rough-toothed dolphins are not known to be fast swimmers. They are known to skim the surface at a moderate speed (Jefferson, 2009a). Swim speeds of this species vary from 5.6 to 16 km/hr (3.0 to 8.6 kts) (Watkins et al., 1987a; Ritter, 2002). Rough-toothed dolphins can dive 30 to 70 m (98 to 230 ft) with dive duration ranging from 0.5 to 3.5 min (Watkins et al., 1987a; Ritter, 2002). Dives up to 15 min have been recorded for groups of dolphins (Miyazaki and Perrin, 1994).

Very little information is available on the hearing sensitivity of rough-toothed dolphins. Cook et al. (2005) performed AEPs on five live-stranded rough-toothed dolphins and found that these dolphins could detect sounds between 5 and 80 kHz; the authors believe that rough-toothed dolphins are likely capable of detecting frequencies much higher than 80 kHz. Rough-toothed dolphins produce sounds ranging from

0.1 kHz up to 200 kHz (Popper, 1980b; Miyazaki and Perrin, 1994; Richardson et al., 1995). Clicks have peak energy at 25 kHz, while whistles have a maximum energy between 2 to 14 kHz (Norris and Evans, 1967; Norris, 1969; Popper, 1980b). There are no available data regarding seasonal or geographical variation in the sound production of this species.

- **Northern right whale dolphin *(Lissodelphis borealis)***

The northern right whale dolphin is classified as a least concern (lower risk) species by the IUCN. The global population in the North Pacific Ocean of the northern right whale dolphin is estimated as 68,000 animals (Jefferson et al., 2008). In the U.S. waters of California, Oregon, and Washington, 12,876 northern right whale dolphins have been estimated (Carretta et al., 2009).

This oceanic species is only found in temperate to subarctic regions of the North Pacific from roughly 34° to 54°N and 118° to 145°W (Jefferson et al., 2008; Lipsky, 2009). This range extends from the Kuril Islands (Russia) south to Japan and from the Gulf of Alaska to southern California. This species has been most often observed in waters ranging in temperature from 8 and 19°C (46.4 to 66.2°F) (Leatherwood and Walker, 1979). Northern right whale dolphins can occur near to shore when submarine canyons or other such topographic features cause deep water to be located close to the coast. Seasonally the northern right whale dolphin exhibits inshore-offshore movements in some areas, such as off southern California (Lipsky, 2009).

Swim speeds for northern right whale dolphins can reach 34 to 40 km/hr (18.3 to 21.6 kts) (Leatherwood and Walker, 1979; Leatherwood and Reeves, 1983). The maximum recorded dive duration is 6.25 min with a maximum dive depth of 200 m (Fitch and Brownell, 1968; Leatherwood and Walker, 1979).

There is no direct measurement of the hearing sensitivity of the northern right whale dolphin (Ketten, 2000; Thewissen, 2002). They produce sounds as low as 1 kHz and as high as 40 kHz or more, with dominant frequencies at 1.8 and 3 kHz (Fish and Turl, 1976; Leatherwood and Walker, 1979). The maximum known peak-to-peak SL of northern right whale dolphins is 170 dB (Fish and Turl, 1976).

- **Southern right whale dolphin *(Lissodelphis peronii)***

The southern right whale dolphin is classified as a data deficient species by the IUCN. The global population estimate for this species is unknown and virtually nothing known regarding the population status of this species.

Southern right whale dolphins only occur in the cold temperate to subantarctic oceans of the Southern Hemisphere between 25° and 65°S; the Antarctic Convergence Zone forms the effective southern limit of this species range (Lipsky, 2009). An oceanic species, the southern right whale dolphin can be found deepwater coastal areas as well (Jefferson et al., 2008). Southern right whale dolphins can swim up to 22 km/hr (12 kts) and dive as long as 6.5 min (Cruickshank and Brown, 1981). These dolphins appear to make dives to about 200 m (656 ft) while foraging (Fitch and Brownell, 1968). The hearing sensitivity of southern right whale dolphins has not been directly measure nor is any sound production information or data available (Ketten, 2000; Thewissen, 2002).

Subfamily Cephalorhynchinae

This group includes the Commerson’s dolphin (*Cephalorhynchus commersonii*), Chilean dolphin (*Cephalorhynchus eutropia*), Heaviside’s dolphin (*Cephalorhynchus heavisidii*), and Hector’s dolphin (*Cephalorhynchus hectori*).

Commerson’s, Chilean, and Heaviside’s dolphins are classified as data deficient species while the Hector’s dolphin is classified as endangered under the IUCN. The worldwide population size for all species of *Cephalorhynchus* spp. is unknown. The South American population of Commerson’s dolphins is estimated as 31,000 individuals (Dawson, 2009), while the Chilean dolphin population is not as well enumerated, with estimates ranging from 59 to several thousand animals (Jefferson et al., 2008; Dawson, 2009). In New Zealand waters, Hector's dolphins are estimated as 111 animals surrounding the North Island with 7,270 animals found around the South Island (Slooten et al., 2002; Dawson, 2009). Only one population estimate of 6,345 animals exists for Heaviside's dolphins in the Cape Town, South Africa region (Dawson, 2009).

Cephalorhynchus dolphins are found only in the temperate shallow (<200 m [656 ft]), coastal waters of the Southern Hemisphere (Goodall et al., 1988; Goodall, 1994a and 1994b; Sekiguchi et al., 1998; Dawson, 2009). In summer, some species are even observed in the surf zone (Dawson, 2009). Commerson's dolphins occur in two distinct populations, one in the Atlantic waters off southern South America (Chile and Argentina), including the Falkland Islands, and the other in the southern Indian Ocean waters off the Kerguelen Islands (Goodall, 1994a; Dawson, 2009). The Chilean dolphin is restricted to the shallow coastal and inshore (estuaries and rivers) waters of Chile from about 33° to 55°S and occurs year-round throughout this range (Jefferson et al. 2008; Dawson, 2009); this species is frequently observed in very close proximity to the shoreline. Hector's dolphins inhabit shallow waters surrounding New Zealand, occurring commonly along the east and west coasts of South Island but with a much smaller population in the waters of the North Island (Slooten and Dawson, 1994). Hector's dolphins are rarely seen more than 8 km (5 mi) from shore or in waters greater than 75 m (246 ft) deep (Jefferson et al., 2008). Heaviside's dolphins are only found along southwestern Africa from Cape Town, South Africa to Namibia (from 17°S to 34°S), typically occurring in shallow water no deeper than 100 m (328 ft) (Jefferson et al., 2008; Dawson, 2009). There is no evidence of large-scale seasonal movement for Heaviside's dolphins (Dawson, 2009).

Commerson's dolphins have been observed swimming at speeds of at least 30 km/hr (16 kts) (Gewalt, 1990), while Heaviside's dolphins swim much more slowly at a typical speed of 1.6 km/hr and a maximum speed of 3.8 km/hr (Davis, 2010). The average foraging dive of the Hector's dolphin ranges from 1 to 1.5 min (Slooten et al., 2002). Heaviside's dolphins also make shallow dives typically less than 2 min to no more than 20 m (66 ft), although they are capable of diving to 104 m and remaining submerged for up to 10 min (Davis, 2010).

There is no direct measurement of the hearing sensitivity of *Cephalorhynchus* dolphins (Ketten, 2000; Thewissen, 2002). Dolphins of this genus produce sound as low as 320 Hz and as high as 150 kHz (Croll et al., 1999). The vocalizations of this genus have been characterized as narrow-band, high frequency, with energy concentrated around 130 kHz and little to no energy below 100 kHz (Au, 1993; Götz et al., 2010). These narrow-band vocalizations of *Cephalorhynchus* dolphins are relatively low power with a high center frequency (Frankel, 2009). The vocalizations of Commerson's and Hector's dolphins have been studied the most extensively. Members of this genus produce only variations of click and no whistles vocalizations (Frankel, 2009).

The mean peak-to-peak SL for the Commerson's dolphin's vocalizations is 177 dB re 1 µPa @ 1 m (Kyhn et al., 2010). Commerson's dolphins emit varied click vocalizations, and those with a high rate of clicks have been termed "cries" that range up to 5 kHz in frequency with a peak frequency around 1 kHz (Dziedzic and DeBuffrenil, 1989). Commerson's dolphins emit three click signal-types that have peak frequencies at 1 to 2.4 kHz, 1.6 to 75 kHz, and 116 kHz (Dziedzic and DeBuffrenil, 1989). Kyhn et al. (2010) recently recorded Commerson's dolphin clicks with a peak frequency of 132 kHz and frequencies ranging from about 110 to ~200 kHz. Hector's dolphin emit sounds that are short (140 microsec) with a high peak frequency of 129 kHz (Thorpe and Dawson, 1991). The clicks of Hector's dolphins range from 82 to 135 kHz with a mean peak frequency of 129 kHz and a SL of 177 dB re 1 µPa @ 1 m (Thorpe and Dawson, 1991; Kyhn et al., 2009). Chilean dolphins emit clicks with a peak frequency at 126 kHz and a SL of 177 dB re 1 µPa @ 1 m (Götz et al., 2010). Heaviside's dolphins emit clicks that are <2 to 5 kHz with a dominant frequency of 800 Hz (Watkins et al., 1977).

Phocoenidae

- **Dall's porpoise (*Phocoenoides dalli*)**

Dall's porpoise is considered lower risk (conservation dependent) under the IUCN. The total population of Dall's porpoise is unknown but is considered to be one of the most common cetacean species in the central North Pacific (Jefferson et al., 2008; Jefferson, 2009b). There are an estimated 104,000 harbor porpoises along the Pacific coast of Japan and 554,000 in the Okhotsk Sea (Jefferson et al., 2008). In U.S. waters, there are an estimated 83,400 Dall's porpoises in the Alaskan stock while 48,376 are estimated for the California, Oregon, and Washington stock (Angliss and Allen, 2009; Carretta et al., 2009).

The Dall's porpoise is found exclusively in the North Pacific Ocean and adjacent seas (Bering Sea, Okhotsk Sea, and Sea of Japan) (Jefferson et al., 2008). This oceanic species is primarily found in deep offshore waters from 30°N to 62°N or in areas where deepwater occurs close to shore, but this species has been observed in the inshore waters of Washington, British Columbia, and Alaska (Jefferson et al., 2008). Distribution in most areas is very poorly defined (Jefferson, 2009b).

Dall's porpoises are thought to be one of the fastest swimming of the small cetaceans (Croll et al., 1999; Jefferson, 2009b). Average swim speeds are between 2.4 and 21.6 km/hr (1.3 and 11.7 kts) and are dependent on the type of swimming behavior (slow rolling, fast rolling, or rooster-tailing) (Croll et al., 1999), but Dall's porpoises may reach speeds of 55 km/hr (29.7 kts) for quick bursts (Leatherwood and Reeves, 1983). They are relatively deep divers, diving to 275 m (900 ft) for as long as 8 min (Ridgway, 1986; Hanson et al., 1998).

There is no direct measurement of the hearing sensitivity of Dall's porpoises (Ketten, 2000; Thewissen, 2002). It has been estimated that the reaction threshold of Dall's porpoise for pulses at 20 to 100 kHz is about 116 to 130 dB RL, but higher for pulses shorter than one millisecond or for pulses higher than 100 kHz (Hatakeyama et al., 1994).

Dall's porpoises produce sounds as low as 40 Hz and as high as 160 kHz (Ridgway, 1966; Evans, 1973; Awbrey et al., 1979; Evans and Awbrey, 1984; Hatakeyama and Soeda, 1990; Hatakeyama et al., 1994). They can emit LF clicks in the range of 40 Hz to 12 kHz (Evans, 1973; Awbrey et al., 1979). Narrow band clicks are also produced with energy concentrated around 120 to 130 kHz (Au, 1993). Their maximum peak-to-peak SL is 175 dB (Evans, 1973; Evans and Awbrey, 1984). Dall's porpoise do not whistle very often.

- **Harbor porpoise (*Phocoena phocoena*)**

The harbor porpoise is classified as vulnerable under IUCN. The global population for the harbor porpoise is unknown. In the Gulf of Maine, there are an estimated 89,054 harbor porpoises (Waring et al., 2009), 27,000 in the Gulf of Saint Lawrence, 28,000 in Iceland waters, 11,000 in Norwegian waters, 36,000 in Kattegat, 268,000 in the North Sea, and 36,000 in the waters around Ireland (Jefferson et al., 2008). There are an estimated 90,407 in Alaskan waters and an estimated 77,980 harbor porpoises occur in the U.S. west coast waters (Angliss and Allen, 2009; Carretta et al., 2009).

Harbor porpoises are found in cold temperate and sub-arctic coastal waters of the northern hemisphere (Gaskin, 1992; Jefferson et al., 1993; Bjorge and Tolley, 2009). They are typically found in waters of about 5 to 16°C (41 to 61°F) with only a small percentage appearing in arctic waters zero to 4°C (32 to 39°F) (Gaskin, 1992). They are most frequently found in coastal waters, but do occur in adjacent offshore shallows and, at times, in deep water (Croll et al., 1999; Gaskin, 1992).

They show seasonal movement in northwestern Europe that may be related to oceanographic changes throughout certain times of the year (Gaskin, 1992; Read and Westgate, 1997; Heimlich-Boran et al., 1998). Although migration patterns have been inferred in harbor porpoise, data suggest that seasonal movements of individuals are discrete and not temporally coordinated migrations (Gaskin, 1992; Read and Westgate, 1997). Three major residential isolated populations exist: 1) the North Pacific; 2) North Atlantic; and 3) the Black Sea (Jefferson et al., 2008; Bjorge and Tolley, 2009). However, there are morphological and genetic data that suggest that different populations may exist within these three regions (Jefferson et al., 2008). For example, there are 10 different stocks in U.S. waters alone, with nine stocks in the North Pacific, and one in the Gulf of Maine in the North Atlantic (Angliss and Allen, 2009; Caretta et al., 2009; Waring et al., 2009).

Maximum swim speeds for harbor porpoises range from 16.6 and 22.2 km/hr (9.0 to 12.0 kts) (Gaskin et al., 1974). Dive times range between 0.7 and 1.7 min with a maximum dive duration of 9 min (Westgate et al., 1995). The majority of dives range from 20 to 130 m (65.6 to 426.5 ft), although maximum dive depths have reached 226 m (741.5 ft) (Westgate et al., 1995).

Harbor porpoises can hear frequencies in the range of 100 Hz to 140 kHz (Kastelein et al., 2002; Villadsgaard et al., 2007). Kastelein et al. (2002) determined the best range of hearing for a two-year-old male was 16 to 140 kHz; this harbor porpoise also demonstrated the highest upper frequency hearing of all odontocetes presently known (Kastelein et al., 2002). Harbor porpoises produce click and whistle vocalizations that cover a wide frequency range, from 40 Hz to at least 150 kHz (Verboom and Kastelein, 1995). The click vocalizations consist of four major frequency components: lower frequency component (1.4 to 2.5 kHz) of high amplitude that are may be used for long-range detection; two middle frequency components consisting of a low amplitude (30 to 60 kHz) and a broadband component (10 to 100 kHz); and a higher frequency component (110 to 150 kHz) that is used for bearing and classification of objects (Verboom and Kastelein, 1995). Vocalization peak frequencies are similar for wild and captive harbor porpoises, with the peak frequencies reported to range from 129 to 145 kHz and 128 to 135 kHz, respectively (Villadsgaard et al., 2007). Maximum SLs vary, apparently, between captive and wild dolphins, with maximum SLs of 172 dB re 1 µPa at 1 m in captive dolphins but range from 178 to 205 dB re 1 µPa at 1 m in wild dolphins (Villadsgaard et al., 2007). Variations in click trains apparently represent different functions based on the frequency ranges associated with each activity.

- **Spectacled porpoise (*Phocoena dioptrica*)**

The spectacled porpoise is one of the world's most poorly known cetaceans. This species is classified as data deficient by the IUCN. There is no information about the abundance of this species (Goodall, 2009b). There are also no data on diving, swim speeds, hearing, or vocalizations.

Spectacled porpoises are circumpolar in occurrence and are found only in the cool temperate, sub-Antarctic, and Antarctic waters of the southern hemisphere (Goodall, 2009b). The species is known from Brazil to Argentina in offshore waters and around offshore islands including Tierra del Fuego, the Falklands (Malvinas), and South Georgia in the southwestern South Atlantic; Auckland and Macquarie in the southwestern Pacific; and Heard and Kergulan in the southern Indian Ocean (Goodall, 2009b). Sightings are most often documented in oceanic waters ranging from 4.9 °to 6.2°C (40.8° to 43°F), but this species has also been sighted in nearshore waters and even in river channels (Goodall, 2009b).

3.2.5 MARINE MAMMALS—PINNIPEDS

Pinnipeds (sea lions, seals, and walruses) include more than 30 species that are globally distributed amphibious mammals with varying degrees of aquatic specialization (Gentry, 1998; Berta, 2009). Walruses are distributed only in Arctic waters, where SURTASS LFA sonar operations will not occur; thus no further discussion of the walrus is included.

Otariids have retained more extensive morphological ties with land. Eared seals are distinguished by swimming with their foreflippers and moving on all fours on land. In contrast, true seals swim with undulating motions of the rear flippers and have a type of crawling motion on land. Otariids have ear flaps (pinnae) that are similar to carnivore ears. Phocid ears have no external features and are more water-adapted. Otariids have also retained their fur coats (Berta, 2009), whereas phocids and walruses have lost much of their fur and instead have thick layers of blubber. Otariids mate on land whereas phocids mate in the water. Otariids leave calving rookeries to forage during lactation, and due to their need to hunt, otariids can only rear pups in limited sites close to productive marine areas (Gentry, 1998). Phocids, on the other hand, fast during lactation and therefore have fewer limitations on breeding site location. On average, pinnipeds range in size from 45 to 3,200 kg (99 to 7,055 lb) and from approximately 1 m (3.3 ft) to 5 m (16.5 ft) in length (Bonner, 1990).

Many pinniped populations today have been reduced by commercial exploitation, incidental mortality, disease, predation, and habitat destruction (Bowen et al., 2009). Pinnipeds were hunted for their furs, blubber, hides, and organs. Some stocks have begun to recover. However, populations of species such as the northern fur seal and the Steller sea lion continue to decline (Gentry, 2009). The reduction in population raises concern about the potential risk of extinction. The ESA, along with CITES and IUCN, designates a protected status generally based on natural or manmade factors affecting the continued existence of species.

Pinnipeds usually feed under water, diving several times with short surface intervals. This series of diving and surfacing is known as a dive bout. Seasonal changes in temperature and nutrient availability affect prey distribution and abundance, and therefore affect foraging efforts and dive bout characteristics. Foraging areas are often associated with ocean fronts and upwelling zones. Feeding habits are most dependent on the ecology of the prey and the age of the animal. Diet composition can change with the distribution and abundance of prey. Additionally, the hunting habits of pinnipeds may change with age. For example, harbor seal pups eat pelagic herring and squid whereas adult harbor seals eat benthic animals. The amount of benthic prey in the diet of the bearded seal also increases with age (Berta, 2009; Bowen et al., 2009). Phocids are generally benthic feeders, whereas in the otariid family, fur seals feed on small fish at the surface and sea lions feed on larger fish over continental shelves (Gentry, 1998).

The abundance of pinnipeds varies by species. For example, crabeater seals have an estimated abundance of 12 million, while the Mediterranean monk seal is estimated at less than several hundred individuals. Phocid species seem to be more abundant than otariids, but the reason for this is unknown since both families have been commercially exploited. Phocids are circumpolar but are most abundant in the North Atlantic and Antarctic Ocean, found in both temperate and polar waters. The northern fur seal, South African fur seal, and subantarctic fur seal are the most abundant of the otariid species, and the ringed, harp, and crabeater seals are the most abundant of the phocid species (Bowen et al., 2009).

Due to the need to give birth on land or on ice, pinniped distribution is affected by ice cover or the location of land, prey availability, predators, habitat characteristics, population size, and effects from humans (Bowen et al., 2009). Most species of pinnipeds reside year round in areas bounded by land in a confined range of distances, although some pinnipeds undergo seasonal migrations to forage. Migration patterns consist of moving offshore between breeding seasons. Pinniped habitats range from shelf to surface waters in tropical, temperate, and polar waters. Some species have even adapted to life in fresh and estuarine waters (Berta, 2009).

Social systems are based on aggregations of pinnipeds forming large colonies for polygynous breeding and raising young. The size of the colonies may correlate with resource availability and predation pressure. Pinnipeds are generally long-lived with longevity estimates of 40 years or more (Berta, 2009). Sexual maturity is usually attained at ages from 2 to 6 years (Boyd, 2009). All pinnipeds produce single young on land or ice and most gather to bear young and breed once a year.

Pinnipeds are known for their diving ability. On average, smaller species dive for roughly 10 min and larger pinnipeds can dive for over an hour. Maximum depths vary from less than 100 m (328 ft) to over 1,500 m (4,921 ft) (Berta, 2009).

Hearing capabilities and sound production are highly developed in all pinniped species studied to date. It is assumed that pinnipeds rely heavily on sound and hearing for breeding activities and social interactions

(Schusterman, 1978; Berta, 2009; Frankel, 2009). They are able to hear and produce sounds in both air and water. Pinnipeds have different functional hearing ranges in air and water. Their air-borne vocalizations include grunts, snorts, and barks, which are often used as aggression or warning signals, or to communicate in the context of breeding and rearing young. Under water, pinnipeds can vocalize using whistles, trills, clicks, bleats, chirps, and buzzes as well as lyrical calls (Schusterman, 1978; Berta, 2009; Frankel, 2009). Sensitivity to sounds at frequencies above 1 kHz has been well documented. However, there have been few studies on their sensitivity to low frequency sounds. Various studies have examined the hearing capabilities of some pinniped species, particularly ringed seals, harp seals, harbor seals, California sea lions, and northern fur seals (Mohl, 1968a; Terhune and Ronald, 1972; Terhune and Ronald, 1975a and 1975b; Kastak and Schusterman, 1996; Kastak and Schusterman, 1998). Kastak and Schusterman (1998) suggest that the pinniped ear may respond to acoustic pressure rather than particle motion when in the water. Sound intensity level and the measurement of the rate of energy flow in the sound field was used to describe amphibious thresholds in an experiment studying low-frequency hearing in two California sea lions, a harbor seal, and an elephant seal. Results suggest that California sea lions are relatively insensitive to most anthropogenic sound in the water, as sea lions have a higher hearing threshold (116.3 to 119.4 dB RL) at frequencies of 100 Hz than typical anthropogenic noise sources at moderate distances from the source. Harbor seals are approximately 20 dB more sensitive to signals at 100 Hz, compared to California sea lions, and are more likely to hear low-frequency anthropogenic noise. Elephant seals are the most sensitive to low-frequency sound under water with a threshold of 89.9 dB RL at 100 Hz. Kastak and Schusterman (1996 and 1998) also suggest that elephant seals may not habituate well to certain types of sound (in contrast to sea lions and harbor seals), but in fact may become more sensitive to disturbing noises and environmental features associated with the noises.

Past sound experiments have shown some pinniped sensitivity to LF sound. The dominant frequencies of sound produced by hooded seals are below 1,000 Hz (Terhune and Ronald, 1973; Ray and Watkins, 1975). Ringed, harbor, and harp seal audiograms show that they can hear frequencies as low as 1 kHz, with the harp seal responding to stimuli as low as 760 Hz. Hearing thresholds of ringed, harbor, and harp seals are relatively flat from 1 to 50 kHz with thresholds between 65 and 85 dB RL (Mohl, 1968b; Terhune and Ronald, 1972, 1975a, 1975b; Terhune 1991). In a recent study, Kastak et al. (2005) found hearing sensitivity in the California sea lion, harbor seals, and the elephant seal decreased for frequencies below 6.4 kHz (highest frequency tested), but the animals are still able to perceive sounds below 100 Hz.

The California sea lion is one of the few otariid species whose underwater sounds have been well studied. Other otariid species with documented vocalizations are South American sea lions and northern fur seals (Fernandez-Juricic et al., 1999; Insley, 2000). Otariid hearing abilities are thought to be intermediate between Hawaiian monk seals and other phocids, with a cutoff in hearing sensitivity at the high frequency end between 36 and 40 kHz. Underwater low frequency sensitivity is between approximately 100 Hz and 1 kHz. The underwater hearing of fur seals is most sensitive with detection thresholds of approximately 60 dB RL at frequencies between 4 and 28 kHz (Moore and Schusterman, 1987; Babushina et al., 1991).

Phocid seals probably hear sounds underwater at frequencies up to about 60 kHz. Above 60 kHz, their hearing is poor. Richardson et al. (1995) indicate that phocids have flat underwater audiograms for mid and high frequencies (1 to 30 kHz and 30 to 50 kHz) with a threshold between 60 and 85 dB RL (Mohl, 1968b; Terhune and Ronald, 1972, 1975a, 1975b; Terhune, 1989, 1991; Terhune and Turnbull, 1995). As mentioned, the elephant seals are the most sensitive to underwater low-frequency sound with a threshold of 89.9 dB RL at 100 Hz (Kastak and Schusterman, 1998).

The sounds produced by pinnipeds vary across a range of frequencies, sound types, and sound levels. The seasonal and geographic variation in distribution and mating behaviors among pinniped species may also factor into the diversity of pinniped vocalizations. The function of sound production appears to be socially important as they are often produced during the breeding season (Kastak and Schusterman, 1998; Van Parijs and Kovacs, 2002).

3.2.5.1 Otariidae Species

The Otariidae family of pinnipeds includes 16 otariid species, of which 15 are included in this document for further consideration (Table 3-4). One otariid species, the Antarctic fur seal, is not considered due to its restricted occurrence in a polar region where SURTASS LFA sonar will not operate.

- **South American fur seal (*Arctocephalus australis*)**

The South American fur seal is listed as a least concern (lower risk) species under the IUCN. The abundance of the Southern fur seal and its subspecies, which only occurs in the Falkland Islands, is not well known. The South American fur seal's coastal and offshore populations are currently estimated at 235,000 to 285,000 animals (Arnould, 2009).

South American fur seals range from central Peru to the Straits of Magellan in the southern Pacific Ocean and from southern Brazil to Uruguay in the southern Atlantic Ocean (Jefferson et al., 2008). Most colonies of South American fur seals are located on offshore islands except in Peru, where the colonies are located on the mainland (Arnould, 2009). Males are sometimes seen seasonally up to 600 km (324 nmi) offshore (Jefferson et al., 2008). These fur seals are believed to occur predominantly in continental shelf and continental slope waters.

South American fur seals have been recorded diving to mean water depths of 34 m and a maximum depth of 170 m with mean and maximum dive durations of 2.5 and 7.1 min, respectively (Riedman, 1990). Thompson et al. (2003) found that satellite tagged South American fur seals foraged in waters 50 to about 600 m deep and swam at an average speed of 1.5 m/sec (2.9 kts).

There is no direct measurement of the hearing sensitivity of South American fur seals. The primary calls made by South American fur seals are whimpers, barks, growls, whines, and moans. There is a strong vocal connection between mother and pups. The female South American fur seal has a call with a frequency between 1 and 5,870 Hz. The pups have a higher frequency call, between 1 and 6,080 Hz (Phillips and Stirling, 2000).

- **New Zealand fur seal (*Arctocephalus forsteri*)**

The New Zealand fur seal is listed as a least concern (lower risk) species under the IUCN. The global population estimate is 135,000 seals, with 35,000 found in Australia (Jefferson et al., 2008). The New Zealand fur seal is a temperate species having two genetically distinct populations. One population is around both the North and South islands of New Zealand, with the larger population around South Island. The second population is found on the coast of southern and western Australia (Jefferson et al., 2008). Their principal breeding colonies occur along the coast of South and Stewart Islands of New Zealand as well as along the coast of western and southern Australia, including off Tasmania at Maatsuyker Island (Arnould, 2009). Breeding colonies also exist at the subantarctic Chatham, Campbell, Antipodes, Bounty, Aukland, and Macquarie islands (Arnould, 2009). The New Zealand fur seal prefers rocky and windy habitats that are protected from the sun for breeding (Jefferson et al., 2008).

New Zealand fur seals forage at night, with varying dive depths and times depending on age and sex. New Zealand fur seal pups were recorded at a maximum dive depth of 44 m (144 ft) for 3.3 min (Baylis et al., 2005). Adult females recorded a maximum dive depth of 312 m (1,024 ft), and a maximum dive time of 9.3 min off the southern coast of Australia (Page et al., 2005). Adult male New Zealand fur seals had a maximum dive of more than 380 m (1,247 ft), and a maximum dive time of 14.8 min (Page et al., 2005). No available swim speed data are available.

In-air vocalizations of the New Zealand fur seal have been described as full-threat calls. These individually distinctive vocalizations are emitted by males during the breeding season (Stirling, 1971).

New Zealand fur seals also produce barks, whimpers, growls, whines, and moans (Page et al., 2002). The hearing capabilities of this species are unknown, and no information exists on frequency of vocalizations.

- **Galapagos fur seal (*Arctocephalus galapagoensis*)**

The Galapagos fur seal is listed as endangered under the IUCN. The population is estimated currently as 12,000 individuals although estimates from the late 1989s were about 40,000 animals (Jefferson et al., 2008; Arnould, 2009).

Galapagos fur seals are non-migratory. Their distributional range is limited to the equatorial region throughout the Galapagos Islands (Arnould, 2009). These seals haul out on rock shorelines with most colonies located in the western and northern parts of the Galapagos Archipelago and occasionally come ashore on the mainland Ecuadorian coast (Jefferson et al., 2008).

The diving habits of Galapagos fur seals are dependent on age. Six-month-old seals have been recorded to dive up to 6 m (20 ft) for 50 sec. Yearlings dive to 47 m (150 ft) for 2.5 min, and 18-month-old juveniles dive up to 61 m (200 ft) for 3 min (Stewart, 2009). The longest and deepest dive recorded by a Galapagos fur seal was 5 min at a depth of 115 m (377 ft) (Jefferson et al., 2008). Galapagos fur seals swim at about 1.6 m/sec (3.1 kts) (Williams, 2009). No information is available on the hearing abilities of this species. Galapagos fur seals produce low frequency long growls (<1 kHz) and short broadband grunts that are less than 2 kHz (Frankel, 2009).

- **Juan Fernandez fur seal (*Arctocephalus philippii)***

The Juan Fernandez fur seal is classified as near threatened under the IUCN. The species was believed to have been hunted to extinction until 1965 when a small remnant population was located. The population is currently estimated at 18,000 seals (Arnould, 2009).

Juan Fernandez fur seals are restricted to the Juan Fernandez island group off the coast of north central Chile (Jefferson et al., 2008). Currently this seal occupies four major breeding colonies and hauls out on rocky shorelines (Arnould, 2009).

Juan Fernandez fur seals can travel an average distance of 653 km (353 nmi) from breeding grounds to feeding grounds, where they forage at depths between 10 and 90 m (35 and 295 ft) (Jefferson et al., 2008). Maximum dive depths for this seal range from 50 to 90 m (163 to 295 ft), with most dives less than 10 m (33 ft) (Francis et al., 1998). The most common dive times lasted less than 1 min, with a maximum dive time of 6 min (Jefferson et al., 2008). Most dives occur at night (Francis et al., 1998). No swim speed information is available.

There is no information available on the hearing abilities of the Juan Fernandez fur seal. The Juan Fernandez fur seal has been recorded producing clicks with a frequency of 0.1 to 0.2 kHz (Richardson et al., 1995). Other information about this species' sound production is not available.

- **South African fur seal (*Arctocephalus pusillus pusillus*)**

South African or Cape fur seals are listed as a species of least concern (lower risk) by the IUCN. The most recent population census in 2004 indicates that the population of South African fur seals is stable at an estimated 2 million animals (Arnould, 2009).

South African fur seals occur along the southern African coast from South Africa to Angola (Jefferson et al., 2008). Breeding occurs at 25 colonies along the coasts of South Africa and Namibia, including four mainland colonies (Arnould, 2009).

South African fur seals feed within approximately 5 km (2.7 nmi) of land and are believed to be non-migratory. Females fur seals dove to an average depth and duration of 45 m (ft) for 2.1 min with the maximum depth and duration of 204 m (669 ft) and 7.5 min (Kooyman and Gentry, 1986). No swim speed data are available for this species. There is also no information available on the hearing abilities or sound production of the South African fur seal.

- **Australian fur seal (*Arctocephalus pusillus doriferus*)**

Australian fur seals are listed as a species of least concern (lower risk) by the IUCN. Most of their breeding and haulout sites are protected by Australian federal, state, and territorial laws. Currently, the population of Australian fur seals is estimated at 92,000 animals (Arnould, 2009).

Australian fur seals are believed to be non-migratory. They are found along the southern and southwestern coast of Australia from just east of Kangaroo Island to Houtman Albrolhos in Western Australia (Jefferson et al., 2008). Breeding colonies are restricted to 10 islands in Bass Strait (Arnould, 2009). Australian fur seals prefer rocky habitats for hauling out and breeding (Jefferson et al., 2008).

Australian fur seals forage at shallow depths along the continental shelf and continental slope waters (Jefferson et al., 2008). An average dive depth and duration of a male off the coast of Australia was 14 m (46 ft) and 2.3 min; the maximum dive depth and duration that were recorded was 102 m (335 ft) and 6.8 min (Hindell and Pemberton, 1997). No swim speed data are available for this species.

There is no information available on the hearing abilities for the Australian fur seal. Vocalizations made by Australian fur seals are not well known. These fur seals produce a variety of sounds such as barks, mother-pup calls, growls, and submissive calls. Tripovich et al. (2008) found that pups had a maximum energy of 1,300 Hz, while yearlings had a maximum energy of 800 Hz. Females had an average call frequency of 262 ± 35 Hz (Tripovich et al., 2008).

- **Guadalupe fur seal (*Arctocephalus townsendi)***

The Guadalupe fur seal is currently classified as threatened under ESA, CITES protected, and considered a near-threatened species under IUCN. The current worldwide population size for this species is unknown. The most recent population estimate, 7,408 seals, was estimated in 1993 (Caretta et al., 2009).

The distribution of Guadalupe fur seals is centered on Guadalupe Island, Mexico with most breeding occurring there, but recently pups have been born at a former rookery in the San Benitos Islands, Mexico and on San Miguel Island, California (Jefferson et al., 2008). They prefer either a rocky habitat or volcanic caves.

The Guadalupe fur seal has been recorded swimming from 1.8 to 2.0 m/sec (3.4 to 3.9 kts) (Gallo-Reynoso, 1994). Guadalupe fur seals are shallow divers, foraging within the upper 30 m (100 ft) of the water column and diving to a mean water depth of 16.9 m (56 ft) for mean a duration of 2.6 min (Gallo-Reynoso, 1994).

There is no direct measurement of auditory threshold for the hearing sensitivity of Guadalupe fur seals (Thewissen, 2002). The only available data on the sound production of this species are that males produce airborne territorial calls during the breeding season (Pierson, 1987).

- **Subantarctic fur seal (*Arctocephalus tropicalis*)**

Subantarctic fur seals are considered a least concern (lower risk) species under the IUCN. The current population of this widely dispersed fur seal is more than 310,000 animals (Arnould, 2009). More than 200,000 seals occur at Gough Island in the South Atlantic with good sized colonies occurring in the southern Indian Ocean at Prince Edward Island with 75,000 animals and Amsterdam Island with 50,000 (Arnould, 2009).

This fur seal species ranges throughout the southern hemisphere from the Antarctic Polar Front northward to southern Africa, Australia, Madagascar, and the South Island of New Zealand with rare vagrants reported from as far north as Brazil (Jefferson et al., 2008). Breeding occurs north of the

Antarctic Convergence in the South Atlantic and Indian Oceans, mostly on the islands of Amsterdam, Saint Paul, Crozet, Gough, Marion, Prince Edward, and Macquarie (Jefferson et al., 2008).

In the summer, subantarctic fur seals commonly dive to water depths averaging 16.6 to 19 m (ft) for 1 min, while dives in the winter seals dive to an average depth of 29 m for 1.5 min; maximum dive depths and durations have been recorded at 208 m (682 ft) and 6.5 min (Jefferson et al., 2008). No swim speed data are available.

There is no information available on subantarctic fur seal hearing. Males make three kinds of in-air vocalizations, including barks for territorial status, guttural growls, or puffs to state territorial boundaries, and high-intensity calls to warn or challenge other males, while females make a loud, tonal honk to call their pups. There is no direct information on frequency of calls of the subantarctic fur seal.

- **Northern fur seal (*Callorhinus ursinus*)**

Northern fur seals are currently classified as a vulnerable species under IUCN and depleted under the MMPA. There is no current global population estimate available for this species. The eastern Pacific stock is estimated to be 665,550 seals (Angliss and Allen, 2009). The San Miguel Island stock is estimated to be 9,424 seals (Carretta et al., 2009).

Northern fur seals are widely distributed across the North Pacific, and are generally associated with the continental shelf break. They range from northern Baja California, north to the Bering Sea, and across the Pacific to the Sea of Okhotsk and the Sea of Japan (Jefferson et al., 2008). Breeding sites include the Commander Islands, Kurile Islands, Pribilof Islands, Robben Island, Bogoslof Island, Farallone Islands, and San Miguel Island (Gentry, 2009). Pups leave land after about four months and must learn to hunt while migrating. The migration routes and distribution of pups is difficult to assess because they are small and difficult to recapture, but a known migration route exists through the Aleutian passes into the Pacific Ocean in November (Gentry, 2009).

Routine swim speeds during migration for this species are 2.85 km/hr (1.54 kts), and during foraging, swim speeds averaged between 0.89 and 2.28 km/hr (0.48 to 1.23 kts) (Ream et al., 2005). Maximum recorded dive depths of breeding females are 207 m (680 ft) in the Bering Sea and 230 m (755 ft) off southern California (Goebel, 1998). The average dive duration is near 2.6 min. Juvenile fur seals in the Bering Sea had an average dive time of 1.24±0.09 min, and an average depth of 17.5 m (57.4 ft) (Sterling and Ream, 2004). The maximum depth for juvenile fur seals was 175 m (574 ft) (Sterling and Ream, 2004).

The northern fur seal can hear sounds in the range of 500 Hz to 40 kHz (Moore and Schusterman, 1987; Babushina et al., 1991), with best hearing ranging from 2 and 12 kHz (Gentry, 2009a). Northern fur seals are known to produce clicks and high-frequency sounds under water (Frankel, 2009). Estimated source levels and frequency ranges are unknown. There are no available data regarding frequency of vocalizations.

- **Steller sea lion (*Eumetopias jubatus*)**

The Steller sea lion is also known as the northern sea lion. The species is classified as an endangered species under IUCN. The Western population is listed as endangered under the ESA, and the Eastern population is listed as threatened under the ESA. However, NMFS has proposed to delist the Eastern DPS (NOAA, 2012b). The Steller sea lion is considered depleted throughout its range under the MMPA. The worldwide population size for this species is estimated to be 100,000 (Loughlin, 2009). The eastern U.S. stock (east of Cape Suckling, Alaska) of Steller sea lions is estimated at between 45,095 and 55,832 individuals, while the western U.S. stock (west of Cape Suckling, Alaska) is estimated at 44,780 sea lions (Angliss and Allen, 2009).

Steller sea lions are found in temperate or sub-polar waters and are widely distributed throughout the North Pacific from Japan to central California, and in the southern Bering Sea. Breeding generally occurs during May through June in California, Alaska, and British Columbia. The northernmost rookery is found at Seal Rocks in Prince William Sound, Alaska, and the southernmost rookery is found at Ano Nuevo Island in California (Loughlin, 2009). They may haul out on sea ice in the Bering Sea and the Sea of Okhotsk, which is unusual for otariids.

Female Steller sea lions on foraging trips during the breeding season had a maximum dive depth of 236 m (774 ft), and the longest dive was greater than 16 min. The average dive depth for foraging females was 29.6 m (97.1 ft). Average dive time was recorded at 1.8 min (Rehberg et al., 2009). Swim speeds of this species are not known.

Kastelein et al. (2005) studied the differences between male and female Steller sea lion hearing and vocalizations; female and pup in-air vocalizations are described as bellows and bleats while underwater vocalizations are described as belches, barks, and clicks. Their study was conducted because Steller sea lion hearing may not resemble that of other tested otariids and because there are large size differences between males and females which mean there could be differences in the size structure of hearing organs and therefore differences in hearing sensitivities. The underwater audiogram of the male showed his maximum hearing sensitivity at 77 dB RL at 1 kHz, while the range of his best hearing, at 10 dB from the maximum sensitivity, was between 1 and 16 kHz and the average pre-stimulus responses occurred at low frequency signals (Kastelein et al., 2005). Female Steller sea lions maximum hearing sensitivity, at 73 dB RL, occurred at 25 kHz (Kastelein et al., 2005). The frequency range of underwater vocalizations was not shown and properly studied in this case because the equipment used could only record sounds audible up to 20 kHz. However, the maximum underwater hearing threshold from this study overlaps with the frequency range of the underwater vocalizations that were able to be recorded, and it was stated by the authors that the Steller sea lions in this study showed signs that they can hear the social calls of the killer whale (*Orcinus orca*), one of their main predators. The killer whale's echolocations clicks are between 500 Hz and 35 kHz, which is partially in the auditory range of the Steller sea lions in this study. This study also showed that low frequency sounds are audible (Kastelein et al., 2005).

Steller sea lion underwater sounds have been described as clicks and growls (Poulter, 1968; Frankel, 2009). Males produce a low frequency roar when courting females or when signaling threats to other males. Females vocalize when communicating with pups and with other sea lions. Pups make a bleating cry and their voices deepen with age (Loughlin, 2009). No available data exist on seasonal or geographical variation in the sound production of this species.

- **California sea lion (*Zalophus californianus*)**

California sea lions are listed as a least concern (lower risk) species under the IUCN. The population size for this species is estimated to be 238,000 seals (Carretta et al., 2009). California sea lions are common along the Pacific coast of the United States and Mexico, ranging from the Tres Marias Islands, Mexico, to the Gulf of Alaska, although California sea lions are rare farther north than Vancouver, British Columbia (Jefferson et al., 2008, Heath and Perrin, 2009). The principal breeding areas for the California sea lion are the Channel Islands off southern California, the islands off the coast of Baja California, Mexico, and in the Gulf of California (Heath and Perrin, 2009).

Lactating females have recorded dives to 247 m (810 ft), lasting over 10 min. Most foraging dives are shallower than 80 m (262 ft) and last less than 3 min (Jefferson et al., 2008). There is no swim speed information available for the California sea lion.

California sea lions can hear sounds in the range of 75 to 64 kHz. Low frequency amphibious hearing tests suggest that California sea lions are relatively insensitive to most anthropogenic sound in the water, as sea lions have a higher threshold (116.3 to 119.4 dB RL) at frequencies of 100 Hz (Kastak and Schusterman, 1998). Underwater sounds produced by California sea lions include barks, clicks, buzzes, and whinnies. Barks are less than 8 kHz with dominant frequencies below 3.5 kHz; the whinny call is typically between 1 and 3 kHz, and the clicks have dominant frequencies between 500 Hz and 4 kHz

(Schusterman, 1967). Buzzing sounds are generally from less than 1 kHz to 4 kHz, with the dominant frequencies occurring below 1 kHz (Schusterman, 1967).

- **Galapagos sea lion (*Zalophus wollebaeki*)**

Galapagos sea lions are classified as endangered under IUCN. The current population is estimated to be between 20,000 and 50,000 seals (Jefferson et al., 2008). Galapagos sea lions are an equatorial species closely related to California sea lions. Their range is restricted to the Galapagos Islands with a small colony on La Plata Island off the coast of Ecuador. Occasionally, vagrants can be seen along the Ecuador and Columbia coasts, particularly around Isla del Coco, Costa Rica, and Isla del Gorgona (Heath and Perrin, 2009).

Galapagos sea lions are a non-migratory species that forage within a few kilometers of the coast, feeding during both the day and night. Their dives average 91.8 ± 35.2 m (301.2 ± 115.5 ft) but have been known to reach as deep as 149 m (489 ft). Average dive duration is 4.0 ± 0.9 min (Villegas-Amtmann et al., 2008). Swim speeds are typically about 2 m/sec (3.9 kts) (Williams, 2009). There is no information available on the hearing abilities or sound production of this species.

- **Australian sea lion (*Neophoca cinerea*)**

The Australian sea lion is listed as endangered under the IUCN due to its small, genetically fragmented population, which appears to be declining at some colonies. Additionally, most major colonies are at risk of extinction from fishery bycatch. The Seal Bay area has been designated as a conservation park for these sea lions (Ling, 2009). The total population of Australian sea lions has most recently been estimated as 9,794 animals (Ling, 2009).

The Australian sea lion is a temperate species found only along the south and west coast of Australia (Jefferson et al., 2008). About 73 colonies exist, with 47 in southern Australia and 26 in western Australia, although only six colonies produce are large enough to produce more than 100 pups per season (Ling, 2009). The largest breeding colonies are located on Purdie Islands, Dangerous Reef, Seal Bay, and The Pages (Ling, 2009).

Females and juveniles do not typically migrate. Australian sea lions are fast, powerful swimmers (Ling, 2009). Female Australian sea lions dive to an average depth and duration of 42 to 83 m (ft) and 2.2 to 4.1 min, with maximum dives ranging from 60 to 105 m (344 ft) (Jefferson et al., 2008). The average duration of all foraging dives was 3.3 min, with a maximum dive time of 8.3 min (Costa and Gales, 2003).

There is no information available on the hearing abilities or sound production of this species. However, females have reported to emit low-frequency pup-attraction calls, while pups emit higher frequency calls (Richardson, et al., 1995).

- **New Zealand sea lion (*Phocarctos hookeri*)**

The New Zealand sea lion, also known as Hooker's sea lion, is listed under the IUCN as vulnerable. This sea lion has an estimated abundance of 12,500 individuals and is considered to be a stable population (Gales, 2009).

This rarely occurring sea lion is endemic to New Zealand waters and has one of the most restricted ranges of all pinnipeds (Gales, 2009). This sea lion occur in two geographically isolated and genetically distinct populations around New Zealand and southern and western coast of Australia (Jefferson et al., 2008). Although once found in all the New Zealand waters, the current breeding range of the New Zealand sea lion is limited to two groups of subantarctic islands, the Auckland and Campbell Islands, with pups occasionally born along the shore of the South Island; approximately 86% of New Zealand sea lion pups are born in the Auckland Islands (Gales, 2009).

New Zealand sea lions are among the deepest and longest divers of the otariids, diving to a mean water depth of 123 m (404 ft) with an average dive duration of 3.9 min (Gales, 2009). The maximum foraging dive depth recorded for a lactating female was 550 m (1,804 ft) and the longest dive time was 11.5 min (Costa and Gales, 2000). Swim speeds are about 1.3 m/sec (2.5 kts) (Williams, 2009).

There is no information available on the hearing abilities of this species. New Zealand sea lions all bark and produce clicks under water (Poulter, 1968).There is no direct data on frequency of vocalizations.

- **South American sea lion (*Otaria flavescens*)**

South American sea lions are listed as a least concern (lower risk) species under the IUCN. The current total population is estimated to be between 200,000 and 300,000 seals (Jefferson et al., 2008), with 110,000 sea lions occurring along the southwestern Atlantic coastal areas (Cappozzo and Perrin, 2009).

South American sea lions are nearly continuously distributed along most of South America from southern Brazil to northern Peru, including the Falkland Islands and Tierra del Fuego (Jefferson et al., 2008). This sea lion is principally concentrated in central and southern Patagonia, where more than 53 breeding colonies are found (Cappozzo and Perrin, 2009). The South American sea lion is primarily found in continental shelf and continental slope waters (Jefferson et al., 2008).

Campagna et al. (2001) found the dives of South American sea lions to be short, typically less than 4 min, and shallow, from 2 to 30 m (6.6 to 98 ft). The maximum depth to which a South American sea lion has been recorded diving is 175 m (574 ft) and the maximum dive duration of 7.7 min (Werner and Campagna, 1995). Median swim speed recorded for this species was 2.7 km/hr (1.46 kt) (Campagna et al., 2001).

There is no information available on the hearing abilities of the South American sea lion. South American sea lions produce most vocalizations during their breeding season, with airborne calls by males characterized as high-pitched, directional calls, barks, growls, and grunts while females exhibited grunts and specific calls with their pups that were long duration and harmonically rich (Ferńandez-Juricic et al., 1999). Frequencies of the measured South American sea lion vocalizations ranged widely from 240 to 2240 Hz (Ferńandez-Juricic et al., 1999).

3.2.5.2 Phocidae Species

The family Phocidae includes 18 species of true or earless seals, of which eight species have been eliminated from further consideration in this document since they occur in areas (polar or inshore) where SURTASS LFA sonar will not operate, leaving 10 phocid seal species to be considered (Table 3-5).

- **Mediterranean monk seal (*Monachus monachus)***

Mediterranean monk seals are listed as endangered under the ESA, classified as critically endangered under IUCN, and protected under CITES. The worldwide population size for this species is estimated to be between 350 and 450 animals (Jefferson et al., 2008), with the largest population of 250-300 seals found in the eastern Mediterranean (Gilmartin and Forcada, 2009). The two breeding populations at Cap Blanc, with about 120 seals, and in the Desertas Islands of the Madeira Islands group, with about 25 seals, remain (Gilmartin and Forcada, 2009).

Although severely contracted from its former range, Mediterranean monk seals are currently distributed throughout the Mediterranean, Black, Ionian, and Aegean Seas and the Sea of Marmara, and in the eastern North Atlantic Ocean from the Strait of Gibraltar south to Mauritania and the Madeira Island (Jefferson et al., 2008; Gilmartin and Forcada, 2009). There is no evidence of seasonal movement for this species. Mediterranean monk seals exhibit high site fidelity and thus only occupy part of their suitable range and habitat (Gilmartin and Forcada, 2009).

No direct data are available on swim speed. Dendrinos et al. (2007) reported a maximum water depth of 123 m (404 ft) for a rehabilitated monk seal that was tagged and released in the Mediterranean Sea. Gazo and Aguilar (2005), however, described the maximum dive depth and duration as 78 m (256 ft) and 15 min while the mean dive depth and duration of the dives of a lactating female were 30 m (98 ft) and 5 min (Gazo and Aguilar, 2005). Kiraç et al. (2002) recorded mean dive durations of 6.4 min for adults and 6.8 min for juveniles.

Although no data are available on underwater hearing or vocalizations of Mediterranean monk seals, some limited data are available for in-air vocalizations of Hawaiian monk seals. Recorded in-air vocalizations of Hawaiian monk seals consist of what has been referred to as a liquid bubble sound (100 to 400 Hz), a guttural expiration (about 800 Hz) produced during short-distance agonistic encounters, a roar (<800 Hz) for long-distance threats, a belch-cough made by males when patrolling (<1 kHz), and sneeze/snorts/coughs of variable frequencies that are <4 kHz (Miller and Job, 1992).

- **Hawaiian monk seal (*Monachus schauinslandi*)**

Hawaiian monk seals are listed as endangered under the ESA, classified as endangered under IUCN, and protected under CITES. Critical habitat for the Hawaiian monk seal has been established from the shore to 37 m (121 ft) of water depth in 10 areas of the Northwest Hawaiian Islands (NWHI) (NOAA, 1988). In 2011, revisions to the Hawaiian monk seal's critical habitat were proposed. The proposed critical habitat would extend the current critical habitat boundaries in the NWHI, including Sand and Midway Islands, from the 37-m to 500-m (121 to 1,640 ft) isobath and would include six new areas in the Main Hawaiian Islands from 5-m (16 ft) on land to the 500-m (1,640 ft) seaward isobath (NOAA, 2011). The best available population estimate for this species is 1,161 individuals (Carretta et al., 2010).

Hawaiian monk seals range throughout the Hawaiian Archipelago and Johnson Atoll (NOAA, 2011). Since the early 1990s, a small but increasing population of monk seals and an increasing number of annual births has been documented in the Main Hawaiian Islands (NOAA, 2011). Hawaiian monk seals exhibit high site fidelity to their natal island (Gilmartin and Forcada, 2009). Monk seals spend a greater proportion of their time at sea, in water depths ranging from 1 to 300 m (3 to 984 ft) in shelf, slope, and bank habitats but come ashore (haul out) on a variety of substrates, including sandy beaches, rocky shores, rock ledges, and emergent reefs. Pupping only occurs on sandy beaches adjacent to protected waters.

No swim speed data are available. This species commonly dive to depths of less than 100 m (328 ft) but have been recorded diving down to depths of 300 to 500 m (984 to 1,640 ft) (Parrish et al., 2002). The Hawaiian monk seal can also dive for up to 20 min and perhaps longer (Parrish et al., 2002). Routine dives range from 3 to 6 min in principally shallow water depths from 10 to 40 m (33 to 131 ft) (Stewart, 2009).

Only one audiogram has been recorded for the Hawaiian monk seal, which indicated relatively poor hearing sensitivity, a narrow range of best hearing sensitivity (12 to 28 kHz), and a relatively low upper frequency limit (Thomas et al., 1990; Kastak and Schusterman, 1999). Above 30 kHz, high-frequency hearing sensitivity dropped markedly (Thomas et al., 1990). However, the audiogram was obtained from a single, untrained seal whose hearing curve suggested that its responses may have been affected by disease or age (Reeves et al., 2001). No underwater sound production has been reported for this species. Recorded in-air vocalizations of Hawaiian monk seals consist of a variety of sounds, including a liquid bubble sound (100 to 400 Hz), a guttural expiration (about 800 Hz) produced during short-distance agonistic encounters, a roar (<800 Hz) for long-distance threats, a belch-cough made by males when patrolling (<1 kHz), and sneeze/snorts/coughs of variable frequencies that are <4 kHz (Miller and Job, 1992).

- **Northern elephant seal (*Mirounga angustirostris)* and Southern elephant seal *(M. leonina)***

The total population estimate for the northern elephant seal is over 150,000 (Jefferson et al., 2008). The population estimate for the California breeding stock of this species is 124,000 as of 2005 (Carretta et al., 2009). The population of southern elephant seals has been estimated at 650,000 seals (Jefferson et al., 2008). Two major populations of southern elephant seals are experiencing a decline while northern elephant seals are increasing in number.

Northern elephant seals occur throughout the northeast north-central Pacific Ocean (Jefferson et al., 2008). They occur during the breeding season from central Baja, Mexico to central California in about 15 colonies (LeBoeuf and Laws, 1994; Stewart and DeLong, 1994). Most of the colonies are located on offshore islands. Northern elephant seals make long, seasonal migrations between foraging and breeding areas, with some individuals making two return trips per year, returning to their southern breeding grounds to molt (Hindell and Perrin, 2009). Northern elephant seals are frequently observed along the coasts of Oregon, Washington, and British Columbia and may reach as far north as the Gulf of Alaska and the Aleutian Islands during foraging bouts (Le Boeuf, 1994). Southern elephant seals have a large range and occur on colonies around the Antarctic Convergence, between 40° and 62°S (King and Bryden, 1981; Laws, 1994). Breeding takes place near the sub-Antarctic zone and sometimes a pup is born on the Antarctic mainland. Southern elephant seals range throughout the Southern Ocean from the Antarctic Polar Front to the pack ice. During non-breeding seasons, both the southern and the northern elephant seals are widely dispersed (Hindell and Perrin, 2009).

Elephant seals spend as much as 90% of their time submerged and are remarkable divers, diving to depths >1,500 m (>4,921 ft) for 120 min (Le Boeuf and Laws, 1994; Hindell and Perrin, 2009). In a study by Davis et al. (2001), an average elephant seal dive duration was recorded as 14.9 min to a maximum dive depth of 289 m (948 ft); average swimming speed was recorded as 1.1 m/sec (2.1 kts). Le Boeuf et al. (1989) reported that northern elephant seals dive to average depths of 500 to 700 m (1,640 to 2,297 ft) with most dives lasting 17 to 22.5 min with the longest dive duration as 62 min. Continuous deep dives are the normal state for these pelagic, deep divers. Dive depths and durations differ between adult male and females depending on the season and geographic location (Stewart, 2009).

Elephant seals may have poor in-air hearing sensitivity due to their aquatic and deep-diving lifestyle. Their ears may be better adapted for in-water hearing in terms of energy efficiency, which is reflected in the lower intensity thresholds under water, as well as receiving and transducing the mechanical stimulus which is reflected in the lower pressure thresholds under water (Kastak and Schusterman, 1999). Kastak and Schusterman (1999) found that hearing sensitivity in air is generally poor, but the best hearing frequencies were found to be between 3.2 and 15 kHz with the greatest sensitivity at 6.3 kHz and an upper frequency limit of 20 kHz (all at 43 dB re: 20 µPa). Underwater, the best hearing range was found to be between 3.2 and 45 kHz, with greatest sensitivity at 6.4 kHz and an upper frequency limit of 55 kHz (all at 58 dB RL) (Kastak and Schusterman, 1999). Kastak and Schusterman (1998) found that northern elephant seals can hear underwater sounds in the range of 75 Hz to 6.3 kHz. Kastak and Schusterman (1996) found hearing sensitivity increased for frequencies below 64 kHz, and the animals were still able to hear sounds below 100 Hz. One juvenile was measured as having a hearing threshold of 90 dB RL at 100 Hz (Fletcher et al., 1996). Since their hearing is better underwater, it is assumed that elephant seals are more sensitive to anthropogenic low frequency sound (Kastak and Schusterman, 1996). There are no direct hearing data available for southern elephant seals.

Elephant seals have developed high-amplitude, low-frequency vocal signals that are capable of propagating large distances. Elephant seals are highly vocal animals on their terrestrial rookeries and are not known to make any vocalizations underwater. Their in-air vocalizations are important for maintaining a social structure. Both sexes of all age classes are vocal. Two main sounds are produced by adults: calls of threat and calls to attract a mate. Yearlings often make a hissing sound (Bartholomew and Collias, 1962). The harmonics in pup calls may be important for individual recognition, extending to frequencies of 2 to 3 kHz (Kastak and Schusterman, 1999). The calls made by males are typically low-frequency, around 175 Hz (Fletcher et al., 1996).

Male northern elephant seals make three in-air sounds during aggression: snorting (200 to 600 Hz, clap threat (up to 2.5 kHz), and snoring (Frankel, 2009). In the air, mean frequencies for adult male northern elephant seal vocalizations range from 147 to 334 Hz (Le Boeuf and Peterson, 1969; Le Boeuf and Petrinovich, 1974). Burgess et al. (1998) recorded 300 Hz pulses from a juvenile female elephant seal between 220 to 420 m (722 to 1,378 ft) dive depths. Adult female northern elephant seals have been recorded with airborne call frequencies of 500 to 1,000 Hz (Bartholomew and Collias, 1962). Pups produce a higher frequency contact call up to 1.4 kHz (Frankel, 2009). There are no available data regarding seasonal or geographical variation in the sound production of either species.

- **Ribbon seal (*Phoca fasciata*)**

Ribbon seals are classified as a data deficient species by the IUCN. Although no current abundance estimates are available for regional or global populations, Burns (1981) estimated the worldwide population of ribbon seals at 240,000 in the mid-1970s, with an estimate for the Bering Sea at 90,000-100,000, while Fedoseev (2000) reported an average population of 370,000 ribbon seals in the Sea of Okhotsk between 1968 and 1990. Mizuno et al. (2002) reported an average abundance of 2,697 seals for the southern Sea of Okhotsk off Hokkaido, Japan for March through April 2000.

The distribution of ribbon seals is limited to the northern North Pacific Ocean and an area of the Arctic Ocean north of the Chukchi Sea, with predominant occurrence in the Bering Sea and Sea of Okhotsk (Jefferson et al., 2008; Fedoseev, 2009). Ribbon seals are associated with the southern edge of the pack ice from winter through early summer, where they pup and molt on the ice that is commonly found along the continental shelf where there is high water circulation (Fedoseev, 2009). During the summer months, ribbon seals have a pelagic phase that may encompass a broader distributional range than when the seals are dependent upon sea ice (Jefferson et al., 2008). Swim speeds and dive data are unknown for this species.

There is no direct measurement of auditory threshold for the hearing sensitivity of the ribbon seal (Thewissen, 2002). Ribbon seals produce underwater sounds between 100 Hz and 7.1 kHz with an estimated SEL recorded at 160 dB (Watkins and Ray, 1977). These seals produce two types of underwater vocalizations, short, broadband puffing noises and downward-frequency sweeps that are long and intense, include harmonics, vary in duration, and do not waver; puffs last less than 1 second and are below 5 kHz while sweeps are diverse and range from 100 Hz to 7.1 kHz (Watkins and Ray, 1977). These authors speculated that these sounds are made during mating and for defense of their territories. There are no available data regarding seasonal or geographical variation in the sound production of this species.

- **Spotted seal (*Phoca largha*)**

Spotted or largha seals are classified as a data deficient species by the IUCN. The Southern Distinct Population Segment of spotted seals, which consists of breeding concentrations in the Yellow Sea and Peter the Great Bay in China and Russia, is listed as threatened under the ESA. The global population for this species is unknown. Jefferson et al. (2008) reported abundances of between 100,000 and 135,000 spotted seals in the Bering Sea, 100,000 to 130,000 seals in the Sea of Okhotsk, and an estimated 4,500 seals in the Bohai Sea off China. The last reliable population estimate for the Bering Sea stock of spotted seals was estimated in 1992, with a maximum of 59,214 seals (Angliss and Allen, 2009). Trukhin (2005 as reported in Burns, 2009) reported an overall population estimate of 290,000 seals in the 1990s. Mizuno et al. (2002) reported an average abundance of 10,099 seals in the southern Sea of Okhotsk off Hokkaido, Japan for March and April 2000. Additionally, Trukhin and Mizuno (2002) reported 1,000 spotted seals in Peter the Great Bay (southwestern Sea of Okhotsk area) and that this population had maintained this stable number of seals for at least 10 years.

Spotted seals occur in temperate to polar regions of the North Pacific Ocean from the Sea of Okhotsk, the Sea of Japan, and the Yellow Sea to the Bering and Chukchi Seas into the Arctic Sea to the Mackenzie River Delta (Jefferson et al., 2008). Spotted seals spend their time either in open-ocean waters or in pack-ice habitats throughout the year, including the ice over continental shelves during the winter and spring (Burns, 2009). This species hauls out on sea ice but also comes ashore on land during the ice-free seasons of the year. The range of spotted seals contracts and expands in association with the ice cover; their distribution is most concentrated during the period of maximum ice cover (Burns, 2009).

When the ice cover recedes in the Bering Sea, some spotted seals migrate northward into the Chukchi and Beaufort Seas. These animals spend the summer and fall near Point Barrow in Alaska and the northern shores of Chukotka, Russia. With increasing ice cover, the spotted seals migrate southward through the Chukchi and Bering Sea region to maintain association with drifting ice. Peak haul-out time is during molting and pupping from February to May (Burns, 2009). Swim speeds and dive times of this species are not known. Dives as deep as 300 to 400 m (984 to 1,312 ft) have been reported for adult spotted seals with pups diving to 80 m (263 ft) (Bigg, 1981).

There is no direct measurement of auditory threshold for the hearing sensitivity of the spotted seal (Thewissen, 2002). Underwater vocalization of captive seals increased 1 to 2 weeks before mating and was higher in males than females. Sounds produced were growls, drums, snorts, chirps, and barks ranging in frequency from 500 Hz to 3.5 kHz (Richardson et al., 1995).

- **Harbor seal (*Phoca vitulina*)**

Harbor seals are also known as common seals. This species is classified as least concern (lower risk) by the IUCN. The global population of harbor seals is estimated to be between 300,000 and 500,000 seals (Jefferson et al., 2008). Five subspecies of the harbor seal have been classified throughout the Northern Hemisphere. In the western North Atlantic there are an estimated 99,340 seals (Waring et al., 2009). In Alaska including the Gulf of Alaska and the Bering Sea, the statewide population of harbor seals is estimated to be 180,017 individuals (Angliss and Allen, 2009). The California stock estimate of harbor seals is estimated to be 34,233 seals, while in Oregon and Washington, 24,732 seals are estimated (Carretta et al., 2009). In inland Washington, there are an estimated 14,612 harbor seals (Carretta et al., 2009).

Harbor seals are one of the most widely distributed pinnipeds in the world. This species is widely distributed in Polar and temperate waters along the margins of the eastern and western North Atlantic Ocean, and the North Pacific Ocean (Jefferson et al., 2008). They also can be found in the southern Arctic Ocean (Jefferson et al., 2008). This species is most commonly found in coastal waters of the continental shelf waters, and can be found in rivers, bays, and estuaries (Jefferson et al., 2008).They primarily inhabit areas that are ice-free. The greatest numbers of breeding animals occur in the northern temperate zone. However, breeding colonies occur both north and south of the zone, depending on environmental, oceanic, and climate conditions.

Harbor seals are generally considered to be sedentary, but their known seasonal and annual movements are varied. They haul out mainly on land, but they do use icebergs in Alaska and Greenland. When they haul out on land, they prefer natural substrates of mud flats, gravel bars and beaches, and rocks. Breeding grounds are generally associated with isolated places such as pack ice, offshore rocks, and vacant beaches (Riedman, 1990).

Maximum swim speeds have been recorded over 13 km/hr (7 kts) (Bigg, 1981). The deepest diving harbor seal was located in Monterey Bay, California, and dove to a depth of 481 m (1,578 ft), and the longest dive lasted 35.25 min (Eguchi and Harvey, 2005). In general, seals dive for less than 10 min, and above 150 m (492 ft) (Jefferson et al., 2008).

Hanggi and Schusterman (1994) and Richardson et al. (1995) reported harbor seal sounds. Social sounds ranged from 0.5 to 3.5 kHz, Clicks range from 8 to more than 150 kHz with dominant frequencies between 12 and 40 kHz. Roars range from 0.4 to 4 kHz with dominant frequencies between 0.4 and 0.8 kHz. Bubbly growls range from less than 0.1 to 0.4 kHz with dominant frequencies at less than 0.1 to 0.25 kHz. Grunts and groans range from 0.4 to 4 kHz. Creaks range from 0.7 to 7 kHz with dominant frequencies between 0.7 and 2 kHz. This species creates a variety of sounds including clicks, groans, grunts, and creaks.

Van Parijs et al. (2000) studied the variability in vocal and dive behavior of male harbor seals at both the individual and the geographic levels. Harbor seals are an aquatic-mating species. The females are forced to forage to sustain a late lactation. For this reason, harbor seals are widely distributed throughout the mating season. Male harbor seals produce underwater vocalizations and alter their dive behavior during mating season. In Scotland, male harbor seals are found to alter their dive behavior in the beginning of July for the mating season. They change from long foraging dives to short dives. Changes in dive behavior during the mating season have also been reported in Norway and Canada. Individual variation in vocalization of male harbor seals has also been recorded in California breeding populations. Male vocalizations also varied individually and geographically in Scotland. This study showed the variability in male vocalizations individually and geographically, as well as the change in dive behavior (Van Parijs et al., 2000).

Van Parijs and Kovacs (2002) studied the eastern Canadian harbor seal in-air and underwater vocalizations. It was determined that harbor seals produce a range of in-air vocalizations and one type of underwater vocalization. The number of vocalizations increased proportionally with the number of individuals present at the haul out sites. In-air vocalizations were predominantly emitted by adult males during agnostic interactions, which suggest that in-air vocalizations are used during male competition. In-air vocalizations were also produced by adult females and sub-adult males which suggest that some types of in-air vocalizations may serve for general communication purposes. The harbor seals in the study also produced underwater roar vocalizations during the mating season. These vocalizations are similar to that of other harbor seals in other geographic locations (Van Parijs and Kovacs, 2002).

The harbor seal can hear sounds in the range of 75 Hz to a maximum of 180 kHz (Mohl, 1968b; Terhune, 1991; Kastak and Schusterman, 1998). Richardson et al. (1995) reported that phocid seals have a mostly flat audiogram from 1 kHz up to approximately 50 kHz with hearing thresholds between 60 and 85 dB RL. In a study by Wolski et al. (2003), harbor seals' hearing was measured using the method of constant stimuli. It was found that harbor seals have good sensitivity between 6 and 12 kHz, and the best sensitivity at 8 kHz at 8.1 dB re 20 $\mu Pa^2 s$ (Wolski et al., 2003).

- **Gray seal (*Halichoerus grypus*)**

Gray seals are classified as a least concern (lower risk) species by the IUCN. Gray seals have a global population estimate of 380,000 seals (Jefferson et al., 2008). In the western North Atlantic there is an estimated population of 125,541 to 169,064 seals (Waring et al., 2009) In the Baltic Sea there is an estimated 17,600 gray seals (Jefferson et al., 2008).

Gray seals occur in temperate and sub-polar regions mostly in the north Atlantic Ocean Baltic Sea and the eastern and North Atlantic (Jefferson et al., 2008). Gray seals breed on remote islands that are typically uninhabited or on fast ice. The biggest island breeding colony is on Sable Island (Hall and Thompson, 2009). Gray seals breed on drifting ice and offshore islands throughout their range. This species is not known to undergo seasonal movements.

Swim speeds average 4.5 km/hr (2.4 kts). Gray seals dives are short, between 4 and 10 min, with a maximum dive duration recorded at 30 min (Hall and Thompson, 2009). A maximum dive depth of over 300 m (984 ft) has been recorded for this species, but most dives are relatively shallow, from 60 to 100 m (197 to 328 ft) to the seabed (Hall and Thompson, 2009).

Gray seals' underwater hearing range has been measured from 2 kHz to 90 kHz, with best hearing between 20 kHz and 50 to 60 kHz (Ridgway and Joyce, 1975). Gray seals produce in-air sounds at 100 Hz to 16 kHz, with predominant frequencies between 100 Hz and 4 kHz for seven characterized call types, and up to 10 kHz for "knock" calls (Asselin et al., 1993). Oliver (1978) has reported sound frequencies as high as 30 and 40 kHz for these seals. There is no available data regarding seasonal or geographical variation in the sound production of gray seals.

- **Hooded seal (*Cystophora cristata*)**

Hooded seals are classified as a vulnerable species by the IUCN. The global population of hooded seals is estimated at 660,000 seals (Kovacs, 2009). Three stocks are recognized to set harvest quotas: Canadian, Davis Strait, and the West Ice (west of Jan Mayen Island) stocks (Kovacs, 2009). The abundance of the West Ice stock has been stable at around 70,000 hooded seals for the last 20 years (Kovacs, 2009).

Hooded seals are found in the high latitudes of the North Atlantic Ocean, and in the Arctic Ocean (Jefferson et al., 2008). Hooded seals are solitary animals except when breeding or molting and are found in the deeper waters of the North Atlantic, primarily off the east coast of Canada, Gulf of St. Lawrence, Newfoundland, Greenland, Iceland, Norwegian waters, and the Barents Sea (Kovacs, 2009). Their winter distribution is poorly understood, but some seals inhabit the waters off Labrador and northeastern Newfoundland, on the Grand Bank, and off southern Greenland (Jefferson et al., 2008). Hooded seals are associated with the outer edge of pack ice and drifting ice throughout much of the year, moving with the drifting pack ice; seals congregate on ice floes for both mating and pupping (Kovacs, 2009). Hooded seals are a migratory species and are often seen far from their haul-outs and foraging sites. Records of migrant hooded seals are not unusual, with juveniles having been observed as far south as Portugal, the Caribbean Sea, and California (Mignucci-Giannnoni and Odell, 2001).

Swim speeds are not known. On average, dive times have been recorded at 15 min or longer. Dive depths range between 100 to 600 m (300 to 2,000 ft). A maximum dive record shows a depth of over 1,000 m (3,280 ft) lasting almost an hour (Kovacs, 2009 in Perrin et al., 2009).

There is no direct measurement of auditory threshold for the hearing sensitivity of the hooded seal (Thewissen, 2002). Hooded seals produce a variety of distinct sounds ranging between 500 Hz and 6 kHz (Frankel, 2009). There are at least three types of LF, pulsed sounds, described as grunt, snort, and buzz that are made by the male underwater. The grunt noise has the highest intensity in the 0.2 and 0.4 kHz range (Terhune and Ronald, 1973). The snort has a broad band of energy ranging between 0.1 and 1 kHz with harmonics occasionally reaching 3 kHz. The buzz has most of its energy at 1.2 kHz with side bands and harmonics reaching 6 kHz (Terhune and Ronald, 1973). All three calls exhibited some pulsing. Female calls in air have major intensities at frequencies of less than 0.5 kHz with a low harmonic and an exhalation of 3 kHz at the end of the call. The sounds produced by hooded seals have a variety of functions ranging from female-pup interactions to fighting behavior and visual displays among males (Terhune and Ronald, 1973; Frankel, 2009). The source levels of these sounds have not been estimated, and there are no available data regarding seasonal or geographical variation in the sound production of hooded seals.

- **Harp seal (*Pagophilus groenlandicus*)**

The harp seal is considered least concern by the IUCN. Population sizes for the three stocks of harp seals in the North Atlantic Ocean were recently estimated as 5.5 million seals for the northwest Atlantic stock, 741,670 animals in the West Ice stock (Greenland Sea near Jan Mayen Island), and 2,425,480 harp seals in the White Sea (Lavigne, 2009; Waring et al., 2009).

Harp seals only occur in the North Atlantic and Arctic Oceans and adjacent seas from northern Russia to Newfoundland and the Gulf of St. Lawrence, Canada in three defined stocks: the “Front” or northwest Atlantic (Newfoundland, Labrador, and the Gulf of St. Lawrence), the “West Ice” or Greenland Sea near Jan Mayen Island, and the “East Ice” in the Barents and White Seas (Waring et. al., 2009). Since 1994, however, increasing and substantial numbers of harp seals, often juveniles, have been recorded in the western North Atlantic from the Gulf of Maine southward to New Jersey (McAlpine and Walker, 1999;

McAlpine et al., 1999; Harris et al., 2002). In the nearly 150 years prior to 1994, only 16 harp seals were reported in the northern Gulf of Maine, while recently more than that number are now reported annually in the Gulf of Maine and southern New England (McAlpine et al., 1999; Waring et al., 2009). Reports of increasing numbers of reported harp seals along the coast of western continental Europe (Denmark to northern Spain) have also reported within the same time period (Van Bree, 1997). The southern limit of the harp seal's range in the western North Atlantic is now considered to extend into the northeastern U.S. waters during winter and spring (Waring et al., 2009).

Previously, harp seals were thought to be shallow divers, but dives to maximum water depths of 568 m (Folkow et al., 2004) and dive durations up to 16 min (Schreer and Kovacs, 1997) now demonstrate that harp seals are moderately deep divers. Folkow et al. (2004) found that more than 12% of all dives recorded during their study were to depths more than 300 m. Harp seal's mean dive durations range from 3.8 to 8.1 min (Lydersen and Kovacs, 1993; Folkow et al., 2004).

The ear of the harp seal is adapted to hear better underwater than in air, as demonstrated by the decreased hearing sensitivity measured in air (Terhune and Ronald, 1971). In-water, harp seals hearing was measured by freefield audiogram from 760 Hz to 100 kHz, with greatest sensitivity at 2 and 23 kHz and thresholds between 60 and 85 dB re 1 µPa (Terhune and Ronald, 1972; Richardson et al., 1995), while the in-air audiogram, measured from 1 to 32 kHz, has the lowest threshold at 4 kHz while the frequency range from 16 to 32 kHz remains constant (Terhune and Ronald, 1971; Ronald and Healey, 1981). Above 64 kHz, the in-water hearing threshold increases by 40 dB per octave (Ronald and Healey, 1981).

Harp seals produce as many as 26 different underwater vocalizations that are usually short in duration and have been described as whistles, grunts, trills, chirps, clicks, knocks, and squeaks (Ronald and Healey, 1981; Serrano, 2001). These seals are especially vocal during breeding, producing as many as 135 calls/min (Serrano and Terhune, 2002). Frequencies of the varied in-water vocalizations range from about 400 to 849 Hz while in-air vocalizations are lower, at about 206 Hz (Serrano, 2001). Harp seals most likely use frequency and temporal separation of their vocalizations together with a wide vocal repertoire (as many as 26 call types) to avoid masking one another (Serrano and Terhune, 2002).

3.2.6 PROTECTED HABITATS

Many habitats in the marine environment are protected for a variety of reasons, but typically habitats are designated to conserve and manage natural and cultural resources. Protected marine and aquatic habitats have defined boundaries and are typically enabled under some Federal, State, or international legal authority. Habitats are protected for a variety of reasons including intrinsic ecological value; biological importance to specific marine species or taxa, which are often also protected by federal or international agreements; management of fisheries; and cultural or historic significance. Three types of marine and aquatic habitats protected under U.S. legislation or Presidential EO, critical habitat, essential fish habitat, and marine protected areas, are described in this section.

3.2.6.1 Critical Habitat

The ESA, and its amendments, require the responsible agencies of the Federal government to designate critical habitat for any species that it lists under the ESA. Critical habitat is defined under the ESA as:

1. the specific areas within the geographic area occupied by a listed threatened or endangered species on which the physical or biological features essential to the conservation of the species are found, and that may require special management consideration or protection; and
2. specific areas outside the geographic area occupied by a listed threatened or endangered species that are essential to the conservation of the species (16 U.S.C. §1532(5)(A), 1978).

Critical habitat is not designated in foreign countries or any other areas outside U.S. jurisdiction. Although not required, critical habitat may be established for those species listed under the ESA prior to the 1978 amendments to the ESA that added critical habitat provisions. Under Section 7 of the ESA, all Federal agencies must ensure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or destroy or adversely modify its designated critical habitat. Critical habitat designations must be based on the best scientific information available and designated in an open public process and within specific timeframes. Before designating critical habitat, careful consideration must be given to the economic impacts, impacts on national security, and other relevant impacts of specifying any particular area as critical habitat.

Seventy-three marine and anadromous species have been listed as threatened or endangered under the ESA. Critical habitat has only been designated for six of the ESA-listed marine mammal, three sea turtle, nine marine or anadromous fish, and three marine invertebrate or plant species (Table 3-6; NMFS, 2011). Although NMFS has jurisdiction over many marine and anadromous species listed under ESA and their designated critical habitat, the U.S. Fish and Wildlife Service also has jurisdiction over marine/anadromous species, such as the manatee, polar bear, walrus, and sea otter; and shares jurisdiction with NMFS for some species, such as the Atlantic salmon, gulf sturgeon, and all sea turtles.

3.2.6.2 Essential Fish Habitat—U.S. EEZ Waters

In recognition of the critical importance that habitat plays to all lifestages of fish and invertebrate species, the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended, protects habitat essential to the production of federally managed marine and anadromous species within the U.S. EEZ. The MSFCMA, reauthorized and amended by the Sustainable Fisheries Act, called for the identification and protection essential fish habitat (EFH). Under the MSFCMA, the NMFS has exclusive federal management authority over U.S. domestic fisheries resources and oversees the nine regional fishery management councils (FMCs) and approves all Fishery Management Plans (FMPs). The 1996 EFH mandate and 2002 Final EFH Rule require that regional FMCs, through federal FMPs, describe and identify EFH for each federally managed species, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitats. The NMFS' Highly Migratory Species (HMS) Division functions as a FMC (Secretarial FMC) to oversee EFH designation and FMP preparation for Atlantic highly migratory species, such as sharks and tuna, since the habitat essential to these species may cross FMC and federal jurisdictional boundaries (NMFS, 2009a).

Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" and the term "fish" as "finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds" (16 U.S.C. §1802[10]). The regulations for implementing EFH clarify that "waters" include all aquatic areas and their biological, chemical, and physical properties, while "substrate" includes the sediment, hard bottom, structures underlying the waters, and associated biological communities that make these areas suitable fish habitats (NOAA, 2002). Habitats used at any time during a species' life cycle (i.e., during at least one of its lifestages) must be accounted for when describing and identifying EFH, including inshore bays and estuaries (NOAA, 2002). Habitat areas of particular concern (HAPC) are subsets of EFH areas that are designated to indicate an areas' rarity, susceptibility to anthropogenic-induced degradation, special ecological importance, or location in an environmentally stressed region. HAPC do not confer additional protection or restriction but are intended to prioritize conservation efforts.

The MSFCMA requires federal agencies that fund, permit, or carry out activities that may adversely affect EFH to consult with the NMFS regarding the potential impacts of the federal actions on EFH and respond

Table 3-6. Marine and anadromous species listed under the ESA for which critical habitat has been designated.

Species	Status Under ESA	Listed Distinct Population Segment (DPS)/Population/Evolutionarily Significant Unit (ESU)	Critical Habitat—Type of Habitat Designated
Marine Mammals			
Beluga whale	Endangered	Cook Inlet	Inshore
Killer whale	Endangered	Southern Resident	Inshore
North Atlantic right whale	Endangered		Marine, nearshore and >12 nmi
North Pacific right whale	Endangered		Marine, nearshore and >12 nmi
Hawaiian monk seal	Endangered		Marine, nearshore <12 nmi
Steller sea lion	Threatened	Eastern	Marine, nearshore and >12 nmi
	Endangered	Western	Marine, nearshore <12 nmi
Sea Turtles			
Green turtle	Endangered	Florida and Pacific Mexico breeding colonies	
	Threatened	All other areas	Marine, nearshore <12 nmi
Hawksbill turtle	Endangered		Marine, nearshore <12 nmi
Leatherback turtle	Endangered		Marine, nearshore <12 nmi and oceanic
Marine/Anadromous Fishes			
Atlantic salmon	Endangered	Gulf of Maine	Inland, river
Chinook salmon	Threatened	California coastal	Inshore, estuarine
	Threatened	Central valley spring-run	Inland, river
	Threatened	Lower Columbia River	Inland, river
	Endangered	Upper Columbia River spring-run	Inland, river
	Threatened	Puget Sound	Inshore
	Endangered	Sacramento River winter-run	Inland, river
	Threatened	Snake River fall-run	Inland, river
	Threatened	Snake River spring/summer-run	Inland, river
	Threatened	Upper Willamette River	Inland, river
Chum salmon	Threatened	Columbia River	Inland, river
	Threatened	Hood Canal summer-run	Inshore
Coho salmon	Endangered	Central California coast	Inshore, estuarine
	Threatened	Oregon coast	Inshore, estuarine
	Threatened	Southern Oregon and northern California coasts	Inshore, estuarine

Table 3-6. Marine and anadromous species listed under the ESA for which critical habitat has been designated.

SPECIES	STATUS UNDER ESA	LISTED DISTINCT POPULATION SEGMENT (DPS)/POPULATION/EVOLUTIONARILY SIGNIFICANT UNIT (ESU)	CRITICAL HABITAT—TYPE OF HABITAT DESIGNATED
Sockeye salmon	Threatened	Ozette Lake	Inland, lake
	Endangered	Snake River	Inland, river
Steelhead trout	Threatened	Central California coast	Inshore, estuarine
	Threatened	Snake River Basin	Inland, river
	Threatened	Upper Columbia River	Inland, river
	Endangered	Southern California	Inland, river
	Threatened	Middle Columbia River	Inland, river
	Threatened	Lower Columbia River	Inland, river
	Threatened	Upper Willamette River	Inland, river
	Threatened	Northern California	Inland, river
	Threatened	South-Central California coast	Inshore, estuarine
	Threatened	California Central Valley	Inland, river
Green sturgeon	Threatened	Southern	Marine, nearshore >12 nmi
Gulf sturgeon	Threatened		Inshore and Marine <12 nmi
Smalltooth sawfish	Endangered	U.S. portion of range	Inshore and Marine <12 nmi
Marine Invertebrates			
Elkhorn coral	Threatened		Marine, nearshore <12 nmi
Staghorn coral	Threatened		Marine, nearshore <12 nmi
Marine Plants			
Johnson seagrass	Threatened		Inshore

in writing to the NMFS or FMC recommendations. NMFS' conservation recommendations are non-binding (NMFS, 2002). Adverse effects are defined as "any impact that reduces quality and/or quantity of EFH"; adverse effects include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH (50 CFR §600). Adverse effects to EFH may result from actions occurring within or outside of the areal extent of the designated EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of federal actions. NMFS (2002) describes the process by which federal agencies can integrate MSFCMA EFH consultations with ESA Section 7 consultations.

Nine FMCs, including the HMS Division of NMFS, are responsible for designating EFH and HAPC in all U.S. territorial waters for hundreds of marine and anadromous fish and invertebrate species (Table 3-7). The types of general habitat that have been designated as EFH in U.S. territorial waters include:

- **Benthic Habitat:** These seafloor habitats may be designated for specific substrate types (e.g., rocks, gravel, sand, clay, mud, silt, shell fragments, and hard bottom). These habitats are utilized by a variety species for spawning/nesting, development, dispersal, and feeding (SAFMC, 1998).
- **Structured Habitats:** Areas that provide shelter for a variety of species and include:
  - Artificial Reef: Human-made structures made of various types of materials and used primarily by adult fishes, especially spawning adults (SAFMC, 1998).
  - Biogenic Habitat: Created by living organisms such as sponges, mussels, hydroids, amphipod tubes, hydroids, red algae, bryozoans, vermeteid and coral reefs, all of which are home to many reef fishes and invertebrates.
- **Pelagic *Sargassum*:** Mats of the pelagic species of the brown algae, *Sargassum,* that are found on the surface of open ocean areas of the North Atlantic Ocean and play a unique role by providing shelter, food source, and a prey aggregating site for numerous fishes, especially the larval lifestage.
- **Marine Waters:** All seawater from the surface of the ocean to the seafloor (i.e., water column) but not including the ocean bottom. Depending upon the species, the designated habitat may refer only to a specific part of the water column, such as surface or bottom waters, to specific water depths in the water column, such as waters from 100 to 1,000 m, or to the entire water column. This habitat may also specify the part of the continental margin over which the marine waters are located, such as continental shelf waters, or to the marine ecological zone of the ocean, such as pelagic waters. This habitat is important for a wide variety of species and lifestages.
  - Surge Zone: This high energy shoreline area is the region of the littoral zone where waves break onto the shore or beach.
- **Surface Water Currents:** Currents such as the Gulf Stream, which is the dominant surface circulation feature in the U.S. Atlantic EEZ waters, is a key dispersal mechanism for larvae of many species of fishes and crustaceans.
- **Topographic Features:** These seafloor habitat areas have high vertical (bathymetric) relief and include seamounts, hard rock banks, escarpments, submarine canyons, deep slope terraces, and the continental or insular shelf break.
- **Estuarine Areas:** Inshore aquatic areas where saltwater and freshwater mix typify estuarine (e.g., bay, river, lagoon) habitats. Specific estuarine habitats, such as salt marshes or beds of submerged aquatic vegetation, may be designated. These types of EFH are very important early developmental habitats for many commercially valuable species that may spend their later juvenile and adult lifestages in marine waters.

Table 3-7. Geographic area of jurisdiction in U.S. EEZ waters and number of species/species groups for which EFH has been designated by each of the nine Fishery Management Councils as well as the number of designated EFH species/species groups in potential SURTASS LFA OPAREAs (CFMC, 2009; GMFMC, 2009; MAFMC, 2009; NEFMC, 2009, NMFS, 2009a; NMFS, 2009b; NPFMC, 2009; PFMC, 2009; SAFMC, 2009; WPFMC, 2009).

Fishery Management Council	Geographic Area of Jurisdiction	Number Species/Species Groups for Which EFH has been Designated	Number Species/Species Groups for Which EFH is Designated in Potential SURTASS LFA OPAREAs
New England FMC	U.S. EEZ waters of Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine	27	15
Mid-Atlantic FMC	U.S. EEZ waters of New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and North Carolina	12	9
South Atlantic FMC	U.S. EEZ waters of North Carolina, South Carolina, Georgia, and eastern Florida (to Key West)	90 plus 2 co-managed with GMFMC	~80
Gulf of Mexico FMC	U.S. EEZ waters of western Florida (from Key West), Alabama, Mississippi, Louisiana, and Texas	62 plus 2 co-managed with SAFMC	62
Caribbean FMC	U.S. EEZ waters of Puerto Rico and U.S. Virgin Islands	304	304
Pacific FMC	U.S. EEZ waters of California, Oregon, and Washington	115	~99
North Pacific FMC	U.S. EEZ waters of Alaska	34	25
Western Pacific Regional FMC	U.S. EEZ waters of Hawaiian Archipelago (including Main and Northwest Hawaiian Islands and Midway), Johnson Atoll, Palmyra Atoll/Kingman Reef, Jarvis Island, American Samoa, Howland Island, Baker Island, Wake Island, Guam, and Northern Mariana Islands	>223	~207
Secretarial FMC (NMFS Highly Migratory Species Division)—Atlantic HMS	U.S. Atlantic and Gulf of Mexico EEZ waters	50	36

- **Vegetated Beds:** Inshore and nearshore beds or communities of algae (e.g., kelp beds), mangroves, or aquatic vegetation (seagrasses). These densely vegetated habitats are sources of shelter and food for many fish and invertebrate species.
- **Marine Protected Areas (MPAs):** Specific waters within the U.S. EEZ under jurisdiction of the WPRFMC where fishing is prohibited or only allowed by special permit. Waters landward of the 91-m (299-ft) isobath surrounding Howland, Baker, and Jarvis Islands, Rose Atoll, and Kingman Reef and in a box designated by four corner geographic coordinates around French Frigate Shoals have been designated as no-take (no fishing) MPAs while waters from shore to the 91-m (299-ft) isobath surrounding Palmyra and Johnson Atolls and Wake Island are low-use MPAs, where fishing is only allowed by special permit (WPRFMC, 2006).

Since SURTASS LFA sonar routinely operates at a minimum distance of at least 12 nmi from shore, the inshore and nearshore types of EFH, such as estuarine areas, vegetated beds, surge zones, structured habitat, and marine protected areas, would not occur in potential SURTASS LFA operational areas within the waters of the U.S. EEZ (Table 3-7). Thus, the amount of EFH designated in potential operating areas is somewhat reduced (Table 3-7). Although EFH is designated for adult lifestages in potential U.S. operating areas, EFH for early developmental stages (i.e., eggs and larvae or equivalent lifestages) dominates much of the oceanic areas in which SURTASS LFA will potentially operate, particularly in U.S. tropical waters.

3.2.6.3 Marine Protected Areas

The term “marine protected area” (MPA) is very generalized and is used to describe specific regions of the marine and aquatic environments that have been set aside for protection, usually by individual nations within their territorial waters, although a small number of internationally recognized MPAs exist. Of the estimated 5,000 global MPAs, about 10% are international (WDPA, 2009). The variety of names and uses of MPAs has led to confusion over what the term really means and where MPAs are used. Internationally, a MPA is considered “any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment” (Kelleher, 1999). In the U.S., a MPA is defined by EO 13158 as “any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein."

MPAs have been proven to be effective conservation tools to manage fisheries, preserve habitat and biodiversity, and enhance the aesthetic and recreational value of marine areas (NRC, 2000b). Although the objectives for establishing protection of marine areas vary widely, MPAs are typically used to achieve two broad objectives: 1) habitat protection, and 2) fisheries management and protection (Agardy, 2001). Many MPAs are multi-use areas while others only allow restricted uses within the designated MPA boundaries.

U.S. Marine Protected Areas

In the U.S., MPAs have conservation or management purposes, defined boundaries, a permanent protection status, and some legal authority to protect marine or aquatic resources. In practice, U.S. MPAs are defined marine and aquatic geographic areas where natural and/or cultural resources are given greater protection than is given in the surrounding waters. U.S. MPAs span a range of habitats including the open ocean, coastal areas, inter-tidal zones, estuaries, as well as the Great Lakes and vary widely in purpose, legal authority, agencies, management approaches, level of protection, and restrictions on human uses (NMPAC, 2009). Currently, about 100 Federal, state, territory, and tribal agencies manage more than 1,500 marine areas in the U.S. and its territories (NMPAC, 2009a). Two federal agencies primarily manage federally designated MPAs. The Department of Commerce’s NOAA manages national marine sanctuaries (NMS), fishery management zones (FMZ), and in partnership with states, national estuarine research reserves (NERR), while the Department of Interior manages the national wildlife refuges (NWRs) and the national park system (NPS), which includes national parks (NPs), national seashores (NSs), and national monuments (NMs).Over the past century in the U.S., Federal, state, territory, and local legislation; voter initiatives; and regulations have created the plethora of 1,500 MPAs that now exist, each of which was established for a specific purpose. The resulting collection of U.S. MPAs, consisting of reserves, refuges, preserves, sanctuaries, parks, monuments, national seashores, areas of special biological significance, fishery management zones, and critical habitat, is so fragmented, unrelated, and confusing that potential opportunities for broader regional conservation through coordinated planning and management are often missed.

To address this situation and improve the nation's ability to understand and preserve its marine resources, Presidential EO 13158 of 2000 called for an evaluation and inventory of the existing MPAs and development of a national MPA system and national MPA center. The EO called for a national system that protects both natural and cultural marine resources and is based on a strong scientific foundation. The Department of Commerce established the National MPA Center (NMPAC), which has inventoried the existing U.S. MPAs and has developed the criteria for the National MPA System. Although EO 13158 provided the formal definition of a MPA, the NMPAC has developed a classification system that provides definitions and qualifications for the various terms within the EO (NMPAC, 2009a). The National MPA System's classification consists of five key functional criteria that objectively describe MPAs:

- Conservation focus (i.e., sustainable production or natural and/or cultural heritage),
- Level of protection (i.e., no access, no impact, no-take, zoned with no-take area(s), zoned multiple use, or uniform multiple use),
- Permanence of protection,
- Constancy of protection,
- Ecological scale of protection (NMPAC, 2009a).

The first two of these criteria, conservation and protection, are the keystones of the classification system. These five criteria influence the effect MPAs have on the local ecosystem and on human users.

In April 2009, the NMPAC, in collaboration with federal, state, and territory agencies, organizations/associations, industry, and the public, announced the establishment of the National MPA System with its initial listing of over 200 MPAs (Tables 3-8 through 3-14). The list of National System MPAs contains all the mutually accepted MPAs that were nominated during the initial listing. Eligible MPAs can become part of the national system by applying to the NMPAC through their managing agency. Federal agencies that function in the marine or aquatic environment have a responsibility under EO 13158. Section 5 of EO 13158 stipulates, "…each Federal agency whose actions affect the natural or cultural resources that are protected by MPAs shall identify such actions. To the extent permitted by law and to the maximum extent practicable, each federal agency, in taking such actions, shall avoid harm to the natural and cultural resources that are protected by an MPA."

Of the more than 200 National System MPAs, only six of those listed in the National System MPAs are in potential SURTASS LFA sonar operating areas, largely because a part or their entire seaward boundary is located beyond 12 nmi from the coastline. These MPAs include:

- Olympic Coast NMS
- Gulf of the Farallones NMS
- Monterey Bay NMS
- Cordell Bank NMS

Table 3-8. MPAs in or adjacent to U.S. Gulf of Mexico waters that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

National Wildlife Refuges (NWR)	National Wildlife Refuges (NWR) (Continued)	National Park (NP) System
Ten Thousand Island	Grand Bay	Everglades NP
J.N. Ding Darling	Breton	Dry Tortugas NP
Matlacha Pass	Delta	
Pine Island	Shell Keys	**National Marine Sanctuary**
Island Bay	Sabine	Florida Keys
Pinellas	Anahuac	Flower Garden Banks
Chassahowitzka	Brazoria	
Crystal River	San Bernard	**National Estuarine Research Reserve**
Cedar Keys	Big Boggy	Rookery Bay
Lower Suwannee	Aransas	
Big Branch Marsh	National Key Deer Refuge	
St. Vincent	Great White Heron	
St. Marks	Key West	
Bon Secour		

Table 3-9. MPAs in or adjacent to Caribbean Sea waters of U.S. territories that are currently part of the National MPA System (NMPAC, 2009c and 2009c).

National Park System	
Virgin Islands Coral Reef NM	Virgin Islands NP

Table 3-10. MPAs in or adjacent to U.S. Alaska waters that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

National Wildlife Refuges	National Park System
Yukon Delta	Glacier Bay NP and Preserve
Alaska Maritime	
Arctic	

Table 3-11. MPAs in or adjacent to U.S. Atlantic waters that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

NATIONAL WILDLIFE REFUGE (NWR)	NATIONAL WILDLIFE REFUGE (NWR) (CONTINUED)	NATIONAL ESTUARINE RESEARCH RESERVE
Cross Island	Martin	Guana Tolomato Matanzas
Pond Island	Supawna Meadows	Waquoit Bay
Rachel Carson	Susquehanna	Jacques Cousteau
Great Bay	Blackwater	
Parker River	Bombay Hook	**NATIONAL PARK SYSTEM**
Mashpee	Eastern Neck	Biscayne NP
Edwin B. Forsythe	Occoquan Bay	Assateague Island NS
Monomoy	Featherstone	
Nomans Land Island	Plum Tree Island	**NATIONAL MARINE SANCTUARY**
Sachuest Point	Fisherman Island	NOAA's Monitor
John H. Chafee	Pea Island	Gray's Reef
Ninigret	Eastern Shore of Virginia	Gerry E. Studds/Stellwagen Bank
Stuart B. McKinney	Alligator River	
Target Rock	Swanquarter	**NATURAL AREA PRESERVES**
Oyster Bay	Cedar Island	Dameron Marsh
Block Island	Waccamaw	Hughlett Point
Conscience Point	Cape Romain	Bethel Beach
Wertheim	ACE Basin	Savage Neck Dunes
Seatuck	Pelican Island	
Cape May	Crocodile Lake	**STATE PARK/PRESERVE/ SANCTUARY**
Prime Hook	Back Bay	Blue Crab Sanctuary
Chincoteague	Mackay Island	False Cape State Park
Wallops Island	Currituck	U-1105 Black Panther Historic Shipwreck Preserve

Table 3-12. MPAs in or adjacent to U.S. Pacific waters off California, Oregon, and Washington that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

NATIONAL WILDLIFE REFUGES	NATIONAL PARK SYSTEM	AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE	AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE	STATE MARINE CONSERVATION AREA
Dungeness	Channel Islands NP	King Range	Irvine Coast	Año Nuevo
Protection Island	Point Reyes NS	Jughandle Cove	Southeast Santa Catalina Island	Greyhound Rock
Grays Harbor	**UNDERWATER PARK**	Saunders Reef	San Clemente Island	Soquel Canyon

Table 3-12. MPAs in or adjacent to U.S. Pacific waters off California, Oregon, and Washington that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

National Wildlife Refuges	National Park System	Areas of Special Biological Significance	Areas of Special Biological Significance	State Marine Conservation Area
Nisqually	Blake Island	Del Mar Landing	Northwest Santa Catalina Island	Portugese Ledge
Willapa	Deception Pass	Gerstle Cove	Farnsworth Bank	Elkhorn Slough
Lewis and Clark	**Special Management**	Farallon Island	Santa Barbara Island	Piedras Blancas
Nestucca Bay	San Juan Channel and Upright	James V. Fitzgerald	San Nicolas Island	Point Lobos
Siletz Bay	Haro Strait	Año Nuevo	Point Lobos	Edward F. Ricketts
Bandon Marsh	**State Marine Recreational**	Redwood National Park	Anacapa Island	Cambria
San Pablo Bay	Morro Bay	Bodega	Begg Rock	Carmel Bay A
Marin Islands	**State Marine Reserve**	Bird Rock	**State Marine Reserve**	Point Sur
Don Edwards San Francisco Bay	Natural Bridges	Point Reyes Headlands	Lovers Point	Big Creek
Sweetwater Marsh	Elkhorn Slough	Double Point	Carmel Pinnacles	White Rock (Cambria)
National Marine Sanctuary	Moro Cojo Slough	Duxbury Reef	Point Sur	Point Buchon
Olympic Coast	Piedras Blancas	Pacific Grove	Big Creek	**Aquatic Reserve**
Cordell Bank	Point Lobos	Julia Pfeiffer Burns	Morro Bay	Maury Island
Gulf of the Farallones	Asilomar	Salmon Creek Coast	Point Buchon	Fidalgo Bay
Monterey Bay	Vandenberg	Carmel Bay	Lovers Point	Cypress Island
Channel Islands	Natural Bridges	Laguna Point to Latigo Point		Cherry Point
Marine Preserve	**Wildlife Area**	Robert E. Badham	**Conservation Area**	**Seabird Sanctuary**
Shaw Island San Juan Islands	South Puget Sound	Santa Rosa Island	Orchard Rocks	Zella M. Schultz/Protection
Friday Harbor San Juan Islands		Santa Cruz Island	Sund Rock	
Argyle Lagoon San Juan Islands		Heisler Park	Brackett's Landing Shoreline Sanctuary	
False Bay San Juan Islands		Sand Diego-Scripps		
Yellow and Low Islands San Juan		La Jolla		
Admiralty Head		San Miguel Island		

Table 3-13. MPAs in or adjacent to U.S. Pacific waters of Hawaii that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

NATIONAL PARK SYSTEM	NATIONAL WILDLIFE REFUGES	STATE MARINE LIFE CONSERVATION DISTRICTS
Papahanaumokuakea Marine NM	Midway Atoll	Hanauma Bay
FISHERY MANAGEMENT AREAS	**STATE RESERVES**	Molokini Shoal
West Hawaii Regional	Ahihi-Kinau Natural Area	Pupukea
NATIONAL MARINE SANCTUARY	Kahoolawe Island	Kealakekua Bay
Hawaiian Islands Humpback Whale		

Table 3-14. MPAs in or adjacent to Pacific Ocean waters of U.S. territories that are currently part of the National MPA System (NMPAC, 2009b and 2009c).

National Wildlife Refuges	National Wildlife Refuges (continued)	National Marine Sanctuary
Guam	Johnston Island	Fagatelle (American Samoa)
Baker Island	Kingman Reef	
Howland Island	Palmyra Atoll	
Jarvis Island		
Rose Atoll		

- Hawaiian Islands Humpback Whale (only Penguin Bank area)
- Papahānaumokuākea Marine NM (NOAA, 2009).

International Marine Protected Areas

Although there are several efforts to document international MPAs, no network or system of international MPAs currently exists. International MPAs encompass a very wide variety habitat types and types of MPAs as well as a good degree of variability in the levels of protection and legal mandates associated with each MPA. It is, thus, even more difficult to compile an international list of MPAs than it is in the U.S. MPAs have been designated by nearly every coastal country of the world, and by current estimates, more than 5,000 MPAs exist globally (Figure 3-6) (Agardy et al., 2003; WDPA, 2009). International waters (i.e., the high seas) are contained within the boundaries of some MPAs such as the Pelagos Sanctuary for the Conservation of Marine Mammals in the Mediterranean (WDPA, 2009). A number of international MPAs have been established for the sole purpose of protecting cetaceans.

Although most international MPAs lie along the coast of the designating country, some international MPAs encompass large extents of ocean area and encompass international as well as territorial waters (Table 3-15). Many of the large oceanic MPAs are also listed as World Heritage Sites (UNESCO, 2009).

Excluding the Arctic and Antarctic regions of the world's oceans, approximately 10 internationally-designated MPAs exist in waters in which SURTASS LFA sonar may potentially operate. The largest of

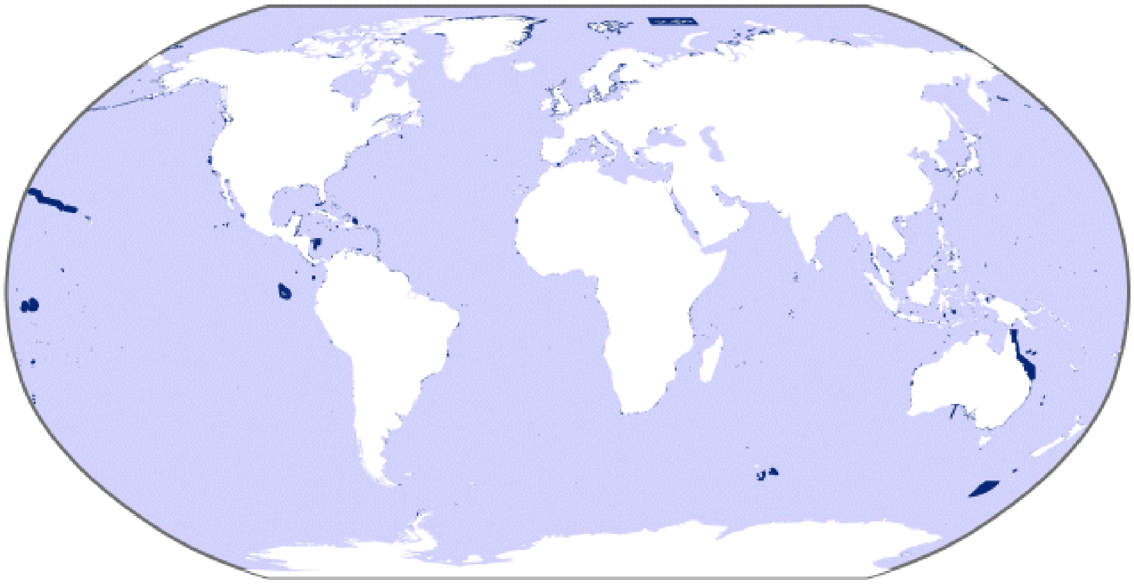


Figure 3-6. Locations (in dark blue) of international MPAs in all world oceans (Wood, 2007).

these MPAs, Phoenix Islands Protected Area, established by the Republic of Kiribati in the southern Pacific Ocean, encompasses 415,000 km^2 of ocean area (WDPA, 2009).

3.3 SOCIOECONOMICS

As SURTASS LFA sonar operates in open ocean areas it has the potential to interact with other activities taking place in these areas, including: commercial fishing, aboriginal subsistence whaling, oceanographic research, and recreational activities. The following section will outline activities that may take place concurrently with SURTASS LFA sonar operations. Many aquatic activities take place in nearshore or inland water areas where SURTASS LFA sonar is not proposed to operate.

3.3.1 COMMERCIAL FISHERIES

The geographic sphere of SURTASS LFA sonar's acoustic influence overlaps the distribution of many fish species. Some pelagic and demersal fish species have the potential to be affected by SURTASS LFA sonar because some have demonstrated response to LF sound (Subchapter 3.2.2). If SURTASS LFA sonar has the potential to affect fish species, then it follows that this could potentially affect commercial fisheries that coincide with geographic areas in which SURTASS LFA sonar may operate. This section provides an overview of global marine fisheries production, employment, and trade for many of the major fishing countries that may be affected by SURTASS LFA sonar. As SURTASS LFA sonar is currently only authorized to operate further than 22 km (12 nmi) from coastal areas, only those fisheries that occur more than the standoff distance will be discussed.

3.3.1.1 Marine Fisheries Production

Marine fishing for commercial, recreational, industrial, or subsistence purposes occurs in almost all global waters with the most productive regions in coastal waters overlying the continental shelves. This is due to their higher primary productivity and the fact that the shallow ocean floor allows for the use of nets and traps. In contrast, in the deep areas of the open ocean where fish populations are less densely distributed, different methods are employed, such as longline and drift nets. Commercial fishermen work offshore waters for species such as sharks, swordfish, tuna, and whales, while recreational fishers seek ocean pelagic species such as billfish, dolphinfish, tunas, and wahoo.

Table 3-15. Examples of larger-scale international MPAs that are located within potential SURTASS LFA sonar operating areas (Protect Planet Ocean, 2009; UNESCO, 2009; WDPA, 2009).

NAME	DESIGNATING COUNTRY	LOCATION	OCEAN AREA
Pelagos Sanctuary for the Conservation of Marine Mammals in the Mediterranean	Italy, Monaco, Spain, and international waters	Mediterranean Sea roughly centered at 8.7796°N, 42.7124°E (Ligurian Sea)	87,492 km^2/ 8,749,200 hectares
Phoenix Island Protected Area	Republic of Kiribati	Pacific Ocean, roughly between Fiji and Hawaiian Islands, (just southeast of Howland Island)	41,500,000 hectares/415,000 km^2
Cocos Island National Park	Costa Rica	280 nmi off Pacific coast of Costa Rica	1,998 km^2/199,790 hectares
Malpelo Island Fauna and Flora Sanctuary	Columbia	~265 nmi off Pacific coast of Columbia; roughly centered at 3°51'07" S and 81°35'4"E	8,575 km^2
Galapagos Marine Reserve	Ecuador	The reserve extends 40 nautical miles out to sea from the islands' baseline; centered at ~0.137°S, 90.629°W	13,000 km^2
Great Barrier Reef Marine Part	Australia	Pacific Ocean; World Heritage Site	344,000 km^2
Heard and Macdonald Islands MPA	Australia	Indian Ocean; 51.663°S, 74.935°E	65,000 km^2
Southeast Commonwealth Marine Reserve Network	Australia	Indian Ocean; >12 nmi from shore but in Australia EEZ	226,458 km^2
Seaflower Marine Protected Area	Columbia	Atlantic Ocean; 13°30'0"N, 81°0'0"W; World Heritage Site	65,000 km^2
Marine Mammal Sanctuary of the Dominican Republic	Dominican Republic	Atlantic Ocean (Caribbean Sea); 19°56'9"N, 69°19'31"W	25,000 km^2

Information on global marine fisheries production by geographic location is compiled annually by the Food and Agriculture Organization (FAO) of the United Nations (UN). Nominal catches, as expressed in metric tons (mt), represent the live-weight-equivalent of fish or other marine species obtained by capture or aquaculture as recorded at the time of landing. Catches are recorded at the location of the landing, providing the FAO with information on the species caught by the landing's country, continent, and FAO fishing zone. The FAO has collected fisheries data by country, detailing nominal catch, consumption rates, trade of fisheries goods, and the economic and ecological impacts of fishing. FAO's nominal catch data cover fish, crustaceans, mollusks, and miscellaneous aquatic animals caught for commercial, recreational, industrial, and subsistence purposes, as well as marine mammals and plants. In their global fisheries production totals, however, FAO does not include marine mammals and plants. Information on marine mammal catches is presented later in this subchapter.

Global Fisheries

The general composition of the majority of global marine fisheries catches in 2006 was marine fishes, crustaceans, and mollusks at a total 82.0 million mt of nominal landings (Table 3-16). Of the top 15 marine fishes landed globally, landings of the Peruvian anchovy are by far the largest, with over 7 million mt caught in 2006 (Table 3-17) (FAO, 2008). Other significant catch volumes include species of pollock, tuna, herring, whiting, mackerel, hairtail, sardine, squid, cod, and shrimp (FAO, 2008). In 2006, China, Peru, and the U.S. remained the top worldwide fisheries producing countries, with China remaining the larger producer (FAO, 2008 and 2009).

Table 3-16. Landings (metric tons) for 2006 of global marine fisheries (FAO, 2008).

ISSCAAP[13] Division	Landings (MT)	Percent of World Landings
Freshwater fish	23,242	<0.1
Diadromous[14] fish	1,296,270	1.58
Marine fish	67,407,975	82.27
Crustaceans	5,682,169	6.94
Mollusks	7,162,595	8.74
Whales, seals, other aquatic mammals[15]	NA[16]	
Miscellaneous aquatic animals	358,387	0.44
Miscellaneous aquatic products	NA	
Aquatic plants[2]	NA	
Total	81,930,638	100

Regional Trends

By ocean basin, the Pacific generates the highest landings of marine fishes in the world (Table 3-18; FAO, 2008). Overall, landings in the Pacific and Indian Oceans continued to increase while landing production in the Atlantic Ocean decreased (FAO, 2008). Global production from capture fisheries (as opposed to those farmed, i.e., aquaculture) has remained basically stable since 2000 when the total capture production was 86 million mt; FAO statistics for capture fisheries for 2006 were 81 million mt (Table 3-16) (FAO, 2008 and 2009). The Northwest Pacific marine fishing region was by far the greatest single contributor to global marine fisheries production, recording over 21 million mt of the global totals for 2006 (FAO, 2008). The Northwest Pacific includes the marine waters of China, Japan, and the Russian Federation and for decades has been the world's most productive fishing region (FAO, 2008). China is the leading fisheries producing nation in the world (Table 3-19).

13 ISSCAAP = International Standard Statistical Classification of Aquatic Animals and Plants.

14 Diadromous fishes are those species that regularly migrate between freshwater and saltwater.

15 Data on aquatic mammals and plants are excluded from all national, regional, and global totals.

16 NA= not available or unobtainable

Table 3-17. Top 15 principal marine species landed globally in 2006 (FAO, 2008).

SPECIES NAME	SCIENTIFIC NAME	LANDINGS (MT)
Anchovetta (Peruvian anchovy)	*Engraulis ringens*	7,007,157
Alaska pollock	*Theragra chalcogramma*	2,860,487
Skipjack tuna	*Katsuwonus pelamis*	2,480,812
Atlantic herring	*Clupea harengus*	2,244,595
Blue whiting (Poutassou)	*Micromesistius poutassou*	2,032,207
Chub mackerel	*Scomber japonicus*	2,030,795
Chilean jack mackerel	*Trachurus murphyi*	1,828,999
Japanese anchovy	*Engraulis japonicus*	1,656,906
Largehead hairtail	*Trichiurus lepturus*	1,587,786
Yellowfin tuna	*Thunnus albacares*	1,129,415
European pilchard (Sardine)	*Sardina pilchardus*	944,012
Jumbo flying squid	*Dosidicus gigas*	848,858
Atlantic cod	*Gadus morhua*	823,482
Akiami paste shrimp	*Acetes japonicus*	729,020
Argentine shortfin squid	*Illex argentines*	704,263

The Southeast Pacific region marine fishery, including all Pacific waters of South America, also was a major contributor to global marine fisheries catches in 2006, providing landings of over 12 million mt (FAO, 2008). This area of the world's oceans has historically been the most dynamic fishing region, due to El Niño/Southern Oscillation events, and is dominated by small pelagic species. In 2006, the combined zones of the Pacific Ocean yielded the majority of all marine catches, with over 50 million mt, or 61% of the world's catches in marine waters (FAO, 2008).

Trends of Top Fish Producing Countries

Brief descriptions (nominal catch, consumption rates, trade of fisheries goods, and the economic and ecological impacts of fishing) of the top worldwide fish producing nations are discussed below. It should be noted that the landing numbers presented in these sections include all capture fisheries, including those from inland and nearshore fisheries, waters in which SURTASS LFA sonar is not currently authorized to operate.

- **China**

China has led the world in landings of marine species since 1997 (Table 3-19) (FAO, 2007a and 2008). With a population of over 1.3 billion and a lengthy continental coastline of approximately 14,500 km, fish and other aquatic products are, and will remain, of nutritional and economic importance to the People's Republic of China (CIA, 2011). Chinese fishing operations take place in the northwestern Pacific Ocean, East China Sea, South China Sea, and Yellow Sea, as well as at distant-water fishing locations in the Pacific Ocean, Atlantic Ocean, and Indian Ocean. China also has a long history of near-shore, inland, and freshwater aquaculture.

Of the more than 3,000 species of marine life that are found along the China's coast, over 100 species are targeted for harvest. These include; finfish, crustaceans, cephalopods, shellfish, seaweed, and

Table 3-18. Nominal worldwide landings for 2000 and 2006 by mass (metric tons) for marine fishing regions (FAO, 2008).

MARINE FISHING AREA	FAO AREA	2000 LANDINGS (MT)	2006 LANDINGS (MT)
Atlantic, Northwest	21	2,068,154	2,198,703
Atlantic, Northeast	27	11,018,183	9,077,072
Atlantic, Western Central	31	1,815,758	1,511,194
Atlantic, Eastern Central	34	3,662,464	3,270,319
Mediterranean and Black Sea	37	1,515,339	1,622,672
Atlantic, Southwest	41	2,295,118	2,368,172
Atlantic, Southeast	47	1,634,473	1,366,737
Atlantic, Antarctic	48	123,562	112,728
Indian Ocean, Western	51	3,968,396	4,470,336
Indian Ocean, Eastern	57	5,089,359	5,773,031
Indian Ocean, Antarctic	58	12,587	11,466
Pacific, Northwest	61	23,202,716	21,581,589
Pacific, Northeast	67	2,477,803	3,069,870
Pacific, Western Central	71	9,715,493	11,249,737
Pacific, Eastern Central	77	1,725,814	1,585,774
Pacific, Southwest	81	714,039	631,232
Pacific, Southeast	87	15,784,720	12,026,124
Pacific, Antarctic	88	870	3,882

Table 3-19. Top 10 worldwide fishing nations by mass landed (FAO, 2008).

COUNTRY	TOTAL 2000 LANDINGS (MT)	TOTAL 2006 LANDINGS (MT)
China	16,987,325	17,092,146
Peru	10,657,260	7,017,491
U.S.	4,717,638	4,859,872
Indonesia	4,082,810	4,759,080
Japan	4,985,894	4,186,980
Chile	4,300,474	4,168,461
India	3,666,427	3,855,467
Russian Federation	3,973,535	3,284,126
Thailand	2,997,124	2,776,295
Philippines	1,896,132	2,318,984

miscellaneous (including jellyfish). In 2006, the total aquatic output of China reached 51.5 million mt, with 17.1 million mt of this total coming from capture fisheries and 34.4 million mt from aquaculture (FAO, 2007a). Of the total output, more than 75% was intended for direct human consumption, with the remaining 13 million tons intended for animal feed and other purposes (FAO, 2007a).

In 2004, fish and other aquatics products represented 10.5% of the Chinese agricultural gross domestic product (GDP), which in turn represents 13.1% of the overall Chinese GDP. By 2011, agriculture represented only 9.6% of China's GDP (CIA, 2011). Total value of fishery and aquaculture products amounted to $45.9 billion in 2005. China is the leading world fish exporter, with $U.S.9 billion and $U.S. 9.3 billion in exports in 2006 and 2007, respectively (FAO, 2007a and 2008). Fishery-related employment in China peaked at 13.7 million people in 2001 (FAO, 2007a).

- **Peru**

Peru's fishery industry is important economically, not only in terms of the foreign currency and jobs that it generates, but also in terms of the volume produced, especially fishmeal and fish oil, and frozen, canned, and cured products for direct human consumption. Peru's fisheries traditionally are based on marine pelagic resources, mainly harvesting anchovy and other fish species such as jack and chub mackerels, but in recent years, landings of giant squid and dolphinfish (dorado) have increased. In 2006, Peru landed over 7 million mt of marine fish products (FAO, 2008). Anchovy catches amounted to 6.4 million mt in 2001, but in 2003 and subsequent years, anchovy landings decreased following an El Nino/Southern Oscillation event that occurred in 2002 through 2003 (FAO, 2007; IFFO, 2009). Aquaculture is also important, with 39,009 mt of fishery products have been cultured in 2008, with aquaculture exports in the same year being valued at $U.S. 94 million (FAO, 2010).

Peruvian fisheries are the second largest generator of foreign currency after mining, contributing $U.S. 619 million to the nation's 2005 GDP, although fisheries production and processing have only contributed ~1.4% to the GDP over the last 10 years (FAO, 2010). Peru's anchovy fishery generates 30 to 35% of the world's fish oil and fishmeal (IFFO, 2009). By recent estimates, fisheries in Peru directly or indirectly employ some 100,000 to 160,000 people (IFFO, 2009; FAO, 2010). In 2008, 8% of Peru's exports were from fisheries, with 75% of that export revenue coming from the export of anchovy-derived fishmeal and fish oil; total 2008 fishmeal and fish oil exports were 1.81 million mt, valued at $U.S. 2.01 billion (IFFO, 2009). In monetary value, the 2008 Peruvian fisheries exports were valued at $U.S. 2.4 billion while fishery imports were valued at $U.S. 73.7 million (FAO, 2010).

- **United States**

Fisheries are an essential aspect of life along the U.S.'s 19,924 km coastline (FAO, 2005). U.S. fisheries are pursued in coastal and U.S. EEZ waters as well as in inland waters (rivers and lakes) and non-U.S. waters. In 2006, the U.S. ranked third in total global marine fishery landings (Table 3-19), harvesting 4.86 million mt at a monetary value roughly equivalent to $4.1 billion in U.S. waters (NMFS, 2007d; FAO, 2008). In 2005, U.S. fishery catch (including aquaculture and capture) accounted for 3.7% of the world's total (NMFS, 2007d). The top U.S. fisheries in terms of revenue for 2006 were shrimp ($456 million), walleye pollock ($429 million), American lobster ($395 million), sea scallops ($385 million), and Pacific salmon ($312 million); these five species/species groups generated $2.0 billion in 2006, accounting for almost 50% of total landings revenue (NMFS, 2007d). Additionally, landings by U.S. fishermen in ports outside the 50 U.S. states/ports and from foreign processing permitted in U.S. waters provided 70 mt, valued at $61 million; most of these landings consisted of tuna and swordfish landed in American Samoa and other foreign ports (NMFS, 2007e). Aquaculture in the U.S. generated an additional 357,741 mt of fishery products for an estimated value of $1,092,386 in 2005 (NMFS, 2007e). In 2005, the U.S. fishing fleet supported 36,150 powered vessels (>5 tons) (FAO, 2005).

In 2006, the U.S. exported edible fishery products worth $4.2 billion for a total export value of $17.8 billion for all fishery products, while importing $13.4 billion of edible fishery products for a total of $27.7 billion of total fish products (NMFS, 2007e; FAO, 2008). Overall, the U.S. fishing industry generated over $103 billion in sales and $44.3 billion in income as well as supported over 1.5 million jobs in 2006 (NMFS, 2007d). U.S. commercial fisheries, including fisheries production and the marketing of fisheries products, contributed $35.1 billion to the U.S. gross national product (GNP) (NMFS, 2007d).

- **Indonesia**

In 2006, Indonesia landed about 4.8 million mt of edible fishery products, which was a slight increase from the 4.5 million mt landed in 2004 (FAO, 2006 and 2008). In 2004, 18.1% of marine fisheries landings came from North Java, with 6.4% in West Sumatra, 2.9% in South Java, 8.7% in Mallacca Strait, 12.2% in East Sumatra, 5.6% in Bali-Nusatenggara, 5.8% in South-West Kalimantan, 3.4% in East Kalimantan, 11.6% in South Sulawesi, 7.3% in North Sulawesi, and 18.0% in Maluku-Papua (FAO, 2006). Overall in 2004, tunas represented 16.6% of the landings while 5.5% of landings were shrimp, 70.3% were other fishes, and 7.6% were other aquatic organisms (FAO, 2006). Although marine fisheries showed an overall increase in production, the landings of tuna and shrimp remained stable.

The contribution of Indonesian fisheries to the 2004 GDP was 2.4%. The port that landed the most fishery production in 2005 was Tual (FAO, 2006). More than 549,100 powered fishing vessels were recorded in 2004 throughout Indonesia (FAO, 2006). Export fishery products from Indonesia reached $1.7 billion in 2004, with the main destination being China, Thailand, Japan, U.S., Singapore, and Republic of Korea. An important indicator of the value of Indonesian fisheries is employment. Fisheries and aquaculture provided nearly 6 million Indonesians with direct employment in 2005, with 3.3 million fishermen and 2.5 million fish farmers being employed (FAO, 2006). As of 2004, there were nearly 730,000 fishing vessels in Indonesia (FAO, 2006).

- **Japan**

Japan consists of numerous islands, with an extensive and complex coastline that is 29,751 km long (FAO, 2009a). Marine fisheries are the most important sector of Japan's fishing industry, which ranks fifth in the world with 2006 landings of 4.19 million mt (FAO, 2008). For statistical convenience, Japanese marine fisheries are divided into three categories: distant-water fisheries (operated mainly on the high seas, as well as under bilateral agreements in the EEZs of foreign countries); offshore fisheries (operated mainly in the domestic EEZ, as well as under bilateral agreements in the EEZs of neighboring countries); and coastal fisheries (operated mainly in waters adjacent to fishing villages). In 2006, the distant-water and offshore fisheries yielded 2.7 million mt in landings with a value of $U.S.5.8 billion while the coastal fisheries landed 1.3 million mt that was valued at $U.S.5.5 billion (FAO, 2009a). Aquaculture plays an important role in the seafood supply of Japan, producing 1.1 million mt in 2007, with a monetary value of $U.S.3.8 billion; seaweeds are the principal (42%) aquaculture product, followed by scallops and oysters (FAO, 2009a). Nearly 239,810 people were employed in the 2006 fisheries businesses in Japan, while that number fell to 204,330 individuals in 2007 (FAO, 2009a). Japan supports an extensive fishing fleet of 232,534 powered vessels (FAO, 2009a).

In 2006, 86% of Japan's domestic fish catch was destined for human consumption, and of that percentage, 16% was exported for a total of $U.S.1.7 billion (FAO, 2009a). Japan, however, remains one of the world's largest fishery product importers, second only to China both in volume and value, accounting for $U.S. 13.2 billion in 2007 (FAO, 2009a). China has been the largest fishery product exporter to Japan since 1998, although imports from China decreased, by value, in 2007 by 13% (FAO, 2009a).

- **Chile**

By 2006, Chile landed 4.2 million mt of fishery products, making it the sixth largest producer of fishery products in the world (FAO, 2008). In 2004, capture fisheries and aquaculture contributed 3.18% or $U.S.2.24 billion to Chile's GNP (FAO, 2004). The dominant marine species landed in Chilean fisheries are anchovy, mackerel, horse mackerel, and sardines.

Chile exported $U.S.2.5 million in fish products during 2004 (FAO, 2007a). Of that total, aquaculture exports accounted for $ U.S.1.6 million of the export value, corresponding to 390,740 mt of products, mainly salmon (92.3%), mussels (2.5%), algae (2.3%) and scallops (1.7%) (FAO, 2004). Almost all of the aquaculture production is exported, mainly to the United States, Japan, and the European Union. The aquaculture industry plays a large role in Chilean fisheries, with 688,000 mt being harvested in 2004. In 2004, the aquaculture industry generated 17,853 direct jobs plus another 20,000 indirect jobs (FAO, 2004).

- **India**

Fisheries play an important role in the national economy, providing direct or indirect employment to an estimated 14.7 million people and contributing 1.07% of the total 2004 GDP or $U.S.7.4 billion (FAO, 2004a). In 2003, the total Indian fisheries production for direct human consumption was 5.6 million mt with another 348,319 mt produced for non-food use; additionally, 5,029 mt of aquatic products were imported, while 461,989 mt were exported (FAO, 2004a). Fishery exports accounted for $ U.S.1.4 million in foreign exchange during 2004 (FAO, 2004a). India's fishing fleet consists of 55,000 traditional motorized craft, 1,250 mechanized boats, and about 100 deep-sea fishing vessels.

Marine fishery landings consist of as many as 65 important species or species groups, with pelagic and mid-water species contributing more than 50% to the total landings volume. About 81% of the fish catch is marketed as fresh or chilled and forms staple food along the coastal and inland landing centers. Aquaculture is becoming an important fishery producer in India, with 2.1 million mt of fishery products produced in 2004 (FAO, 2004a). Fish and shrimp are predominantly cultured in India.

- **Russian Federation**

With the second longest coastline in the world and access to three oceans and numerous seas along its borders, commercial fisheries are an important industry in Russia. In 2006, fisheries contributed $U.S.3.02 billion to the Russian Federation GDP (FAO, 2007b). The fishery sector has remained generally stable in absolute terms in recent years, so its share of the GDP has decreased as the economy in general has expanded. Despite this large contribution nationally, Russian fisheries are currently unable to meet domestic demand for fish and seafood products due to the decreasing catch and the growing export to the East Asia markets (which remain much more attractive for the fishing enterprises than delivery to the domestic market). The fishery industry provides employment to 145,000 to 150,000 people (FAO, 2007b).The majority of Russia's fishery landings come from within its marine waters with landings from foreign waters or the high seas contributing less than 25% to the total landings, which were 3.8 million mt in 2006 (FAO, 2008). Aquaculture provides little to overall fishery production, contributing just 3.6% in 2005 to total fishery landings (FAO, 2007b).

In 2004 to 2005, landing from the northeast Atlantic (including the Barents Sea) region of the Russian Federation supplied 40% of the total national catch, while the northwest Pacific (mainly the seas of the Russian Far East including the Sea of Okhotsk, Sea of Japan, and Bering Sea) contributed 56% of the overall catch (FAO, 2007b). Most of the catch consisted of Alaska pollock (44%), herring (13%), cod (10%), and Pacific salmon (9%). The Russian fishing fleet consisted of 2,500 fishing vessels, 46 floating factories, and 366 transport vessels in 2002 with 5,500 motorized boats in the inland fishery (FAO, 2007b).

- **Thailand**

Marine fisheries have a significant socio-economic role in Thailand, with fisheries contributing $U.S.3.1 billion or 1.2% to the GDP (FAO, 2009b). Landings in 2006 were about 3 million mt, increasing to 3.5 million mt in 2007, with more than 58% of the landings resulting from marine fisheries with the remainder from aquaculture and inland fisheries (FAO, 2009b). Only about 60% of the marine landings came from Thai waters with the remaining 40% harvested from waters outside Thailand's EEZ. As much as 68% of the marine fish landings come from the east coast of Thailand while 32% are harvested from the west coast of peninsular Thailand.

In 2000, the marine fishery in Thailand consisted of 58,119 motorized vessels with many more traditional vessels also used for smaller scale enterprises. Overall, as many as 2 million people are employed in Thai fisheries-related industries, including aquaculture (FAO, 2009b). In 2008, $U.S.6 billion of fishery products were exported by Thailand, while $U.S.2.4 billion were imported.

Aquaculture has been historically important in Thailand, with both coastal and freshwater aquaculture industries now thriving. Total aquaculture production in 2007 was nearly 1.3 million mt, valued at $U.S.2.4 billion; coastal aquaculture accounted for 64% of the total production volume and 71% of the value (FAO, 2009b). Shrimp are the principal species cultured by coastal aquaculture with fishes such as tilapia and catfish cultured by freshwater aquaculture facilities.

- **Philippines**

In 2003, the reported marine fisheries production of the Philippines was 2.2 million mt and had risen to 2.3 million mt by 2006 (FAO, 2003 and 2008). The 2003 production was valued at $U.S.1.8 billion, accounting for 2.2% of the GDP. More than 2 million people were employed by fishery-related businesses in 2002, with more than 800,000 motorized boats and rafts employed in the municipal[17] fishing sector alone (FAO, 2003). The catch from municipal fisheries in 2003 constituted 54.5% small pelagics, 22.9% tunas, 7.4% demersal fishes, and 15.2% invertebrates, while the commercial fisheries catch in 2003 was comprised of small pelagics (59.6 %), tunas (36.2%), and demersal fishes (4.2%). Municipal fishermen in the Philippines commonly use fish aggregating devices called payao, or bamboo rafts, which are located some distance from shore and from which the fishermen moor their boats and fish with handlines (FAO, 2003).

Aquaculture production includes both marine and freshwater cultivation. In 2003, aquaculture produced 17.7% of the total fish production of the Philippines, with the principal cultured products including seaweed (988,889 mt), milkfish (202,973 mt), tilapia (109,373 mt), and jumbo tiger shrimp (34,997 mt) (FAO, 2003). The Philippines is the world's largest producer of carageenophyte (*Kappaphycus* spp. and *Eucheuma* spp.) seaweed.

The Philippines is an exporter as well as importer of fish and fishery products. Total exports of fish and fishery products amounted to 202,016 mt with a value over $U.S.525.4 million in 2003. The exported products consisted mainly of fresh and processed fish, crustaceans, mollusks, shrimp, and seaweed. For the past several years, the Philippines have been importing large quantities of pelagic fishes, such as tuna, and fishmeal; the 2003 value of the fishery-related products amounted to $U.S.80.4 million (FAO, 2003).

3.3.1.2 Fisheries Trade

Fisheries and aquaculture play, either directly or indirectly, an essential role in the livelihoods of millions of people around the world. In 2006, 43.5 million people were directly engaged, part time or full time, in primary production of fish, either by fishing or in aquaculture (FAO, 2007a). In the last three decades, employment in the primary fisheries sector has grown faster than the world's population and employment in traditional agriculture. Eighty-six percent of the fishers and fish farmers worldwide are located in Asia, with China having the most (8.1 million fishers and 4.5 million fish farmers) (FAO, 2007a). Fishery employment in China experienced strong increases in the 1980s and 1990s, to peak at 13.7 million people in 2001 but declining by 8% in the period 2001 to 2006 (FAO, 2007a). In 2006, other countries

17 Coastal fisheries that operate within 15 km (8 nmi) of the coast and use small motorized and non-motorized, traditional boats called bancas. Commercial fisheries operate beyond 15 km from shore and use large, motorized vessels to fish.

with a significant number of fishers and fish farmers were India, Indonesia, the Philippines, and Viet Nam. Most fishers are small-scale, artisanal, operating on coastal and inland fishery resources (FAO, 2007a).

While the number of people employed in fisheries and aquaculture has been growing steadily in most low-income and middle-income countries of the world, employment in the sector has fallen or remained stationary in most industrialized economies. In Japan and Norway, the numbers of fishermen have more than halved since 1970, down 61% and 42%, respectively (FAO, 2007a). In many industrialized countries, the decline has occurred mainly in capture fisheries, while the number of working in aquaculture has increased. In 2006, the estimated number of fishers in industrialized countries was about 860,000, representing a decline of 24% compared with 1990 (FAO, 2007a).

In addition to its contribution to economic activity, employment, and in generating foreign exchange, trade in fish and fishery products plays an important role in improving food security and contributes to meeting nutrition needs. Fish and fishery products are highly traded, with more than 37% (live weight equivalent) of total production being traded internationally. In 2006, 194 countries reported exports of fish and fishery products with world exports of fish and fishery products reached $85.9 billion; this represented an increase of 62.7% from 1996 (FAO, 2007a and 2008).

Since 2002, China has been the world’s largest exporter of fish and fishery products and has further consolidated its leading position over the last few years (Table 3-20). In 2006, China’s exports reached $U.S.9.0 billion and grew further to $9.3 billion in 2007 (FAO, 2008). China’s fishery exports have increased remarkably since the early 1990s. This increase is linked to its growing fishery production, as well as the expansion of its fish-processing industry, reflecting competitive labor and production costs. Despite this growth, fishery exports represented only 1% of China’s total merchandise exports in 2006 and 2007 (FAO, 2007a). In addition to exports from domestic fisheries production, China also exports reprocessed imported raw material, adding considerable value in the process.

China has also experienced a significant increase in its fishery imports over the past decade. In 2006, it was the sixth-largest importer, spending $U.S.4.1 billion, with imports reaching $4.5 billion in 2007 (FAO, 2007a). This growth has been particularly noticeable since the country’s accession to the World Trade Organization (WTO) in late 2001, as a consequence of which it lowered import duties, including those on fish and fishery products. The growth in imports is partly a result of the above-mentioned imports by China’s processors of raw material for reprocessing and export. However, it also reflects China’s growing domestic consumption of species, mainly of high value, that are not available from local sources.

In addition to China, other developing countries play a major role in the fishery industry. In 2006, 79% of world fishery production took place in developing countries, with exports of fishery products representing 49% ($42.5 billion) and 59% (31.6 million mt) of world exports (FAO, 2007a). An important share of their exports consisted of fishmeal (35% by quantity but only 5% by value). In 2006, developing countries contributed 70% of the world’s non-food fishery exports, by quantity, and significantly increased their share of the quantity of fish exports destined for human consumption, from 43% in 1996 to 53% in 2006 (FAO, 2007a).

3.3.1.3 Marine Mammals

As previously noted, information on nominal catches of marine mammals is not included in total fisheries catch data; however, FAO does compile data on marine mammal catches as reported by each country. Unlike the fisheries data, catch volume reflects the number of the individual species caught, not the total weight in metric tons.

Whale captures are guided by measures set forth by the International Whaling Commission (IWC), who also designate whale sanctuaries. The IWC set limits on the numbers and sizes of whales that may be captured and determines seasons and areas for whaling. The IWC was established under the International Convention for the Regulation of Whaling signed in 1946 and membership in the IWC is open to any country that adheres to the 1946 Convention.

Table 3-20. Top 10 exporters and importers of fish and fishery products (FAO 2007a and 2008).

EXPORTERS	1996	2006	APR[18] (%)
	(U.S. $ MILLIONS)		
China	2,857	8,968	12.1
Norway	3,416	5,503	4.9
Thailand	4,118	5,236	2.4
U.S.	3,148	4,143	2.8
Denmark	2,699	3,987	4.0
Canada	2,291	3,660	4.8
Chile	1,698	3,557	7.7
Viet Nam	504	3,358	20.9
Spain	1,447	2,849	7.0
Netherlands	1,470	2,812	6.7
Top 10 Subtotal	23,648	44,073	6.4
Total for Remainder of World	29,139	41,818	3.7
World Total	52,787	85,891	5.0
IMPORTERS			
Japan	17,024	13,971	2.0
U.S.	7,080	13,271	6.5
Spain	3,135	6,359	7.3
France	3,194	5,069	4.7
Italy	2,591	4,717	6.2
China	1,184	4,126	13.3
Germany	2,543	3,739	3.9
United Kingdom	2,065	3,714	6.0
Denmark	1,619	2,838	5.8
Republic of Korea	1,054	2,729	10.0
Top 10 Subtotal	41,489	60,533	3.8
Total for Remainder of World	11,297	25,357	8.4
World Total	52,786	85,890	5.0

- Ensure risks of extinction are not seriously increased (highest priority);
- Enable harvests in perpetuity appropriate to cultural and nutritional requirements; and
- Maintain stocks at highest net recruitment level, and if below, ensure they move towards it.

In 1982 the IWC implemented a “pause” or moratorium in commercial whaling, which took effect during the 1985 to 1986 whaling season and is still in effect today. Aboriginal subsistence whaling and collections for scientific research conducted by member nations are still permitted, however.

18 APR refers to the average annual percentage growth rate for 1996 to 2006.

3.3.2 SUBSISTENCE HARVESTING OF MARINE MAMMALS

Under current IWC regulations, aboriginal subsistence whaling is permitted for Denmark (specifically for takes of fin, minke, bowhead, and humpback whales in Greenland's waters), the Russian Federation (for Siberia with takes of gray and bowhead whales), St. Vincent and The Grenadines (for Bequia with takes of humpback whales), and the U.S. (for Alaska native groups with takes of bowhead whales and for Washington [Makah] with takes of gray whales) (Table 3-21). It is the responsibility of national governments to provide the Commission with evidence of the cultural and subsistence needs of their people. The Scientific Committee provides scientific advice on safe catch limits for such stocks.

With the completion of the Revised Management Procedure for commercial whaling, the Commission asked the Scientific Committee to begin the process of developing a new procedure for the management of aboriginal subsistence whaling—the Aboriginal Whaling Management Procedure (AWMP). This is an iterative and ongoing effort. The Commission will ultimately establish an Aboriginal Whaling Scheme that comprises the scientific and logistical (e.g., inspection/observation) aspects of the management of all aboriginal fisheries. Within this framework the scientific component might comprise some general aspects common to all fisheries and an overall AWMP within which there will be common components and case-specific components (IWC, 2009a).

As of early 2012, the AWMP had not yet been completed or made public. Until the AWMP is completed, the Committee provides advice on a more stock by stock basis, carrying out major reviews according to the needs of the Commission in terms of establishing catch limits and the availability of data. It also carries out brief annual reviews of each stock (IWC, 2009b).

3.3.2.1 Subsistence Harvesting of Marine Mammals by U.S. Native Groups

In the U.S., subsistence uses of cetaceans by subsistence hunters is currently permitted in Alaska. Since 2007, the IWC reported that the Makah Tribe took one gray whale while subsistence hunters in Alaska took a total of 222 bowhead whales (Table 3-21; IWC, 2009b and 2012). Subsistence uses of marine mammals in the Gulf of Alaska include the harvest of harbor seals and Steller sea lions along coastal and inshore, including bay, areas of the gulf. As many as six Alaskan Native groups subsistence hunt harbor seals in the Gulf of Alaska, although the Dena'ina only occasionally hunt harbor seals, and four Native groups hunt Steller sea lions, with the Southeastern Alaska Native groups only occasionally harvesting Stellers (Wolfe et al., 2009; Table 3-22). Subsistence products that are derived from harbor seals and Steller sea lions by these Alaskan Native groups include oil, meat, and skins. Subsistence hunting of harbor seals and Steller sea lions is a specialized activity amongst Alaska Native groups, with only 30% and 3% of the surveyed native households hunting harbor seals and Steller sea lions, respectively (Wolfe et al., 2009).

Two stocks of harbor seals have been distinguished for the waters of the Gulf of Alaska, the Gulf of Alaska and Southeast Alaska stocks (Allen and Angliss, 2011). During 2008, 1,274 harbor seals of these two stocks were harvested or struck but lost; this was the second lowest number of animals harvested/struck since 1992 (Wolfe et al., 2009). The largest numbers of harbor seals taken by subsistence hunting in the overall Gulf of Alaska are in the southeastern Alaska region by the Tlingit and Haida tribes, who in 2008 harvested or struck 41% of the total number of harbor seals (Wolfe et al., 2009). Harbor seals were taken in all months of 2008, but harvests peaked in March and November, although the seasonal trends were not as distinguishable as that in the previous years since records have been documented beginning in 1992 (Wolfe et al., 2009). More male than female harbor seals were harvested and more adults than juveniles were taken in 2008 (Wolfe et al., 2009).

The Steller sea lions in the Gulf of Alaska occur in two stocks, the Western or Eastern stocks, although the Western stock also encompasses waters of the Bering Strait and Bering Sea (Allen and Angliss, 2011), where SURTASS LFA sonar will not be operated. In 2008, 63 Steller sea lions were harvested or struck but lost in the waters of the Gulf of Alaska, with Steller's being taken in every month (Wolfe et al., 2009). Peaks in harvest occurred in February through April and again in November, although the

Table 3-21. Aboriginal subsistence hunting as reported by the IWC from 2007 through 2010 (IWC, 2009b and 2012).

Subsistence Nation	Ocean Area[19]	Harvested Marine Mammal Species						
		Fin	Humpback	Sei	Gray	Minke	Bowhead	Total
2007								
Denmark: W. Greenland	NA	12	0	0	0	167	0	179
Denmark: E. Greenland	NA	0	0	0	0	2	0	2
St. Vincent and The Grenadines	NA	0	1	0	0	0	0	1
Russia	NP	0	0	0	131	0	0	131
U.S.: Alaska	NP	0	0	0	0	0	63	63
U.S.: Washington (Makah Tribe)	NP	0	0	0	1	0	0	1
Total		12	1	0	132	169	63	377
2008								
Denmark: W. Greenland	NA	14	0	0	0	153	0	167
Denmark: E. Greenland	NA	0	0	0	0	1	0	1
St. Vincent and The Grenadines	NA	0	2	0	0	0	0	2
Russia	NP	0	0	0	130	0	2	132
U.S. (Alaska)	NP	0	0	0	0	0	50	50
Total		14	2	0	130	154	52	352
2009								
Denmark: W. Greenland	NA	10	0	0	0	164	3	177
Denmark: E. Greenland	NA	0	0	0	0	4	0	4
St. Vincent and The Grenadines	NA	0	1	0	0	0	0	1
Russia	NP	0	0	0	116	0	0	116
U.S. (Alaska)	NP	0	0	0	0	0	38	38
Total		10	1	0	116	168	41	336
2010								
Denmark: W. Greenland	NA	5	9	0	0	186	3	203
Denmark: E. Greenland	NA	0	0	0	0	9	0	9
St. Vincent and The Grenadines	NA	0	3	0	0	0	0	3
Russia	NP	0	0	0	118	0	2	120
U.S. (Alaska)	NP	0	0	0	0	0	71	71
Total		5	12	0	118	195	76	406

seasonal trend is weak due to the reduced number of animals harvested in comparison to the early 1990s (Wolfe et al., 2009). Similarly to the harbor seal harvest, more males than female Steller sea lions were taken but more juveniles were taken than adults in the 2008 subsistence harvest.

3.3.3 Marine Recreational Activities

In addition to fishing, other recreational activities in marine waters include boating, surfing, water skiing, swimming, diving, and whale watching. Many of these activities would not be affected by SURTASS LFA

19 NA= North Atlantic Ocean, NP=North Pacific Ocean

Table 3-22. Alaskan Native Groups subsistence harvesting harbor seals and Steller sea lions in the Gulf of Alaska (Wolfe et al., 2009).

ALASKAN NATIVE GROUP	ALASKA REGION
Harbor Seals	
Alutiiq	Central Gulf of Alaska
Eyak	Central Gulf of Alaska
Tlingit	Southeastern Alaska
Haida	Southeastern Alaska
Tsimshian	Southeastern Alaska
Dena'ina	Cook Inlet
Steller Sea Lions	
Alutiiq	Kodiak Island, Gulf of Alaska
Tlingit	Southeastern Alaska
Haida	Southeastern Alaska
Tsimshian	Southeastern Alaska

sonar transmissions because they are conducted above the water's surface and/or do not involve the use or creation of underwater sound. Also, many of these activities occur mostly in coastal waters, away from where SURTASS LFA sonar would operate. An exception may be whale watching where there may be a possibility that whale behavior would be affected but only if sonar operations were being conducted nearby. Only those activities that could be affected, even remotely, by SURTASS LFA sonar are further addressed in this subchapter.

3.3.3.1 Swimming and Snorkeling

Recreational swimming and snorkeling occur in marine waters worldwide. Most swimming sites are located immediately adjacent to the coastline and well within 5.6 km (3 nmi) of the coast. Most swimming activity occurs at the air/water interface, (i.e., immediately adjacent to the ocean's surface). For snorkeling activity, the swimming area nominally extends from the surface to depths not greater than 2 m (6.5 ft); deeper depths than this are unlikely for the average recreational swimmer. Other than for very short periods of time, people usually do not go below 2 m (6.5 ft).

3.3.3.2 Recreational Diving

Recreational diving sites are generally located between the shoreline and the 40 m (130 ft) depth contour, but can occur outside this boundary. Global diving statistics indicate a substantial growth in activity as measured by the number of divers that were certified during that time. The Professional Association of Diving Instructors (PADI), the world's largest dive training organization, issued 932,486 diving certifications in 2008 (PADI, 2008a). In fact, between 1967 and 2008, PADI issued a cumulative total of 17,532,116 diving certifications (PADI, 2008a).

It is estimated that over 1.2 million dive trips are taken to warm-water destinations each year (Simmonds, 1997), including the Caribbean, Gulf of Mexico, Pacific Ocean, Mediterranean Sea, and Indian Ocean, as well as other locations (Tables 3-23 and 3-24). Surveys of the demographics of diving students and instructors conducted by PADI show that between 2002 and 2008 most divers were males approximately 30 years old (PADI, 2008b).

Table 3-23. Worldwide major recreational diving locations (Scuba Travel LTD, 2009).

DIVING LOCATION—GREATER ATLANTIC OCEAN	**DIVING LOCATION—GREATER PACIFIC OCEAN**
Bay of Pigs, Cuba	Aliwal Shoal, South Africa
Cenotes, Playa Del Carmen, Mexico	Protea Banks, South Africa
Palancanar Bricks, Cozumel, Mexico	Sodwana Bay, South Africa
Cozumel, Mexico	Malpelo Island, Colombia
Santa Rosa Wall, Cozumel, Mexico	Manta Ray Night Dive, Kailua Kona, Hawaii, U.S.
Dos Ojos (Los Cenotes), Playa del Carmen, Mexico	Holmes Reef, Coral Sea, Australia
Dirty rock, Cocos Island, Costa Rica	Yongala, Australia
Pedras Secas, Noronha, Brazil	Perpendicular wall, Christmas Island, Australia
Great Blue Hole, Belize	Pixie pinnacle and pixie wall, GBR, Australia
Half Moon Wall, Belize	Navy Pier, Western Australia
Los Testigos Islands, Venezuela	Osprey Reef, Coral Sea, Australia
Sugar Wreck, Grand Bahama Island, Bahamas	Cod Hole, Northern Great Barrier Reef, Australia
Wreck of the Bahama Mama, New Providence, Bahamas	Fish Rock, Off South West Rocks in NSW, Australia
Bloody Bay wall, Little Cayman, Cayman Islands	Canibal Rock, Komodo, Indonesia
Stingray City, Grand Cayman, Cayman Islands	Castle Rock - Komodo National Park, Indonesia
Shark Alley, Grand Cayman, Cayman Islands	Gili Air, Indonesia
Diamond Rocks, Kilkee, Ireland	Lombok Strait, Indonesia
The Canyons, Utila, Honduras	Liberty, Bali, Indonesia
Blockship Tabarka, Scapa Flow, Orkney, United Kingdom	Lekuan 1, Bunaken National Park, N. Sulewesi, Indonesia
Booroo, Isle of Man, United Kingdom	Blue Corner Wall, Palau, Micronesia
Eddystone Reef, United Kingdom	Ulong Channel, Palau, Micronesia
Toucari Caves, Dominica	Peleliu Express, Palau, Micronesia
DIVING LOCATION—INDIAN OCEAN	Tiputa pass, Rangiroa, New Zealand
Office, Mozambique	Rainbow Warrier, New Zealand
Great Basses reef, Sri Lanka	Poor Knights, New Zealand
Mafia Island, Tanzania	President Coolidge, Vanuatu
Mnemba Island, Tanzania	Puerto Galera, Philippines
Manta reef, Mozambique	Tubbataha, Palawan, Philippines
Marbini Padre, Malaysia	Wakaya Passage,Fiji
Barra Reef, Mozambique	Shark Fin Point, Fiji
East Timor	Fish Factory, Vuna Reef, Taveuni, Fiji
DIVING LOCATION—GREATER MEDITERRANEAN Sea	Fujikawa Maru, Truk Lagoon (Chuuk Lagoon)
Big Brother, Egyptian Red Sea	Rangali Madivaru, Maldives
Blue Hole, Dahab, Egyptian Red Sea	The Express, Kuredu, Maldives
Daedelus, Egyptian Red Sea	The Point, Layang - Layang
Elphinstone Reef, Egyptian Red Sea	Garuae Pass, Fakarava Island, French Polynesia
Cirkewwa, Malta	Tiputa Pass, Rangiroa, Polynesia
Blue Hole,Gozo, Malta	Barracuda Point, Sipadan Island, Malaysia
Ras Mohammed, Egyptian Red Sea	Turtle Tavern, Sipadan, Malaysia

Table 3-23. Worldwide major recreational diving locations (Scuba Travel LTD, 2009).

DIVING LOCATION—GREATER MEDITERRANEAN SEA	DIVING LOCATION—GREATER PACIFIC OCEAN
Ghiannis D, Egypt	Hanging Garden, Sipadan, Malaysia
Jackson Reef, Egypt	South Point, Sipadan, Malaysia
Little Brother, Egyptian Red Sea	Sipadan Drop Off, Malaysia
Shark and Yolanda Reef, Egyptian Red Sea	Similans, Thailand
Chios island, Greece	Hin Muang, Thailand
St. Johns, Egypt	Japanese Gardens, Koh Tao, Thailand
Straits of Tiran, Egyptian Red Sea	Richelieu Rock, Thailand
The Zenobia, Cyprus	Grand Central Station, Gizo, Solomon Islands
Thistlegorm, Egyptian Red Sea	Darwin Island and Arch, Galapagos
Umbria, Sudan	Gordon's Rock, Galapagos
Sha'ab Rumi South, Sudan	Wolf Island, Galapagos
	Joel's, Papua New Guinea
	Cortes Bank, California, U.S.
	Tanner Bank, California, U.S.

Table 3-24. National Marine Sanctuaries that are considered to be recreational dive sites for SURTASS LFA.

NATIONAL MARINE SANCTUARY	OCEAN LOCATION/U.S. STATE
Monitor	Northwest Atlantic/North Carolina
Gray's Reef	Northwest Atlantic/Georgia
Florida Keys	Northeastern Gulf of Mexico/Florida
Flower Garden Banks	Northern Gulf of Mexico/Texas
Channel Islands	Northeast Pacific/California

3.3.3.3 Whale Watching

Whale watching[20] worldwide has expanded rapidly over the last decade and is now considered a major component of global ecotourism, with an overall annual growth rate of 3.7%. However, regions such as Asia, Central America/Caribbean, and South America have experienced even higher growth rates in whale watching, with annual growth of 17%, 13%, and 10%, respectively (O'Connor et al, 2009). An estimated 13 million people participate in whale-watching excursions in 119 countries and territories, generating total revenue of $U.S.2.1 billion (O'Connor et al., 2009). Whale watching has become an industry of more than 3,300 whale watching trip operators that employ 13,200 people (O'Connor et al., 2009). North America (Canada and the U.S.) is the world's largest whale watching destination, with over 6

20 Whale watching refers to the viewing of all wild cetaceans, including whales, dolphins, and porpoises.

million whale watchers in 2008; despite record numbers of whale watchers, the North American whale watch industry is mature with one of the lowest annual growth rates. Australia is the only other country that takes more than 1 million people whale watching each year (O'Connor et al., 2009).

Due to the seasonal occurrence of cetaceans in many worldwide regions due to migrational movements, by association, whale watching is often a seasonal enterprise. Although whale watching is nearly always done from boats, some operators offer whale watching excursions in airplanes and helicopters. Most whale-watching activities focus on humpback, gray, northern and southern right, fin, blue, minke, sperm, short-finned pilot, and killer whales, as well as bottlenose dolphins (Hoyt, 2001).

The IWC and other organizations concerned with the preservation of cetaceans worldwide support whale watching as a sustainable use of cetacean resources (Spalding, 1998; IWC, 2004). In 1996, the IWC first adopted the following general principles for managing the then emerging whale watching industry to help minimize adverse effects on whale populations:

- Manage the development of whale watching to minimize the risk of adverse impacts;
- Design, maintain, and operate platforms to minimize the risk of adverse effects on cetaceans including disturbance from noise; and
- Allow the cetaceans to control the nature and duration of "interactions" (IWC, 2004).

There are; however, costs to whale watching. In addition to the possible pollution from to the use of boats and trash thrown into the water by whale watchers, there are also the unknown potential effects on cetacean behavior and health as well as and the risk of harassment and harm to the very cetaceans that are being viewed. Ship strikes, for instance, are a risk associated with whale watching. Of the 134 ship strike accounts where the type of vessel is known 19 ship strike reports were by whale-watching vessels (Jensen and Silber, 2004).

3.3.4 Research and Exploration Activities

This section summarizes the various research and exploration activities occurring or expected to occur in the ocean, with a focus on those activities that generate or make use of acoustic signals in conducting their operations. These acoustics signals could be hampered by SURTASS LFA sonar transmissions, or they could interfere with SURTASS LFA sonar operations. These could occur because of the signals/transmissions interfering with each other through masking, production of anomalous data, or raising overall ambient noise levels. Included are activities undertaken by private companies for commercial purposes as well as those by government agencies and their contractors. The discussion is restricted to activities that are conducted undersea. Surface activities such as maritime transportation, surface research, and fishing are excluded from consideration.

3.3.4.1 Oceanographic Research

Acoustic and seismic research has contributed more to understanding Earth's physical history, natural hazard potential, and climate systems than perhaps all other scientific technology combined. Sound travels freely through the oceans and can be used to measure topography and to map geology, ocean temperatures, and currents. Marine acoustic surveys are fundamental tools guiding explorations of this planet. Numerous scientific research vessels from around the world are engaged in studying all of the Earth's oceans and the underlying seafloor. The data that are being collected are critical to informed decision making regarding our future (LDEO, 2004). Researchers use ship-mounted equipment and unmanned and manned submersible vehicles. For example, several U.S. institutions, including the Woods Hole Oceanographic Institution; Scripps Institution of Oceanography at the University of California, San Diego; Lamont-Doherty Earth Observatory at Columbia University; and several science centers operated by NMFS, conduct research each year over the world's oceans.

Remotely Operated Vehicles (ROVs)

Remotely operated vehicles are unmanned underwater robots that are controlled by a pilot, via a tether that is spooled out from a support vessel (i.e., either a ship or another underwater vehicle). NOAA owns or leases ROVs such as the Kraken, Phantom, Hela, Jason/Medea, and Spectrum II, which are fitted with camera, lighting, and sampling systems that allow scientists to be virtually transported, through real-time video transmission, to depths beyond 21,385 feet. ROVs are commonly used in situations when scuba diving is not feasible due to depth and time limitations or when expensive manned submersibles are not cost effective. The advantages of ROVs include greatly extended bottom times, reduced human risk, reduced operating costs, and the ability to deploy in harsher environments. ROVs have been used to conduct research in a wide range of environments—from the tropics to the poles.

The NOAA Office of Ocean Exploration and Research has ordered a deep-ocean ROV for use on the Okeanos Explorer. Built by Phoenix International and a sister-vehicle to a new U.S. Navy ROV, this vehicle will dive up to a 19,685 foot depth and use high definition video cameras to provide exceptional new data from the ocean floor. The ROV will be part of a "two-body" system with a camera sled operating just above the ROV. This will provide additional sensors and lighting and a valuable overhead view for scientists. The system will also include an "X-bot," a very small ROV able to access confined or hazardous areas such as submarine caves (NOAA, 2009a)

ROVs are also controlled using transponders, and a typical research effort involves placement of multiple transponder units on the ocean floor. Transponders send and receive HF FM signals to and from the research vehicle and the controlling ship on the surface. Signals establish location and control movement of the vessel and support its data-gathering activities.

With over 900 work class vehicles built to date and over 500 in commercial operation ROVs have become an important tool, without which development of offshore oil and gas would have been severely restricted (PRLog, 2006). The World AUV and ROV Report (PRLog, 2006) values the 2004 world market for ROV operations at $600 million and forecasts that after some years of difficulties, the long-term growth trend will resume and is predicted to reach $750 million in 2008. The five-year forecast shows Western Europe, North America, and Africa to be the most significant regions (PRLog, 2006). Support of offshore oil and gas drilling operations and construction support are shown as the largest sectors, together with submarine cable maintenance—but this activity is mostly not open to competitive tendering.

Autonomous Undersea Vehicles (AUVs)

Autonomous undersea vehicles (AUVs) are the most recent class of undersea research technology and can be described as a rapidly evolving class of un-tethered and unmanned submersibles. As the name suggests, AUVs can be preprogrammed to conduct various measurements, video surveillance, etc. Since they are independent of the surface, they are typically battery powered and controlled by computers using various levels of artificial intelligence. As platforms for scientific sensors, these vehicles operate at depths, over distances and with endurances that cannot be achieved with the same economies using human-guided devices. To date, most scientific AUVs have executed wide-area seafloor surveys and habitat characterization missions.

NOAA operates a number of AUVs for these purposes and, through its Undersea Research Program, offers the use of two state-of-the-art vehicles to undersea researchers: a high-endurance Slocum-class underwater glider capable of diving to depths of 656 feet from Webb Research, and a new large-frame, deepwater Explorer-class vehicle capable of diving to 7217 feet from International Submarine Engineering. The latter vehicle began operations in 2006 (NOAA, 2009b).

The Autonomous Undersea Systems Institute (AUSI) is an independent research institute that coordinates research for AUVs and related systems. Research programs include intelligent AUV control, architectural issues, long-range AUV development, and problem solving. AUSI hosts the International Symposium on Unmanned Untethered Submersible Technology at the University of New Hampshire.

The Autonomous Undersea Vehicle Applications Center (AUVAC) brings together academic, private sector, and government organizations in support of AUVs, in order to advance AUV system technology, promote AUV interoperability, and increase AUV availability in support of national ocean community needs. AUVAC recently published a website to encourage collaboration within the AUV community, from the point of view of both users and research and technology developers. This website documents current and emerging AUV technologies and makes this information available to prospective users (AUVAC, 2009).

Manned Submersible Vehicles

Manned submersible vehicles are also used in ocean research. These vehicles communicate with their deployment ship using radios. Through the use of human occupied submersibles, scientists can be physically transported to great depths of the oceans, far beyond the physiological restrictions of wet diving on the human body.

Submersibles owned by NOAA include the Pisces IV and V, two of only nine submersibles in the world that can dive to depths of more than 6,562 feet. Both carry a pilot and two scientists. The submersibles are custom equipped to accommodate a variety of mission requirements. Standard gear includes external video and still cameras, two hydraulic manipulator arms, a conductivity/temperature/depth profiler and sonar. Their use has provided unprecedented knowledge of the Pacific’s undersea volcanic processes and deep sea coral habitats. Through partnerships, NOAA can also lease other submarines, including the Johnson Sea Link, Delta, and Alvin (NOAA, 2009c)

Seismic Surveys

Seismic surveys are conducted using air gun arrays, multi-beam bathymetric sonars, and sub-bottom profilers. The air guns are towed behind the source vessel and emit a seismic pulse which is then picked up by a hydrophone and map out the earth’s crust. The multi-beam sonar images the seafloor using short pulses at high frequency. The sub-bottom profiler maps the bottom topography while supplying information on sedimentary features (LGL, 2003).

Ocean Acoustic Tomography

Ocean acoustic tomography is a research effort initiated by Scripps, the Massachusetts Institute of Technology (MIT), and others to determine the effectiveness of LF sound transmissions to map features of ocean circulation. LF sound slows down or speeds up as it travels across boundaries of different temperatures, pressures, or salinities. Although travel times must be measured to a nominal accuracy of 1 millisecond, tomographic transmissions consist of long coded signals lasting 30 seconds or more. These transmissions are audible near the source, but over most of the ocean they are below ambient noise levels, requiring sophisticated spread-spectrum signal processing techniques to recover them (WHOI, 2008). The ATOC project, an international research effort utilizing LF sound to observe temperature change in the oceans, has been completed in California and Hawaii. Under a program that concluded in 2007, Scripps reused the sound source in Hawaii for its North Pacific Acoustic Laboratory (NPAL). NPAL's objectives combined:

- A second phase of research on the feasibility and value of large-scale acoustic thermometry;
- Long-range underwater sound transmission studies; and
- Marine mammal monitoring and studies.

The Kauai acoustic source began transmitting in late 1997, continuing through fall 1999. After a hiatus of two years while marine mammal permitting issues were sorted out, the Kauai acoustic source resumed transmissions in January 2002, continuing to transmit for another 5 years at regular 4-day intervals (NPAL, 2009).

University-National Oceanographic Laboratory System (UNOLS)

The University-National Oceanographic Laboratory System (UNOLS) is a consortium of 61 academic institutions involved in federally-funded oceanographic research. Seventeen of these institutions operate the 22 ships of the UNOLS Fleet (UNOLS, 2009). Ship schedules, geographic locations of proposed cruises, and other information about UNOLS are available at http://www.gso.uri.edu/unols/unols.html.

3.3.4.2 Oil and Gas Production

Major offshore oil and gas production regions include the continental shelf of the U.S. (Prudhoe Bay, Gulf of Mexico, and Southern California), the coasts of Venezuela and Mexico, the Persian Gulf, the North Sea, and the waters off Indonesia. Deepwater (greater than 305 m [1,000 ft]) oil and gas exploration activities are on the rise due to improved technology spurred by the discovery of high production reservoirs in deeper waters. As such, oil and gas production activities are extending to greater depths and associated greater distances from the coastline. In 2006 Chevron, Devon Energy, and Norway-based Statoil ASA announced the successful discovery of oil at a staggering depth beneath the surface of the Gulf of Mexico. Their well delves through 2,134 meters (7,000 feet) of seawater and more than 6,100 meters (20,000 feet) of seafloor to strike oil in the lower tertiary formation (National Geographic News, 2006).

The U.S. Outer Continental Shelf (OCS) refers to 1.7 billion acres of submerged lands for which the Federal government has jurisdiction seaward of state boundaries, generally beginning 3 nmi off the coastline (for all states except Texas and Gulf coast Florida, which have a 9 nmi state limit) and extending 200 nmi to the edge of the EEZ. In 2009, the OCS accounted for 11.5% (2,506 billion ft^2) of the nation's natural gas production and 31% (593,754 barrels) of its oil production (MMS, 2010). This was a decrease from the 2007 OCS production, that accounted for 14% (2,860 billion ft^2) of the U.S. natural gas production and 27% (429,329,179 barrels) of oil production from 3,795 production facilities on 8,124 Federal leases that covered more than 43 million acres (MMS, 2009).

Currently, two types of offshore geophysical surveys are performed to obtain information on subsurface geologic formations in order to identify potential oil and gas reserves. Both methods employ high-energy seismic surveys (HESS). High-resolution seismic surveys are used in the initial site evaluation for drill rig emplacement and platform design. Deep seismic surveys are used to more accurately assess potential hydrocarbon reservoirs.

Seismic surveying operations are conducted from ships towing an array of acoustic instruments, including air guns, which release compressed air into the water, creating acoustic energy that penetrates the sea floor. The acoustic signals are reflected off the subsurface sedimentary layers and recorded near the ocean surface on hydrophones spaced along streamer cables. Alternatively, cable grids are laid on the ocean floor to act as receivers and are later retrieved.

In addition to air guns, seismic surveys utilize numerous other MF and HF acoustic instruments including multi-beam bathymetric sonar, side-scan sonar, and sub-bottom profilers. These data acquisition systems are commonly used along with air guns and map the ocean floor in great detail.

When commercially viable reserves are identified, wells are drilled to confirm the presence of exploitable resources. Initial wells in a field are drilled from a ship and once commercial levels of production are proven, permanent platforms and pipelines are installed. Alternatively, a new type of floating facility, representing an alternative to platform construction, may be used. Four or five development wells go into production, while the remaining wells are capped and abandoned. Capping is accomplished by ROVs or manned submarine vehicles.

Subsea systems to install wellhead and related equipment on the ocean floor are used in the construction of 5 to 7% of wells while the remaining systems use surface wellhead equipment. Both types of systems use divers to connect production lines to pipeline systems. Installation of pipelines also requires survey of the seafloor to select a pipeline route. These surveys generally rely on the use of sonars that generate HF sound waves such as chirps and pinger signals.

Once wells and wellheads are established, they are operated around the clock for their project life, except for periods of maintenance and repair. Divers are occasionally needed to repair pipeline connections or subsea production systems. Divers also participate in removal of the platform and capping of wells when the field is abandoned.

AUV technology has developed as the offshore oil industry has ventured into much deeper waters. Conventional survey techniques with towed sensors were not practical due to the length of cable required to enable the tow fish to be as close to the seabed as possible to achieve the data resolution required. With the longer cable lengths, positioning accuracy also deteriorated and the length of time to conduct the surveys increased dramatically caused by the vessel line turns required for grids to be surveyed. A typical AUV will carry acoustic side-scan, profilers, and swathe systems as well as Inertial Navigation Systems and acoustic telemetry for communication with the mother vessel, all leading edge technology. AUV propulsion is supplied by on-board batteries or fuel cells which have to be able to operate for up to 60 hours without changes. The electrical power is provided from the reaction of chemicals stored in the vehicle. AUV equipment has to be strong physically to withstand the pressures at depths of 3,500 m. The technologies being used are right at the cutting edge and are complex, sophisticated and expensive, but the survey results being achieved from the sonars, profilers and swathe systems are startling (Offshore Technology, 2008).

3.3.5 COASTAL ZONE MANAGEMENT

The Coastal Zone Management Act (CZMA) was enacted on October 27, 1972, to encourage coastal states, Great Lake states, and U.S. territories and commonwealths (collectively referred to as coastal states) to develop comprehensive programs to manage and balance competing uses of and impacts to coastal resources. The CZMA created a federal-state partnership in the management and use of coastal resources. An important part of this partnership involves the requirement that Federal agency activities affecting the coastal zone be consistent to the maximum extent practicable with the state's approved enforceable policies.

NOAA's Office of Ocean and Coastal Resource Management (OCRM) works with the Nation's coastal states and territories to manage and conserve ocean and coastal uses and resources. Thirty-four out of 35 coastal states and territories have active NOAA-approved coastal zone management programs. The 35th state, Illinois, is currently developing its coastal program.

The specific coastal zone management policies identified under state programs vary depending upon the specific issues faced by their region. Many policies address the use, management, and/or development of land within the designated coastal region, often to reduce coastal hazards, promote water-dependent or appropriate land uses, and provide public access. Some policies seek to improve air or water quality in the coastal areas. Others address the protection of sensitive marine resources and habitats, support for coastal recreational activities, and the promotion of marine and estuarine research and education. While coastal zone management programs provide detailed recommendations on a variety of projects that may occur in coastal waters, they do not regulate the movement of commercial, recreational, or military shipping or boating. In addition, none of the programs contain specific provisions regarding sonar activities or related acoustic impacts.

Each state's coastal zone management program is required to contain the following elements:

- Identification of the boundaries of the coastal zone subject to the management program;
- Definition of permissible land uses and water users within the coastal zone;
- Inventory and designation of areas of particular concern within the coastal zone;

- Identification of the means by which the State proposes to exert control over the land and water uses;
- Broad guidelines on priorities of uses in particular areas;
- Description of the organizational structure proposed to implement the program;
- Definition of the term “beach” and a planning process for the protection of, and access to, public beaches and other public coastal areas of environmental, recreational, historical, aesthetic, ecological, or cultural value;
- Planning process addressing the location of energy facilities; and
- Planning process addressing shoreline erosion.

The landward boundaries of the coastal zone vary by state, reflecting both the natural and man-made environment. The seaward boundaries generally extend to the outer limits of the jurisdiction of the state, but not more than 5.6 km (3 nmi) into the Atlantic or Pacific Oceans or Great Lakes (or 16.7 km [9 nmi] for Texas and Gulf Florida). The extent of each state’s coastal zone boundary, however, is defined by each state in their coastal zone management plan.

If any Federal activity affects state coastal resources, they are subject to Section 307(c)(1) of the Federal Coastal Zone Management Act Reauthorization Amendments of 1979, which requires federal agencies conducting or supporting activities within or outside the coastal zone that affect any land, water use, or natural resources of the coastal zone to be consistent, to the maximum extent practicable, with the enforceable policies of the affected state’s coastal zone management program. A determination of consistency must be submitted by the responsible federal agency to the affected state’s coastal program or commission for review. The determination generally includes a detailed description of the proposed activity, its expected effects upon the land or water uses or natural resources of the state’s coastal zone, and an evaluation of the proposed activity in light of the applicable enforceable policies in the state’s program.

Most of the state programs also identify geographic “areas of particular concern.” Areas of particular concern are typically areas of high natural productivity or essential habitat for living resources, including fish and wildlife, and areas where development and facilities are dependent upon the utilization of, or access to, coastal waters.

The Final SURTASS LFA Sonar OEIS/EIS (see DoN, 2001 Final OEIS/EIS Table 3.3-5) provided information on the areas of particular concern and the relevant coastal zone management policies for each coastal state/territory near which SURTASS LFA sonar is likely to be operated.

THIS PAGE IS INTENTIONALLY LEFT BLANK

4.0 IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

This chapter supplements the analyses and results on the potential impacts or effects on various components of the environment that could result from the implementation of the proposed action, and of alternatives to the proposed action. The basis for this analysis is consistent with the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001) and FSEIS (DoN, 2007a) and has been updated based on the best available literature, the Long Term Monitoring Program of current SURTASS LFA sonar operations, and continuing research. Further, no new data contradict any of the assumptions or conclusions presented in Chapter 4 of both the FOEIS/EIS and FSEIS; hence, their contents are incorporated herein by reference.

For SURTASS LFA sonar alternatives, potential impacts should be reviewed in the context of the basic operational characteristics of the system:

- A maximum of four systems, with the potential to be deployed in the Pacific-Indian Ocean area and in the Atlantic Ocean-Mediterranean Sea area.
- The USNS IMPECCABLE (T-AGOS 23) is equipped with a SURTASS LFA sonar system. Three additional VICTORIOUS Class (T-AGOS 19) platforms have been equipped with or, are scheduled to be outfitted with, compact LFA (CLFA) systems (see Subchapter 2.1). These vessels are, or will be, U.S. Coast Guard-certified for operations. In addition, they will operate in accordance with all applicable federal and U.S. Navy rules and regulations related to environmental compliance. SURTASS LFA sonar vessel movements are not unusual or extraordinary and are part of routine operations of seagoing vessels. Therefore, there should be no unregulated environmental impacts from the operation of the SURTASS LFA sonar vessels.
- At-sea missions would be temporary in nature (see Subchapter 2.2 [Operating Profile]). Of an estimated maximum 294 underway days per year per vessel, the SURTASS LFA sonar would be operated in the active mode a maximum of 240 days. During these 240 days, active transmissions would occur for a maximum of 432 hours per year per vessel. (See Subchapter 2.2).
- Average duty cycle (ratio of sound “on” time to total time) of the SURTASS LFA sonar active transmission mode is less than 20%. The typical duty cycle, based on historical LFA operational parameters since 2003 is nominally 7.5 to 10%. That is, 7.5 to 20% of the time the LFA transmitters could be on; and 80 to 92.5% of the time the LFA transmitters would be off, thus adding no sound into the water. On an annual basis, each SURTASS LFA vessel is limited to transmitting no more than 4.9% of the time (432 hrs/8,760 hrs).

The types of potential effects on marine animals from SURTASS LFA sonar operations can be broken down into several categories:

- **Non-auditory injury**: This includes the potential for resonance of the lungs/organs, tissue damage, and mortality. For the purposes of the SURTASS LFA sonar analyses presented in this SEIS/SOEIS, all marine animals exposed to underwater sound with >180 dB re 1 µPa (rms) RL are evaluated as if they are injured (Level A “harassment” under the MMPA). Even though actual injury would not occur unless animals were exposed to sound at a level greater than this value (Southall et al., 2007), the analysis in the document will continue to define LFA’s injury level as >180 dB re 1 µPa (rms) RL. This should be viewed as a conservative value, used to maintain consistency in the analytical methodologies previously utilized in LFA environmental impact statements (DoN, 2001 and 2007a), in

References to Underwater Sound Levels
• **References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa @ 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).** • **In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).** • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS/SOEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for the energy of all the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for details. As discussed in Appendix C, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001 and 2007a).**

incidental take application under the MMPA, and in consultations under the Endangered Species Act (ESA).

- **Permanent threshold shift (PTS)**: A severe situation occurs when sound intensity is very high or of such long duration that the result is a permanent hearing loss on the part of the listener, which is referred to as permanent threshold shift (PTS). This constitutes Level A "harassment" under the MMPA, as does any other injury to a marine mammal. The intensity and duration of an underwater sound that will cause PTS varies across species and even among individual animals. PTS is a consequence of the death of the sensory hair cells of the auditory epithelia of the ear and a resultant loss of hearing ability in the general vicinity of the frequencies of stimulation (Salvi et al., 1986; Myrberg, 1990; Richardson et al., 1995). PTS results in a permanent elevation in hearing threshold—an unrecoverable reduction in hearing sensitivity (Southall et al., 2007).
- **Temporary threshold shift (TTS)**: Underwater sounds of sufficient loudness can cause a temporary condition known as temporary threshold shift (TTS) in which an animal's hearing is impaired for a period of time. After termination of the sound, normal hearing ability returns over a period that may range anywhere from minutes to days, depending on many factors, including the intensity and duration of exposure to the sound. Hair cells may be temporarily affected by exposure to the sound, but they are not permanently damaged or killed. Thus, TTS is not considered an injury (Richardson et al., 1995; Southall et al., 2007), although during a period of TTS, animals may be at some disadvantage in terms of detecting predators or prey.
- **Behavioral change**: Various vertebrate species are affected by the presence of intense sounds in their environment (Salvi et al., 1986; Richardson et al., 1995). Behavioral responses to these sounds vary from subtle changes in surfacing and breathing patterns, to cessation of vocalization, to active avoidance or escape from regions of high sound levels (Wartzok, et al., 2004). For military readiness activities, such as the use of SURTASS LFA sonar, Level B "harassment" under the MMPA is defined as any act that disturbs or is likely to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or significantly altered. Behaviors include migration, surfacing, nursing, breeding, feeding, and sheltering. The National Research Council (NRC, 2005) discusses biologically significant behaviors and possible effects. It states that an action or activity becomes biologically significant to an individual animal when it affects the ability of

the animal to grow, survive, and reproduce. These are the effects on individuals that can have population-level consequences and affect the viability of the species (NRC, 2005). While sea turtles and fish do not fall under MMPA harassment definitions, like marine mammals, it is possible that loud sounds could disturb the behavior of fish and sea turtles, resulting in similar consequences as for marine mammals.

- **Masking and impaired communications**: The presence of intense sounds in the environment can potentially interfere with an animal's ability to hear sounds of relevance to it and reduce acoustic information essential to conspecies communications. This effect, known as "auditory masking," could interfere with the animal's ability to detect biologically-relevant sounds, such as those produced by predators or prey, thus increasing the likelihood of the animal not finding food or being preyed upon.
- **Stress:** The potential for acoustically-induced stress in marine mammals is presented as part of the cumulative effects discussion in Subchapter 4.7.1.2.

The acoustic environment in the ocean is dynamic, consisting of both anthropogenic and natural noises. The understanding of the transmission of sound, or acoustic propagation, in the ocean environment is important to the readers' comprehension of this complex subject. A tutorial on the fundamentals of underwater sound was provided as Appendix B of the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001) to assist the reader in understanding the technical aspects of the document. The information in this appendix remains valid, and its contents are incorporated herein by reference. Additional references pertinent to this discussion include:

- Urick, R.J. 1983. Principles of Underwater Sound, 3rd Edition. Los Altos, California: McGraw-Hill, Inc.
- Richardson, W.J., C.R.J. Green, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. San Diego, California: Academic Press.
- Bradley, D.L. and R. Stern. 2008. Underwater Sound and the Marine Mammal Environment: A Guide to Fundamental Principles. Marine Mammal Commission. Rockville, Maryland.
- OMP and MAI (Office of Marine Programs and Marine Acoustics, Inc.). 2010. Discovery of sound in the sea (DOSITS). Office of Marine Programs, University of Rhode Island. <http:www.dosits.org>. (Scowcroft et al., 2006).

4.1 POTENTIAL IMPACTS ON FISH SPECIES AND STOCKS

Since the original SURTASS LFA sonar FOEIS/EIS (DoN, 2001) and FSEIS (DoN, 2007a), there have been a number of relevant studies on the potential effects of underwater sound on fish, including sharks, and several other pertinent studies that have come forth. This sub-chapter will provide summaries of the recent research and update the analysis of the potential effects of the alternatives based on the following SURTASS LFA sonar operational parameters:

- Small number of SURTASS LFA sonar systems to be deployed;
- Geographic restrictions imposed on system employment;
- Narrow bandwidth of SURTASS LFA sonar active signal (approximately 30 Hz);
- Slowly moving ship, coupled with low system duty cycle, would mean that fish would spend less time in the LFA mitigation zone (180-dB SPL sound field); therefore, with a ship speed of less than 9.3 km/hr (5 kt), the potential for animals being in the sonar transmit beam during the estimated 7.5 to 20% of the time the sonar is actually transmitting is very low; and
- Small size of the LFA mitigation zone (180-dB SPL sound field) relative to fisheries provinces and open ocean areas.

Due to the lack of more definitive data on fish/shark stock distributions in the open ocean, it is not feasible to estimate the percentage of a stock that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth during an LFA sound transmission.

4.1.1 Potential Impacts on Fish (Class Osteichthyes) Stocks

There have been several studies on the effects of both Navy sonar and seismic airguns[1] that are relevant to potential effects of SURTASS LFA sonar on Osteichthyes (bony fish). In the most pertinent of these, the Navy funded independent scientists to analyze the effects of SURTASS LFA sonar on fish. Results from this study were originally presented in the FSEIS (DoN, 2007a). The findings from this study have been presented at conferences, peer-reviewed and published in scientific journals (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010). These results have now been updated with a related study that examined in detail the effects of SURTASS LFA sonar on fish physiology (Kane et al., 2010). Several other studies have assessed the effects of seismic airguns on fish. Thus, while most research before 2001 studied the effects of sounds using pure tones of much longer duration than the SURTASS LFA sonar signals (see FOEIS/EIS, Subchapter 4.1.1.1), many of the more recent studies provide insight into the impact of each of these sounds on fish. With the caveat that only a few species have been examined in these studies, the investigations found little or no effect of high intensity sounds on a number of taxonomically and morphologically diverse species of fish; and there was no mortality as a result of sound exposure, even when fish were maintained for days post-exposure.

4.1.1.1 Non-Auditory Injury

A number of investigators have suggested that fish exposed to high intensity sounds could show a range of non-auditory injuries, extending from the cellular level to gross damage of the swim bladder and circulatory system (reviewed in Popper and Hastings, 2009a). However, the bulk of the data suggesting such injuries come from studies that tested the effects of explosives on fish (Yelverton et al., 1975; and reviews in Hastings, 2008 and Popper and Hastings, 2009a and 2009b). There is less evidence for such damage (albeit, from very few studies) when fish are exposed to sounds similar to those produced by sonars, pile driving, shipping noise, and other anthropogenic sources.

Studies estimating the effects of sound on terrestrial mammals suggest that lungs and other organs are potentially damaged by sound (Fletcher et al., 1976; Yang et al., 1996; Dodd et al., 1997; see also Henderson, 2008 for review of noise standards for humans). There is also some evidence, in “gray” literature reports (i.e., non-peer-reviewed), that high sound pressure levels may cause tearing or rupturing of the swim bladder of some (but not all) fish species (Gaspin, 1975; Yelverton et al., 1975). Most recently, similar results have been observed in fish exposed to the impulsive sounds from pile driving when fish are at an undetermined range but very close to the pile driving source (Abbott and Bing-Sawyer, 2002; Caltrans, 2004). However, such studies have yet to be repeated under controlled experimental conditions and none have received scientific peer review (Popper and Hastings, 2009b).

The only studies that examined the effects of sound on non-auditory tissues have been the recent work using SURTASS LFA sonar (undertaken by the U.S. Navy) and seismic airguns, both of which are reviewed below (Popper et al., 2005b, 2007; Song et al., 2008; Kane et al., 2010). The significant point from these studies is that neither source, despite being very intense, had any effect on non-auditory tissues. In all fish, the swim bladder was intact after exposure, and in the one study that involved an expert fish pathologist (to ensure that the non-auditory tissues of the fish sacrificed were examined properly), there was no damage to tissues either at the gross or cellular levels (Popper et al., 2007; Kane

---

1 Seismic airguns differ from SURTASS LFA sonar in that they generally transmit in the 5 to 20 Hz frequency band and their typical airgun array firing rate is once every 9 to 14 seconds, but for very deep water surveys, the rate could once every 42 sec. Airgun acoustic signals are typically measured in peak-to-peak pressures, which are generally higher than continuous sound levels from other ship and industrial noise. Broadband SLs of 248 to 255 dB SPL (peak-to-peak) are typical for a full-scale array but can be as high as 259 dB SPL. Airgun onset is generally much more rapid (sharper) than that of sonar.

et al., 2010). These studies provide the first direct evidence that sounds, including seismic airguns and SURTASS LFA sonar, may be of concern, but that does not necessarily mean that they kill or damage fish. However, it must be cautioned, as done by Hastings et al. (1996), McCauley et al. (2003), Popper et al. (2007), and Kastelein et al. (2008) (among others) that all studies to date have been done with a very limited number of species, and that extrapolation among species, and to other sound sources (or even to other levels or durations of the same sound sources), must be done with extreme caution, at least until there are more data upon which to base any extrapolations.

Few studies have directly examined the effects of sound on fish mortality (see reviews in Popper and Hastings, 2009a, b), although recent studies using high intensity seismic airguns and LFA and mid-frequency active (MFA) sonars have found no mortality (McCauley et al., 2000 and 2003; Popper et al., 2005b, 2007; Hastings et al., 2008; Halvorsen et al., 2012). In contrast, one report by Turnpenny et al. (1994) suggested that sound exposure could produce substantial damage in caged fish. However, reviews by subject matter experts found problems with this report and concluded that it did not appear to reflect the best available science on this issue for several reasons. Further discussion on this issue is provided in Subchapter 4.1.1.2 of the FSEIS (DoN, 2007a), which is incorporated by reference herein.

4.1.1.2 Permanent Loss of Hearing

A number of studies have examined the effects of high intensity sound on the sensory hair cells of the ear. These cells transduce (convert) the mechanical energy in the sound field into a signal that is compatible with the nervous system. Loss of these cells in terrestrial animals results in permanent hearing loss (Fletcher and Busnel, 1978; Saunders et al., 1991). Thus, it is likely that comparable damage to sensory hair cells in fish could also result in hearing loss. However, while there are studies indicating some damage to sensory hair cells in fish resulting from exposure to very intense underwater sound, only one study (Smith et al., 2006) has measured fish hearing before and after such damage occurred. Although it looks at a non-marine species hearing specialist, exposed to sounds lower in intensity than SURTASS LFA sonar, pile driving, and seismic studies, this study shows rapid repair of hair cells and recovery of hearing (Smith et al., 2006). While these data suggest that at least one species with damaged sensory hair cells also had hearing loss, it is clear that there was recovery from both cell damage and hearing loss, with hearing coming back even before all sensory hair cells were repaired.

There have been four earlier studies that examined the effects of high intensity sounds on fish ears. Hastings et al. (1996) investigated the effects of intense sound stimulation on the ear and lateral line of a non-specialist freshwater fish (*Astronotus ocellatus,* the oscar). The investigators exposed fish for one hour to a continuous sound signal at 300 Hz and a RL of 180 dB re 1 µPa (rms), and upon examination four days afterward found some damage to the sensory hair cells of two of the otolith organs[2], the lagena[3] and utricle[4]. There was no apparent damage with other frequencies, sounds with shorter duty cycles, or shorter stimulation time, or when the ear was studied immediately after the cessation of stimulation. The interpretation of these results by the investigators was that exposure to a high intensity underwater sound has the potential to damage the sensory cells of the ears of fish. However, the sound has to be continuous and last at least one hour; and the damage was only evident some time after exposure.

Additional studies suggest that intense sound may result in damage to the sensory hair cells in the ears of other species. Cox et al. (1986a, 1986b; 1987) exposed goldfish (*Carassius auratus*), a freshwater hearing specialist, to pure tones at 250 and 500 Hz at 204 and 197 dB re 1 µPa (rms) RL, respectively, for two hours. They found some indications of sensory hair cell damage, but these were not extensive.

---

2 The otolith organs sense gravity and linear acceleration such as from due to initiation of movement in a straight line. Persons or animals without otolith organs or defective otoliths have poorer abilities to sense motion as well as orientation to gravity.

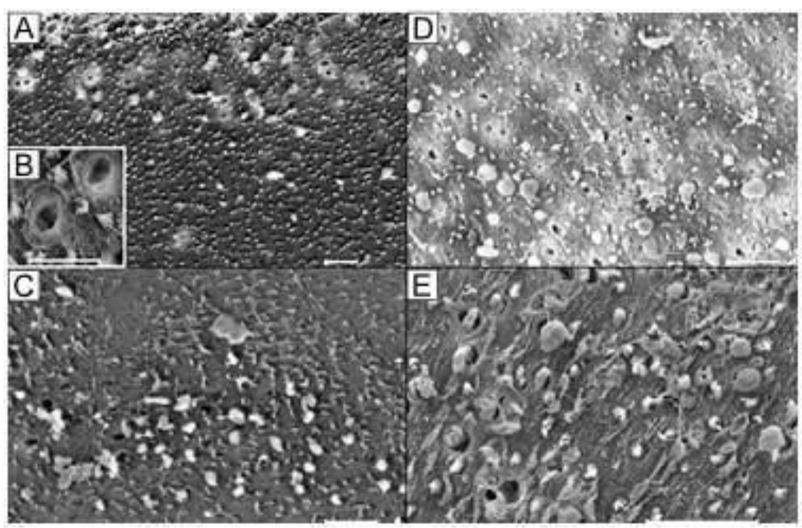
3 The laguna is part of the vestibular system in fish and amphibians, and it contains the asterisci otolith. In fish, the laguna is implied in hearing and the registration of vertical linear acceleration.

4 The utricle sends input to the brain via the superior division of the nerve.

Enger (1981) determined that some ciliary bundles (the sensory part of the hair cell) on sensory cells of the inner ear of the Atlantic cod (*Gadus morhua*) were damaged when exposed to underwater sounds at several frequencies from 50 to 400 Hz at 180 dB re 1 µPa (rms) RL for 1 to 5 hours.

McCauley et al. (2003) examined the effects on the sensory tissues of the ears of the Australian fish, the pink snapper (*Pagrus auratus*), after exposure to a seismic airgun. Fish were placed in a cage and exposed to emissions of a single seismic airgun that was moved toward and away from the test cage. The airgun had a SL of 222.6 dB re 1 µPa at 1 m (peak to peak), or 203.6 dB re 1 µPa at 1 m (rms). It was deployed at 5 m (16.4 ft) depth and towed from a distance of 400 to 800 m (1,312 to 2,625 ft) from the cage to a position as close as 5 to 15 m (16.4 to 49.2 ft) to the cage and then back to the starting point. The goal was to present a signal that was similar to that which fish might encounter if they are near an active airgun survey that is moving back and forth over a survey site.

The animals were maintained for varying time periods post-exposure. The fish were then sacrificed, and the ears examined using scanning electron microscopy (SEM) (Figure 4-1). The investigators reported that there was some damage to the ciliary bundles of the sensory hair cells of the saccular sensory epithelium (the other end organs were not examined). Additionally, the extent of damage increased the longer the period between animal exposure and examination. The animals that were maintained the longest, to 58 days post-exposure, had the greatest damage to ciliary bundles, according to the investigators. Significantly, all of the experimental animals survived for the full 58 days post-exposure and were fed and appeared to behave normally. While indirect evidence, these observations suggest that there was no other permanent injury to the fish such as damage to the swim bladder.



Scanning electron micrographs of the saccular sensory epithelium of the pink snapper following exposure to a seismic airgun (see text for parameters). (a, b, c) Epithelia from fish sacrificed 18 hours after exposure to the airgun. The photographs show numerous holes and "blebbing" (i.e., blistering). (d and e) Photographs from saccular epithelia of fish sacrificed 58 days after exposure. This tissue shows extensive damage. Scale bars: a, 20 µm; b, 2 µm; c, d, e, 20 µm. (From McCauley et al., 2003).

Figure 4-1. Scanning electron micrographs of the saccular sensory epithelium of the pink snapper following exposure to a seismic airgun.

Although both the Hastings et al. (1996) and McCauley et al. (2003) studies, as well as a study by Enger (1981), suggested that high-intensity sounds could potentially result in damage to sensory hair cells, it is important to note several caveats in considering these results. These caveats (as pointed out by the authors of the two more recent papers) include: 1) the use of only a few species in the studies and that these species may not be representative of other species; 2) the inability of the caged fish in any of the studies to depart the immediate sound field and thus lessen sound exposure and the likelihood of damage; and 3) the relatively long duration of the experimental sounds as compared to the shorter exposures that might be expected with SURTASS LFA sonar or other types of human-generated underwater sounds at high signal levels.

As will be discussed below, a recent study on the effects of SURTASS LFA sonar sounds on three species of fish (rainbow trout, channel catfish, and hybrid sunfish), also examined long-term effects on sensory hair cells of the ear. In all species, even up to 96 hours post-exposure, there were no indications of any damage to sensory cells (Popper et al., 2005a, 2007; Halvorsen et al., 2006).

Another potential issue with regard to damage to the ear is that it may be possible for fish to regenerate or repair damaged sensory cells resulting from exposure to intense sounds (Smith et al., 2006). While this does not occur in mammals (where hair cell loss leads to permanent deafness), regeneration and restoration of hearing appears to occur in birds (reviewed in Dooling and Dent, 2001). Moreover, Lombarte et al. (1993) found that sensory hair cells in the ear of the oscar that have been damaged by the ototoxic drug[5] gentamicin sulphate would regenerate within 10 to 15 days of the termination of the drug regime. More recently, Smith et al. (2006) showed recovery of hair cells from noise damage in the goldfish (*Carassius auratus*), a species of hearing specialist. Unlike mammals, fish continue to produce sensory hair cells throughout much of their lives (Lombarte and Popper, 1994; Higgs et al., 2002). Since hair cells recover from drug damage, and at least one species is now known to be able to recover from damage due to long-term exposure to increased background sounds (Smith et al., 2006), it may be speculated that there might be recovery from at least some levels of noise injury in all fish. However, while the Smith et al. (2006) study shows recovery from general increases in background noise, it must be kept in mind that these sounds were far lower in intensity than other underwater anthropogenic sounds (e.g., sonar, seismic exploration, pile driving). In addition, it is not yet known if hair cell replacement would occur after very high magnitudes of damage, or if the recovery would be fast enough to prevent mortality if the fish could not adequately hear prey or predators. Moreover, the results from the McCauley et al. (2003) study showed no signs of recovery 58 days after damage from very intense seismic airgun exposure and, in fact, there was more damage at 58 days than immediately after exposure.

4.1.1.3 Temporary Loss of Hearing—Experimental Results

In addition to the possibility of causing permanent injury to fish ear sensory hair cells, underwater sound may cause TTS, a temporary and reversible loss of hearing that may last for minutes to days. TTS is quite common in humans and often occurs after being exposed to loud music. The precise physiological mechanism for TTS is not well understood. It may result from fatigue of the sensory hair cells because of their being over-stimulated or from some small damage to cells that are repaired over time. The duration of TTS depends on a variety of factors including intensity and duration of the stimulus.

The first TTS study on fish showed that a 149 dB re 1 µPa (rms) RL exposure to a pure tone for eight continuous hours might cause TTS of more than 10 dB SPL in goldfish (Popper and Clarke, 1976). More recently, a series of studies have further demonstrated TTS in a number of different species using both continuous tones and various noises.

Smith et al. (2004a, 2004b, 2006) examined the effects of increased background noise on hearing capabilities of goldfish (*Carassius auratus*) and tilapia (*Oreochromis niloticus*). The purpose of these studies was to determine the detailed parameters of hearing loss that might be expected from exposure to sounds that differ in duration, and in which animals were tested over different recovery times post-exposure. Smith et al. found that goldfish showed a 5-dB SPL TTS after only 10 minutes of exposure to band-limited noise (0.1 to 10 kHz, approximately 170 dB re 1 µPa (rms) RL overall spectral sound pressure level). Following three weeks of exposure to the same stimulus, goldfish had a 28-dB SPL TTS

---

5 Ototoxic drugs are drugs that can cause temporary or permanent hearing loss. They can also make an existing hearing loss worse.

and the fish took more than two weeks to return to normal hearing. These results should be noted in context with those for tilapia cited below.

Generally, similar results were obtained for goldfish exposed to white noise at 158 dB re 1 µPa (rms) RL for 24 hours by Wysocki and Ladich (2005). In this study, the investigators found that recovery of full hearing sensitivity took up to two weeks. They also investigated temporal resolving power[6] of goldfish before and after noise exposure and found a decrease in temporal resolution capabilities that continued for up to three days. This kind of hearing loss could be critical since many species of fish appear to use temporal patterns of sounds to discriminate between sounds (e.g., sounds of different species) (Myrberg and Spires, 1980). Thus, the effects of noise exposure in fish may not only result in effects on the lowest sound detectable (threshold), but also the way that fish resolve signals from one another.

In contrast to hearing losses in goldfish as reported by Smith et al. (2004b) as well as Wyoscki and Ladich (2005), Smith et al. (2004a) showed no TTS after up to 21 days of noise exposure at 170 dB re 1 µPa (rms) RL for the hearing-generalist tilapia. It is not particularly surprising that the results differ between goldfish and tilapia since the former is a hearing specialist with high sound sensitivity while tilapia is a hearing generalist and does not hear as well as goldfish.

These findings were also partly supported by Scholik and Yan (2001), who studied another hearing specialist, the fathead minnow (*Pimephales promelas*), and found that there was substantial hearing loss that continued for more than 14 days after termination of a 24-hour exposure to white noise from 0.3 to 2.0 kHz, with an overall spectral sound pressure level of 142 dB re 1 µPa (rms) RL. In contrast, Scholik and Yan (2002) studied effects of sound exposure in a hearing generalist, the bluegill sunfish (*Lepomis macrochirus*) and found no TTS.

While these earlier studies demonstrated TTS in some species and not in others, all of them used relatively low-intensity sounds that are well below the levels that fish might encounter when exposed to signals such as those produced by SURTASS LFA sonar, pile driving, or seismic exploration using airguns (or nearby movement of high-tonnage shipping). Several recent studies, however, tested the effects of such high-intensity sound not only on hearing, but also on other non-auditory structures. In each case, the study was designed to provide what might be considered “worst-case” sound exposure and to have all appropriate controls to ensure that the results were from the noise and not from human handling or other factors. Several studies that deal with seismic airguns are of interest from a scientific sense regarding SURTASS LFA sonar. They showed there were differences in the effects of airguns on the hearing thresholds of different species. Additional studies deal directly with SURTASS LFA sonar.

Effects of Seismic Airguns on Fish Hearing

Popper et al. (2005b) examined the effects of exposure to a seismic airgun array on three species of fish found in the Mackenzie River Delta near Inuvik, Northwest Territories, Canada. The species included one hearing specialist, the lake chub (*Couesius plumbeus*), and two species that are not known to have specializations that would enhance hearing, the northern pike (*Esox lucius*), and the broad whitefish (*Coregonus nasus*). In brief, caged fish were exposed to 5 or 20 shots from a 12,000 cubic centimeters (cc) (730 in^3) airgun array. The signals were fully calibrated and, unlike in earlier studies, exposure was determined not only for SPL (rms), but also for peak sound levels and for sound exposure levels (SELs). In this study in the 2 Hz to 10 kHz band, average mean peak SPL was 207 dB re 1 µPa RL, the average mean 90% SPL (rms) sound level was 197 dB re 1 µPa RL, while the average mean SEL was 178 dB re 1 μPa^2-sec RL.

6 Temporal resolving power is the ability to discriminate between time intervals of different lengths. If a time interval is too short, then a sound will be heard as continuous rather than being made up of pulses. Fish sounds are often pulses that are repeated rather quickly, and different sounds, or sounds of different species, may have different pulse intervals. If a fish cannot discriminate among different intervals, it has poor ability to discriminate among different sounds.

The study was designed so the level of sound exposure would be as substantial as any that these species are likely to encounter in a riverine seismic survey where there is a single pass of the fish by the seismic device.[7] Fish were placed in a test cage, exposed to the airgun array, and then tested for hearing immediately after sound exposure, and then 24 hours post-exposure. Testing was done by the auditory evoked potentials (AEP) method used by Smith et al. (2004a) and Scholik and Yan (2001, 2002). In addition, the experiment used baseline animals that were never placed in the test cage and control animals that were handled in precisely the same way as test animals, other than for exposure to the airgun sound.

The results (Figure 4-2) showed a temporary hearing loss for both lake chub and northern pike to both 5 and 20 airgun shots. There was no hearing loss to the same signals in the broad whitefish, a relative of salmon. Hearing loss was on the order of 20 to 25 dB at some frequencies for both the northern pike and lake chub, and recovery took place within 24 hours, with fish hearing returning to normal. While a full pathological study was not conducted, fish of all three species survived the sound exposure and were alive more than 24 hours after exposure. Those fish of all three species sacrificed after AEP testing had intact swim bladders. There was no apparent external or internal damage to other body tissues (e.g., no bleeding or grossly damaged tissues), although it is important to note that the observer in this case (unlike in the following LFA study) was not a trained pathologist.

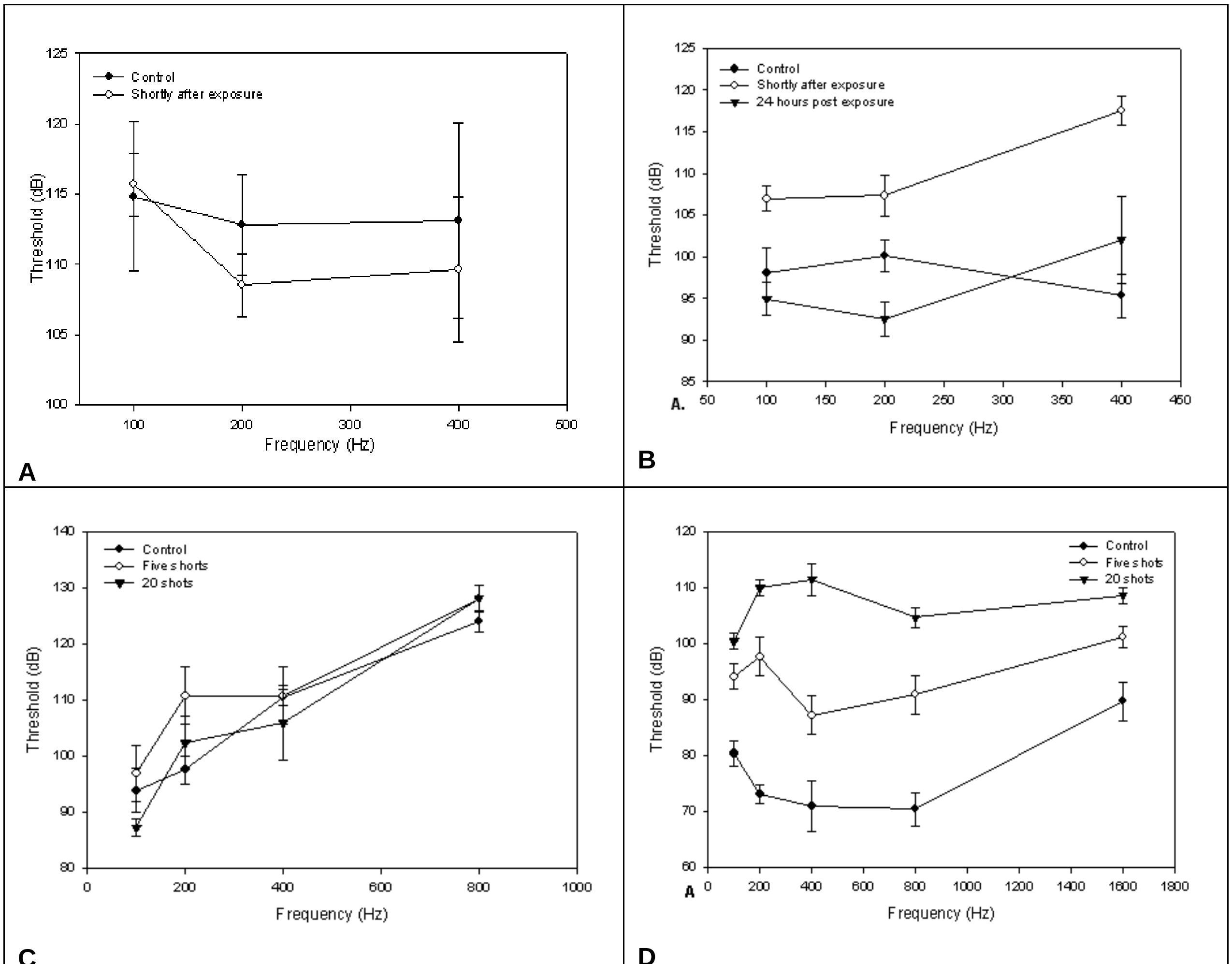
Most importantly, this study showed that there were differences in the effects of airguns on the hearing thresholds of the different species studied. In effect, these results substantiate the argument made by Hastings et al. (1996) and McCauley et al. (2003) that it is difficult to extrapolate among species with regard to the effects of intense underwater sounds.

More recently, Hastings et al. (2008) examined the effects of seismic airguns on hearing in several tropical reef fish species in Western Australia following exposure to sound from a 2,055 cubic-inch seismic airgun array being used in a three-dimensional marine seismic survey. The experiments included several fish species, including a hearing specialist, the pinecone soldierfish (*Myripristis murdjan*), and three species that are not known to have any structures that would increase hearing sensitivity: the blue green damselfish (*Chromis viridis*), the sabre squirrelfish (*Sargocentron spiniferum*), and the bluestripe seaperch (*Lutjanus kasmira*). The fish were exposed in the field to an actual airgun survey and then brought to a boat in which they were tested for hearing changes. The cumulative SEL was 189-190 dB re 1 μPa^2-sec at the closest point of the seismic airgun passing of the fish, and some fish were exposed to two passes of the array, while others to one pass. Appropriate controls were used to allow for effects of handling of animals.

Results showed no effect on hearing in any species other than the blue green damselfish. In this species, there was no hearing loss reported one day after testing, but at either 4 or 7 to 8 days after testing there was a significant hearing loss (up to 15 dB SPL) at 225 and 455 Hz but not at other tested frequencies. While the explanation for this hearing loss is not clear, Hastings et al. (2008) point out that these were the smallest fish in the study, and it is possible that lack of food over the post-exposure period resulted in physiological problems that were manifested in hearing loss.

The lack of any hearing effect on the reef fish is interesting, particularly as compared to the results from Popper et al. (2005b), who found some hearing loss in some species after exposure to cumulative SEL of about 183 dB re 1 μPa^2-sec. The differences between the studies are important, but many factors could account for this, including use of very different species, different types of airguns, or the actual sound

7 In oceanic seismic surveys, the survey boat pulls the seismic device back and forth across the survey area in repeated paths, with each path parallel to, but some distance from, the previous path. Thus, an animal remaining in the vicinity of the middle of the survey area(e.g., foraging) would be exposed to repeated signals for a far longer time than in a river survey where the survey boat moves continuously in one direction. The McCauley et al. (2003) study was designed to more closely resemble an ocean survey, though it only pulled the airgun to and from the caged fish twice.



Results from exposure of fish to a seismic survey (Popper et al., 2005b). (A) Thresholds of broad whitefish for control and experimental animals showing no statistically significant hearing loss. (B) Thresholds from northern pike just after exposure and 24 hours post-exposure. Fish showed a significant hearing loss just after exposure, but thresholds were not significantly different from controls at 24 hours. (C) Thresholds for small, young of the year, northern pike. Interestingly, these fish showed no hearing loss compared to controls after exposure to 5 or 20 airgun shots. (D) Lake chub, a hearing specialist, showed substantial hearing loss after 5 shots of the airguns and even more loss after 20 shots. Both groups of animals, however, showed full recovery of hearing loss within 24 hours. (All figures from Popper et al., 2005b).

Figure 4-2. Hearing thresholds for different fish in a study investigating the effects of exposure to a seismic airgun array on fish hearing.

spectrum to which fish were exposed. Those in the Popper et al. (2005b) study were in shallow water with limited low frequency propagation, whereas those in Hastings et al. (2008) were in deeper water, with more low frequency energy in the signal. How this would change the effects of sound on fish hearing is not known, but points to the difficulty in extrapolating data between experiments at this stage of our knowledge.

Effects of SURTASS LFA Sonar on Fish Hearing

Dr. Popper and his colleagues (Popper, et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010) examined whether exposure to high-intensity, low frequency sonar, such as the Navy's SURTASS LFA sonar, would affect fish. An LFA sonar array has the potential to ensonify fish with sound levels over 180 dB re 1 µPa (rms) RL within approximately 1 km (0.54 nmi) from the array. Moreover, LFA sonar uses frequencies from 100 to 500 Hz, the range in which most fish are able to detect sound and the range of best hearing for many species (Fay, 1988a; Popper et al., 2003; Ladich and Popper, 2004). Thus, the sonar not only has the hypothetical potential to damage organ systems in fish due to the signal intensity, but it has the direct potential of affecting hearing because the auditory system of many fish is most sensitive in the frequency range in which the sonar operates.

- **Fish species studied**

This study, which took place at the Naval Undersea Warfare Center (NUWC) sonar test facility on Seneca Lake, NY, examined the effect of LFA on hearing, the structure of the ear, and select non-auditory systems in the rainbow trout (*Onchorynchus mykiss*) and channel catfish (*Ictalurus punctatus*) (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010). Additional studies were done with a hybrid sunfish species, *Lepomis* sp.

The rainbow trout is a hearing generalist (or "non-specialist"), while the channel catfish is a specialist[8]. These two species were chosen since there is evidence that there may be a significantly different impact of underwater noise exposure on fish that hear well and those that do not hear well, as discussed above with regard to TTS as a result of exposure to lower intensity sounds (Hastings et al., 1996; Smith et al., 2004a, b; Popper et al., 2005a). Most importantly, rainbow trout were chosen for study since they are excellent reference species[9] for listed salmonids from the U.S. west coast, all of which are of the same genus as rainbow trout. Listed species of this genus could not be tested in the Seneca Lake study since it would have been too difficult to import the fish to the experimental site in the numbers needed for study. In addition, since there is a chance that fish could escape from the experimental apparatus, it was not appropriate to use species that are not endemic to the test site. Adding new species to Seneca Lake could potentially impact the lake ecosystem in unpredictable ways.

In addition to being in the same taxonomic genus, rainbow trout are also a good reference species for listed salmonids because the species have similar, if not identical, ears and hearing sensitivity (Song and Popper, in prep) and the rainbow trout is a freshwater ecotype of the ESA-listed marine steelhead trout. Hearing tests of hatchery-raised chinook salmon (*Oncorhynchus tshawytscha*) show that hearing sensitivity and range of hearing is very similar to that of rainbow trout (Popper et al., 2005a). Since the ears and hearing sensitivity are essentially the same for the rainbow trout and another member of the genus *Oncorhynchus* (Pacific salmons and Pacific trouts), it is likely that the rainbow trout can serve as the model species/system in other anthropogenic sound studies, as in the LFA study.

- **Experimental overview**

The facility at Seneca Lake, where the SURTASS LFA sonar study was conducted, is an acoustic free-field environment that enabled the investigators to have a highly calibrated sound source and to monitor the sound field as well as the behavior of the fish throughout the experiments. The facility has a large

8 In a recent review, Popper and Fay (2009b) have argued that the terms hearing "generalist" and "specialist" should be dropped since there is so much overlap in hearing capabilities and mechanisms among different species. Instead, Popper and Fay suggest that different hearing capabilities should be treated on a "continuum" of capabilities (Popper and Fay, 2009b). For more details, see discussion in Chapter 3.

9 It would be impossible to test even those species most likely to be exposed to LFA to determine effects. Instead, select species must be examined and used as "reference species" (e.g., species that are very similar to, but not the same as, the species of concern). It is very common to use reference species in animal studies, and a great deal of relevant information can be learned from such species.

barge in the middle of the lake and a nearby shore support facility that has room for holding animals and conducting all hearing and other tests.

In brief, experimental fish were placed in a test tank that was 1 m (3.3 ft) on a side and made of 1.27 cm (0.5 in) thick Lexan® clear plastic sheets (Figure 4-3). The tank was designed to allow free flow of water throughout the tests to ensure that fish were at the best experimental temperature and had oxygenated water. Two video cameras external to the test tank were used to observe the behavior of the fish (with images and sounds recorded on digital tape) as the test tank was raised and lowered, and during sound presentations.

The photo shows the test tank. The braces to the left and right support the video cameras (black) used to monitor fish throughout the experiments. The small black objects suspended from cables in the test tank are an array of hydrophones used to monitor the sound throughout the experiments. An additional hydrophone (right) was used to monitor the sound outside of the tank.

Figure 4-3. Photograph of experimental tank (with rainbow trout) being lifted out of the water.

Prior to conducting experiments with live animals, calibration tests were performed on the sound field inside and around the fish test tank. These data showed that the variation in sound level was small in different regions of the test tank, indicating that the acoustic field inside was sufficiently uniform for the studies. For a single tone, the maximum RL was approximately 193 dB re 1 µPa (rms) at 196 Hz and the level was uniform within the test tank to within approximately ±3 dB. The experimental sounds were produced using a single SURTASS LFA sonar transmitter excited at 1,600 V, giving an approximate SL of 215 dB re 1 µPa at 1 m (rms). The signal used was generated electronically and was very similar to the actual sonar signal train used by the Navy. The frequency range of the signal was from 170 to 320 Hz.

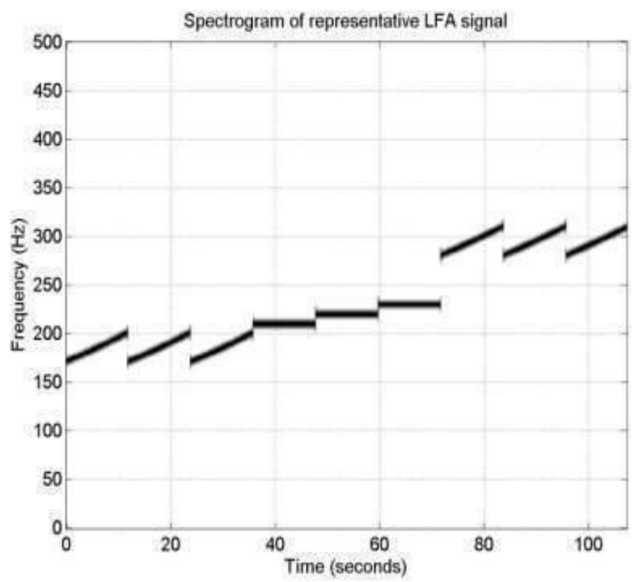
All fish were from the same supplier. They were randomly assigned to one of the three experimental groups. Baseline group animals had no handling other than moving to the Seneca Lake facility. Experimental group animals were placed in the test tanks and exposed to sound. Control group animals were handled in precisely the same way as experimental animals but without the sound presentation.

Experimental groups were exposed to one of three test signals. These included: 1) MAX: maximum sound level; 2) MAX-6, 12, or 18: the maximum signal lowered by 6, 12, or 18 dB SPL; and 3) MAX*2: the maximum signal but at twice the duration of the MAX signal.

Each test consisted of three presentations of the LFA signal separated by a quiet period. In all but the MAX*2 experiment, sound presentations were 108 sec long and separated by 9 min of silence. In the MAX*2 trials, the LFA sound duration was 216 sec with an 18 min quiet period. The longer quiet interval was required with MAX*2 in order to allow the LFA transducer to cool. The overall test sequence for each tank was: slowly lower tank to depth–transmit signal–quiet–repeat signal-quiet-repeat signal–and then slowly raise the test tank to the surface.

The test signal consisted of three hyperbolic frequency-modulated (HFM) sweeps centered at 185 Hz with a 30-Hz bandwidth, 210-Hz tone, 220-Hz tone (labeled as Tone 2), 230-Hz tone, and three more HFM sweeps centered at 295 Hz with a 30-Hz bandwidth (Figure 4-4).

All test, control, and baseline animals were evaluated to determine hearing sensitivity using the AEP method. Fish were then sacrificed to determine any effects on inner ear structure. Additional fish from each group were sacrificed for analysis by an expert fish pathologist, who determined any effects on gross structure and tissue pathology.



The signal was 108 sec long (except in MAX*2 tests where the signal was 216 sec long). Each test consisted of three presentations of this signal, separated by a 9 or 18-minute silent interval during which time the projector cooled down.

Figure 4-4. Schematic of one presentation of the LFA signal used in the SURTASS LFA sonar experiments.

- **Results of SURTASS LFA sonar study: Hearing tests**

The overall findings of the study (Popper et al., 2007) show the following with respect to effects on fish hearing:

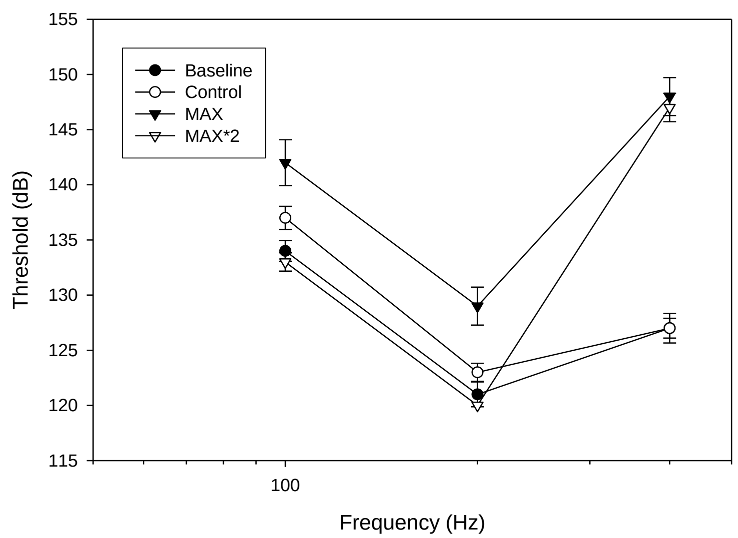
1. No fish died as a result of exposure to the experimental source signals. Fish all appeared healthy and active until they were sacrificed or returned to the fish farm from which they were purchased.
2. Fish behavior[10] after sound exposure was no different from behavior prior to or after tests. At the onset of the sound presentation, the trout would tend to move to the bottom of the experimental tank, but this did not last for the duration of the sound. Immediately after the sound was turned off the fish would mill around the tank in the same pattern as they did prior to sound presentation. Catfish showed an immediate quick "startle"[11] response and slight motion of the body, but then the fish

10 Note that behavior in the tank has no relevance to how fish would behave if they were not confined to the tank. Behavior monitoring was done only to provide insight into the health of the fish during the experiments and to compare in-cage responses before, during, and after sound exposure.

11 The word "startle" is used with caution. The behavior of the fish was, indeed, one that indicated detection of something unknown—a rapid movement over a short distance. However, the word "startle" has taken on a very specific meaning for some

tended to line up facing the signal source and generally stayed in that position for the duration of the sound. Once the sound was turned off, the catfish would return to normal “milling” around the tank in a pattern that was statistically no different from pre-sound patterns.

3. Catfish and some (but not all) specimens of rainbow trout showed 10 to 20 dB SPL of hearing loss immediately after exposure to the LFA sound when compared to baseline and control animals (Figure 4-5), but hearing appeared to return to, or close to, normal within about 24 hours for catfish. Recovery data on rainbow trout that had a hearing loss was insufficient to reach firm conclusions on the time for recovery, but preliminary data suggest that recovery is likely to occur in less than 96 hours. Moreover, there is evidence that hearing loss in the trout, when it occurs at all, is primarily at 400 Hz, while it is over the complete range of frequencies (200 to 1,000 Hz) tested for catfish.



ıese data are for rainbow trout and ɔmpare hearing for baseline and ɔntrol animals, and animals that ceived MAX and MAX*2 signals. ata represent means and standard rrors of the means. Note that aximum hearing loss occurred at)0 Hz where there was over a 20 dB PL TTS. It is not clear why there was ore hearing loss after MAX imulation than MAX*2 but this could e related to signals being closer gether in the former. (Note: the ıresholds” shown are not calibrated ıd so do not reflect the lowest ɔunds that fish necessarily hear at ese frequencies.)

Figure 4-5. Examples of hearing data obtained in the SURTASS LFA sonar studies.

4. There is an interesting and potentially very important variation in the effects of exposure on trout. Some groups of trout showed hearing loss, while others did not. All animals received identical treatment, and the only variable between experimental times was likely to be how the fish were raised prior to their being obtained for study. The significance here is not only were there differences in the effects of sound on different species, but there may also be differences within a species, depending on environmental and other variables. However, and most importantly, under no circumstances did exposure to LFA sound result in unrecoverable hearing loss in rainbow trout, and there was no effect on any other organ systems (see below). While there is no direct evidence to support the differences in effect on different groups of rainbow trout, another study at the Laboratory of Aquatic Bioacoustics at the University of Maryland has shown that fish from the identical genetic stock (i.e., probably same parents) will have different hearing thresholds, possibly depending on how the eggs were stored prior to being allowed to develop (Wysocki et al., 2007). This provides an additional variable in trying to understand the effects of sound on fish, but also indicates that not all salmonids have their hearing affected by exposure to intense sounds.

fish biologists and includes a twist of the body (c-start) at the onset of a stimulus and then rapid movement away from the stimulus. In these experiments, the video recording was not fast enough to determine if an actual c-start occurred.

- **Results of SURTASS LFA and mid-frequency sonar study: ear and non-auditory tissues**

As part of the SURTASS LFA study, and an accompanying study on the effects of mid-frequency (MF) sonar on fish (done in a manner identical to that for the SURTASS LFA), fish were examined for effects on the inner ear tissues responsible for hearing and on other non-auditory body tissues. Unlike all but one earlier study, the analysis of non-auditory tissues was carried out by an expert fish pathologist[12], whereas the analysis of inner ear tissue was conducted by an expert on fish inner ear structure[13]. Work was done to the highest standards of pathology to ensure that even the most subtle damage at the gross and cellular levels would be found.

Tissue for analysis of gross tissue pathology and histopathology (cellular structure) was taken from fish exposed to the same sounds, and under the same conditions, as fish tested for hearing changes. The tissue for inner ear studies were taken from fish sacrificed after they had been tested for hearing.[14] Preliminary results for rainbow trout were reported by Popper et al. (2007), where it was documented that there was no damage to any inner ear sensory cells and no pathology was found in any body structure at the gross and histopathologic level, including heart, brain, gills, swim bladder, kidney, or other tissues.

Preliminary analysis of the LFA data was presented in a report by Kane (2007). Since the FSEIS (DoN, 2007a), more extensive analysis of exposed tissue has been completed for both the LFA and MFA studies. The results of this tissue analysis have undergone peer review and been published (Kane et al., 2010). The results from the examinations were direct and simple: 1) no pathological effects from LFA sound exposure up to 193 dB re 1 µPa (rms) RL; 2) no short- or long-term effects to ear tissue from LFA sound exposure up to 193 dB re 1 µPa (rms) RL; and 3) no pathological effects from exposure to MF sounds for 15 sec with a maximum received signal level of 210 dB re 1 µPa (rms).

- **Conclusions from SURTASS LFA sonar study**

The critical question addressed in the SURTASS LFA sonar study was whether this kind of sound source impairs the survival of fish and, more importantly, whether survival would be impaired in a normal environment when a ship using SURTASS LFA sonar is in the vicinity of a fish. In answering this question, several factors must be taken into consideration.

First, the sound level to which fish were exposed in these experiments was 193 dB re 1 µPa (rms) RL, a level that is only found within about 200 m (656 ft) of the LFA source array. Thus, the likelihood of exposure to this or a higher sound level is small, considering all the possible places a fish might be relative to the sound source. The volume of the ocean ensonified by a single SURTASS LFA sonar source at 193 dB re 1 µPa (rms) RL or higher is very small compared to the ocean area ensonified by the LFA source at lower sound levels.

Second, the LFA sound used in the study can be considered to represent a "worst-case" exposure. In effect, the exposure during the experiments was likely substantially greater than any exposure a fish might encounter in the wild. In the study described here, each fish received three exposures to a high-level LFA sound (a total of 324 sec in the MAX tests and 628 sec in the MAX*2 tests). However, under normal circumstances the SURTASS LFA sonar source is on a moving ship. A fish in one location will only receive maximum ensonification for a very few seconds (depending on ship speed and whether the

---

12 Andrew S. Kane, Ph.D., is the Director of the Aquatic Pathobiology Laboratory, Environmental Pathogens Institute of the University of Florida, and Associate Professor of Environmental and Global Health. Dr. Kane researches environmental pathology and toxicology of freshwater and marine organisms.

13 J. Song, Ph.D., Division of Fishes, National Museum of Natural History, Smithsonian Institution. Dr. Song's current research focus is on understanding the new genotypical explanation of the peripheral innervation patterns for assessing morphological homologies in phylogenetic and systematic studies.

14 This was not done for histopathology since any handling of fish in hearing tests could result in lesions (e.g., from handling during AEP tests), so a procedure was adopted to use animals from the exposure (and controls) that were not used in hearing tests.

fish is moving or not, and its direction of motion and speed). Prior to reaching the closest point of approach to the fish, or after the boat has moved on, the sound level would be much lower. Thus, rather than receiving 100 sec of maximum exposure, a fish would receive much less exposure. Since exposures at three to six times the maximum level did not cause damage to fish, and only what appears to be a temporary limited hearing loss, it is unlikely that a shorter exposure would result in any measurable hearing loss or non-auditory damage to fish unless they were so close to the SURTASS LFA sonar source that they received a maximum output.

Finally, it should be noted that 193 dB re 1 µPa (rms) RL had no real adverse effects on the fish tested. Even in an exposure scenario where fish were subject to the maximum output of a sonar array this exposure would be for a minimal period of time. While it was not possible to present a higher sound level to the fish in this experiment, it is very likely that a shorter exposure than 100 sec to an even higher sound level may not have adversely affected the fish. In effect, it is likely that fish could be even closer than 200 m (656 ft) to the source array and not be damaged by the sounds.

4.1.1.4 Additional Sonar Data

While there are no other data on the effects of LFA on fish, there is a recent study of some relevance, since it examined the effects on fish from sonar for the Norwegian Navy. In a report published in 2005, fish larvae and juvenile fish were exposed to simulated sonar signals in order to investigate potential effects on survival, development, and behavior (Jørgensen et al., 2005). The study used herring (*Clupea harengus*) (standard lengths 2 to 5 cm [0.79 to 2.0 in]), Atlantic cod (*Gadus morhua*) (standard length 2 and 6 cm [0.29 and 2.4 in]), saithe (*Pollachius virens*) (4 cm [1.6 in]), and spotted wolffish (*Anarhichas minor*) (4 cm [1.6 in]) at different developmental stages (Jørgensen et al., 2005). While the study's authors referred to these sonar sounds as low frequency, the Norwegian sonar signal's frequency (1.5 to 6.5 kHz) is higher than the signal used by SURTASS LFA sonar (100 to 500 Hz) and in the frequency range of U.S. Navy MFA sonar.

Fish in Jørgensen et al. (2005) were placed in plastic bags 3 m (9.8 ft) from the sonar source and exposed to between four and 100 pulses of 1-sec duration of pure tones at 1.5, 4, and 6.5 kHz. Sound levels at the location of the fish ranged from 150 to 189 dB re 1 µPa (rms) RL. The sounds were designed to mimic those of actual sonar signals used by the Norwegian Navy. The investigators found no effects on fish behavior during or after exposure to sound (other than some startle or panic movements by herring for sounds at 1.5 kHz). The investigators found no effect on behavior, growth (length and weight), or survival of fish kept as long as 34 days post-exposure (Jørgensen et al., 2005). All exposed animals were compared to controls that received similar treatment other than for exposure to the actual sound. Similar to the LFA studies (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010), pathology of internal organs showed no damage as a result of sound exposure. The only exception to almost full survival was exposure of two groups of herring tested with SPLs of 189 dB re 1 µPa (rms) RL, where there was a post-exposure mortality of 20 to 30% (Jørgensen et al., 2005). While these were statistically significant losses, it is important to note that this sound level was only tested once and so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors.

In another Norwegian study, but with wild fish, Doksæter et al., (2009) examined responses of killer whales and herring to what they call low frequency sonar (but 1 to 2 kHz) and mid frequency sonar (6 to 7 kHz). They monitored, using bottom-mounted echosounders, the response of over-wintering herring to sonar exposure from operational naval sonars towed above the fish. The results showed herring did not respond to either sonar, but they did show marked reaction to feeding sounds of killer whales (a predator of herring), indicating that the lack of response to sonar was because the sonar, unlike the killer whale sounds, did not bother the fish enough to evoke a behavioral reaction.

4.1.1.5 Extrapolation to Other Species

The results of the SURTASS LFA sonar study, as well as the recent studies on seismic airguns (Popper et al., 2005b; Hastings et al., 2008), should only be extrapolated to other species with considerable caution. This caution is based on potential differences among species in structure of the auditory system and hearing capabilities. As discussed below, the degree of hearing loss in a species may vary depending on the level of the signal above the hearing threshold of the fish. Other variables that may ultimately be involved in the amount of hearing loss are signal duration, frequency characteristics of the sound, and whether the sound is impulsive or coherent (including continuous sounds). The same variables may also affect the amount of non-auditory damage that might occur.

At the same time, the rainbow trout in the LFA study and the species in the seismic airgun studies differ considerably from one another in hearing structures, distribution of fish taxa, and hearing capabilities. None of these fish showed any tissue damage as a result of sound exposure, and hearing loss was relatively small (and non-existent in the Hastings et al., 2008 study) and recovery was fairly rapid. Thus, recognizing the need for caution when extrapolating among species, these results strongly indicate that SURTASS LFA sonar is likely to have a negligible impact on fish when they are exposed to underwater LFA sound signals within the decibel levels used in these studies.

Overview of Hearing Effects of Noise Exposure

In reviewing the results of their study and that of the few previous studies, Hastings et al. (1996) suggested that sounds 90 to 140 dB re 1 µPa (rms) above a fish's hearing threshold may potentially injure the inner ear of a fish. This suggestion was supported in the findings of Enger (1981) in which injury occurred only when the stimulus was 100 to 110 dB re 1 µPa (rms) above threshold at 200 to 250 Hz for the Atlantic cod. Hastings et al. (1996) derived the values of 90 to 140 dB re 1 µPa (rms) above threshold by examining the RLs that caused minimal injury in their test fish, the oscar, and then hypothesizing that extensive injury would require more energy. They suggest that RLs of 220 dB to 240 dB re 1 µPa (rms) would potentially cause extensive damage to sensory hair cells in non-specialist fish. Calculations for a hearing specialist such as the squirrelfish (*Myripristi berndti*) using the Hastings et al. (1996) values (i.e., 90 to 140 dB re 1 µPa [rms] above threshold) (see Figure 3-3) indicate RLs of 140 to 190 dB re 1 µPa (rms) continuously for at least one hour would be necessary to induce damage to inner ear sensory cells. Interestingly, exposure to about 190 dB dB re 1 µPa^2-sec SEL did not cause hearing loss in the pinecone soldier fish (*Myripristis murdjan)* (Hastings et al., 2008), a species that is likely to have hearing thresholds similar to the squirrelfish. Thereby, these results provide additional evidence to suggest that RLs of over 190 dB re 1 µPa (rms) will not result in hearing loss, much less damage to sensory cells.

The results of Smith et al. (2004a, 2004b, 2006) and Scholik and Yan (2001, 2002) provide further experimental evidence in support of the hypothesis proposed by Hastings et al. (1996). Moreover, Smith et al. (2004b) were able to use their data to hypothesize that noise-induced threshold shifts in fish may be somewhat linearly related to the sound pressure difference (SPD) between that of the noise and the baseline hearing threshold of the fish. They called this the *LIN*ear *T*hreshold *S*hift (LINTS) hypothesis. A similar finding has been reported in birds and mammals. The actual SPD required to cause TTS in a fish is very likely related to frequency since the baseline hearing threshold in fish varies by frequency. Other variables are likely to be the duration of sound exposure, whether the sound is continuous (as in the Smith et al., 2004a, 2004b experiments), or whether the sound is impulsive.

While these variables need further study, there is preliminary evidence that the LINTS hypothesis (Smith et al. 2004b) holds for impulsive as well as continuous signals. In an analysis of their airgun results, Popper et al. (2005b) found the same relationship for these sounds as found by Smith et al. (2004b) for continuous noise. Moreover, the Popper et al. (2005b) work examined several hearing generalists and, for the first time, used RLs that were sufficiently above threshold (therefore a large SPD) to result in TTS in such species. This is in contrast to the studies by Smith et al. (2004a, 2004b) and Scholik and Yan (2002), where there was no TTS in hearing generalists. Presumably, the lack of TTS in those generalists was because of an insufficiently high SPD between noise and the baseline hearing threshold.

Finally, the results from the SURTASS LFA sonar study further support the LINTS hypothesis, since both species tested generally followed predictable amounts of threshold shift based on the levels of sound exposure. This is significant since it extends the usefulness of the hypothesis beyond continuous pure tones and impulsive noise to modulated signals. At the same time, it is very likely that with a more detailed analysis of the hypothesis it will be possible to more broadly understand the effects of sounds at different frequencies, intensities, durations, and waveforms on hearing loss. However, at this point it would not be reasonable to use the LINTS hypothesis in any but the broadest sense here since there are too few data to permit ready extrapolation among species.

4.1.1.6 Behavioral Change

This issue concerns the behavior of fish near a high intensity underwater sound source, beyond effects on the ear itself. This is likely to be a much greater issue than physiological effects since it is possible that fish, as other animals, will show behavioral reactions and changes in response to sounds that are much lower than levels needed to cause hearing loss, or ear or non-auditory tissue damage. The potential behavioral impacts range from the possibility of fish avoiding the sound and thus changing their habitat (potential economic impact to subsistence fisheries) to possibly preventing fish from engaging in basic life functions such as breeding, feeding and sheltering (which could presumably result in fish stock declines).

One caveat to developing an understanding of effects of sounds on behavior is that such studies are only useful when fish are unconstrained. That is, if fish are in any kind of cage or tank, no matter what the size, it is possible that the physical barriers will result in behaviors that would not normally be encountered in the wild in response to exposure to the same type of signal. Even if the cage is large, such as in the study by Sarà et al. (2007) on behavior of bluefin tuna (*Thunnus thynnus*) in a large pen during exposure to nearby boats, there is reason to believe that the behavior of the fish could have been altered by the presence of the pen walls, and so the behavior reported, of fish swimming from boat noise, could have been an artifact of the fish "knowing" that they were confined.

Most studies that examined effects on behavior involved confined animals, and so the results must not be taken as indicative of how fish would respond in the wild. Klimley and Beavers (1998) played back a 75 Hz phase-modulated signal (37.5-Hz bandwidth) to three species of rockfish (*Sebastes flavidus*, *S. ariculatus,* and *S. mystinus*) (presumably, but not demonstrated to be, non-specialists) in a pen in Bodega Bay, CA. The RLs were 145 to 153 dB re 1 µPa (rms). The fish exhibited little movement during the playback of the low frequency signals, and the behavior did not differ from that exhibited during a control period during which the sound was not played. Fish that started out close to the sound source did not move away, nor was there any apparent movement toward the source during playback. Most fish occupied the zone closest to the sound projector the duration of the test and control periods.

Similarly, while the behavior of fish were observed during the investigations of the effects of SURTASS LFA sonar sounds on rainbow trout and channel catfish (Popper et al., 2005a), the fish were in a cage 1 m (3.3 ft) to a side, and so they were constrained from moving during sound exposure. Preliminary quantitative analysis of the results of these studies show that while rainbow trout exhibited a small response at the onset of the sounds, they quickly returned to their pre-stimulus behavior and continued this way for the duration of the sound presentation, and even when the specific components of the sound changed. Channel catfish, in contrast, generally showed an initial "startle"[11] response to the sound and then moved to the bottom of the test tank while most fish oriented themselves toward the sound source, and stayed in that position for the duration of the signal. Furthermore, they would show a "startle" response each time the specific sound changed. As soon as the sound was turned off, the fish would resume pre-stimulus patterns of swimming. At the same time, for both the Klimley and Beavers (1998) study and the more recent SURTASS LFA sonar study, how the fish might have reacted if they were able to swim away is not known.

Other studies, however, provide some evidence that the low frequency noise produced by fishing vessels and their associated gear results in fish avoiding the vessels (Maniwa, 1971; Suzuki et al., 1979; Konigaya, 1980; Soria et al., 2003; and see review in Mitson, 1995; Dalen et al., 2007a). Similar results have been found for incoherent, impulsive airgun sounds (Engås et al., 1996; McCauley et al., 2000;

Engås and Løkkeborg, 2002; Slotte et al., 2004; reviewed in Dalen, 2007b). However, in each of these studies (other than McCauley et al., 2000), fish behavior was not actually observed and results were based on fish catch rates before and after presentation of sounds from a seismic airgun. Aside from the McCauley et al. (2000) study (which included fish behavior observations), it is possible that the other three studies (which used fish catch rates as a metric), may have perceived temporary changes in fish responses to trawls and long-lines, and that there was no other alteration in behavior or movements of the fish from the fishing sites. However, using fish-finding sonar, Slotte et al. (2004) found that fish in the vicinity of the airguns appeared to go to greater depths after airgun exposure compared to their vertical position prior to the airgun usage. It should be noted, however, that the statistics in the fishing reports have been criticized by Gausland (2003) in a non-peer-reviewed report that suggested that declines in catch rate might be explained by other factors and that catch rates do not differ significantly from normal seasonal variation over several fishing seasons.

In one additional study, Hassel et al. (2004) examined effects of seismic airgun exposure on caged lesser sandeel (*Ammodytes marinus*). Received sound levels were not measured in the cages. Mortality for the sandeels was the same in experimental and control cages, and was attributed to deployment of the cages and handling and confinement of the animals. The authors reported a small decline in sandeel abundance in the study region shortly after the seismic activity, but this quickly returned to pre-seismic levels.

Effects of other types of sounds on caged fish were investigated by Kastelein et al. (2008), who indicated that some fish species would show a sharp startle response when suddenly presented with a sound. While none of the sounds was anything like LFA or other sonars, the critical result of the study of caged animals was that each species showed different responses (or no responses) to different sounds. While the responses may not have been typical of what might be seen in uncaged animals exposed to the same sound, the useful outcome of this study was to reinforce the issue raised by others that extrapolation between/among species with respect to response type and/or responses to different types of sounds must be done with extreme caution.

While not directly related to sonar, but of scientific interest since unrestrained fish were used, Wardle et al. (2001) used a video system mounted on a reef to examine the behaviors of fish and invertebrates after exposure to seismic airguns (maximum RL of 210 dB re 1 µPa (rms) at 16 m (53 ft) from the source and 195 dB re 1 µPa (rms) RL at 109 m (358 ft) from the source). The results showed no observable damage to any animals or changes in behavior, or that any animals left the reef during the course of the study. The aforementioned studies support the conclusions presented below.

4.1.1.7 Masking

A sound reaching a fish, even at levels lower than those that could potentially cause PTS or TTS, may have a significant impact by preventing the fish from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators (Myrberg, 1981; Popper et al., 2004). The obscuring of sounds of interest by interfering sounds, generally at similar frequencies is referred to as masking (Fletcher, 1929; Richardson et al., 1995).

The studies on auditory masking in fish have been limited in the number of species studied. The results show that species that have been studied are generally affected by masking signals in much the same way as are terrestrial animals; most masking occurs when the masking sound is close in frequency to the sound being tested (Fay, 1974, 1988b; Fay and Megela-Simmons, 1999). If the masking signal is of significantly different frequency from the frequencies of importance to the fish, then much less (or no) masking may occur, although there is also some evidence that in at least some species, any noise signal may mask other signals, and that the degree of masking may be frequency-independent.

One of the problems with existing masking data is that the bulk of the studies have been done with goldfish (*Carassius auratus auratus*), a freshwater hearing specialist, where there may be a correlation between the degree of masking and how similar the masking signal and test signal are. The data on other species are much less extensive. As a result, little is known about masking in non-specialist fish. Tavolga

(1967) was the first to study the effects of noise on pure-tone detection in two non-specialist fish species. He reported that the masking effect was generally a linear function of masking level, independent of frequency. His measurements were of tonal thresholds at the edges of a masking band centered at 500 Hz for the blue-striped grunt (*Haemulon sciurus*). Results suggested that there are critical bands for fish, as in mammals, and these have now been confirmed in other species (reviewed by Fay and Megela-Simmons, 1999). In addition, Buerkle (1968) studied five frequency bandwidths for Atlantic cod in the 20 to 340 Hz region. Chapman and Hawkins (1973) found that ambient noise at higher sea states in the ocean have masking effects in Atlantic cod, haddock, and pollock.

Most recently, Vasconcelos et al. (2007) examined, in a laboratory setting, whether broad-band boat noise could mask detection of hearing conspecific's sounds in the Lusitanian toadfish (*Halobatrachus didactylus*) (a sound-producing in-shore species that is never likely to encounter LFA or MFA sonar). Results of these lab-based experiments suggest that boat noise in the frequency range of best hearing in this species can result in masking. While this result confirms the idea that all fish can have hearing masked, it is difficult to extrapolate these data to determine the potential for masking in wild animals, since it is not clear in the setup used in this experiment whether the fish were subject to pressure or particle motion signals. This is particularly relevant since this species is very likely to primarily detect particle motion, and thresholds and signal levels for masking were determined in terms of pressure. Moreover, these were captive and restrained animals, so results may be questionable

Thus, based on limited data, it appears that for fish, as for mammals, masking may be most problematic in the frequency region of the signal. For SURTASS LFA sonar this would be whatever 30-Hz (approximate maximum) bandwidth signal is being transmitted (within the 100-500 Hz frequency band); although each transmitted signal changes frequency band within ten seconds, which would diminish the potential for any masking effects.

Therefore, existing evidence supports the hypothesis that masking could have an effect on fish, particularly those where predominant biological signals and best hearing frequencies occur at similar frequencies as the SURTASS LFA sonar. However, given the nominal 7.5% duty cycle and 60-second signal duration (average), masking would be temporary. Additionally, the 30-Hz (approximate maximum) bandwidth of SURTASS LFA sonar is only a small fraction of the animal's hearing range. Most fish have hearing bandwidths >30 Hz. In summary, masking effects are not expected to be severe, because the SURTASS LFA sonar bandwidth is very limited, signals do not remain at a single frequency for more than ten seconds, and the system is usually off over 90% of the time.

4.1.1.8 Conclusions for Potential Impacts on Fish (Class Osteichthyes) Stocks

If SURTASS LFA sonar operations occur in proximity to fish stocks, members of some fish species could potentially be affected by LF sounds. Even then, the impact on fish is likely to be minimal to negligible since only an inconsequential portion of any fish stock would be present within the 180-dB sound field at any given time. Moreover, recent results from direct studies of the effects of LFA sounds on fish (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010) provide evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB re 1 µPa [rms] RL) have minimal impact on at least the species of fish that have been studied. Nevertheless, the 180-dB criterion is maintained for the analyses presented in this SEIS/SOEIS, with emphasis that this value is *highly conservative* and protective of fish.

The Viability of a 180-dB Criterion

Over the past two decades, regulators have sought to use a 180 dB re 1 µPa (rms) RL as the sound level at which any effect might occur on fish (though different organizations define the kind of effect that takes place at 180 dB re 1 µPa [rms] RL differently). However, recent data, and recent regulatory considerations, have substantially raised the level at which potential injury might come to fish, and this needs to be taken into consideration in terms of this analysis and future analyses of effects on fish. The basis for the increase comes from recent peer-reviewed scientific literature and regulator considerations.

Recent Findings

Several recent studies have shown that sounds substantially above 180 dB re 1 µPa (rms) RL have little or no effect on fish (Popper et al., 2005b, 2007; Hastings et al., 2008; Kane et al., 2010). In addition, a number of “gray literature” studies of pile driving (reviewed in Popper and Hastings, 2009b) have shown no damage to fish tissues when received sound levels are very high.

Perhaps the best of these gray literature studies was by Abbott et al. (2005) who investigated the effects of pile driving on caged fish of three species: shiner surfperch (*Cymatogaster aggregata*), Chinook salmon (*Oncorhynchus tshawytscha*), and northern anchovy (*Engraulis mordax*) at the Port of Oakland. The fish were caged at a distance of 9.75 m (32 ft) from the pile being driven and exposed to four minutes of pile driving (over 200 sound pulses) with average peak received SPL of 185-189 dB re 1 µPa. Following exposure, fish were sacrificed using excellent pathology methodology with appropriate controls. The results showed no differences in mortality or pathology between sound-exposed and control animals.

Other pile driving studies, while not nearly as well done as the Abbott et al. (2005) investigation (reviewed in Popper and Hastings, 2009b), also suggest that exposure to multiple presentations of very intense pile driving does not cause tissue damage in various species of fish. No studies have examined effects of pile driving on hearing.

Tissue damage has also been investigated in studies of seismic exposure (Popper et al., 2005b; Song et al., 2008) where fish were exposed to 5 or 20 blasts of seismic airguns with a received sound level of over 195 dB re 1 µPa (peak-to-peak). There was some temporary hearing loss in two species (discussed earlier) but not all species. Also, there was no evidence of tissue damage to the swim bladder or other non-auditory tissues (though Popper et al. do point out that a qualified fish pathologist did not examine this tissue), and there was no damage to ear tissue, as evaluated by an expert (Song et al., 2008). Some damage was found to sensory hair cells in the ears of pink snapper after exposure to sounds of seismic airguns (McCauley et al., 2003). The differences in the results between the two studies are not fully understood, but may be due to the very different acoustic environments of the studies (Popper et al., 2005b). Interestingly, while McCauley et al. found some damage to sensory cells of the ears, there was no mortality (nor was there mortality in the Popper et al. [2007] study) even when fish were kept 58 days post-exposure. In the only sonar studies that examined tissue damage in other than larvae, investigations of the effects of SURTASS LFA sonar with a received sound level of 193 dB re 1 µPa (rms) resulted in no damage to auditory or non-auditory tissues (Popper et al., 2007; Kane et al., 2010) and no tissue damage was found for mid-frequency sonar at a received sound level of 210 dB re 1 µPa (rms) (Kane et al., 2010).

It is possible that sound could result in behavioral effects on fish and/or in hearing loss, as discussed previously. Popper et al. (2005b) found a very small level of hearing loss in two of three species studied, and some hearing loss was found after exposure to SURTASS LFA sonar in the hearing specialist catfish, and in some, but not all, rainbow trout (Popper et al., 2007). Most recently, Hastings et al. (2008) found no hearing loss at all in several reef fishes and minimal loss at a few frequencies in others, to cumulative SEL RL of 189 to 190 dB re 1 µPa^2-sec.

There have been no studies that examine actual behavioral changes in free-ranging fish[15] as a result of exposure to any kinds of sounds (see previous discussion). Thus, it is not yet clear if and how such sounds might change behavior.

While these results do not specifically address the issues of behavioral effects, it is clear that sound levels well above 180 dB re 1 µPa (rms) have no, or very little, physiological affect on fish. Moreover, in all cases where an effect has been shown, the effect has been the result of exposure to a much longer

15 Studies of fish in cages or nets are not indicators of whether sound has an effect on behavior since the restraints themselves alter fish behavior.

duration sound, and/or sounds with much sharper onsets, than the transient exposures fish would experience in encountering LFA sonar.

The major discussion related to noise criteria for fish has focused in areas related to pile driving in aquatic environments. Recommendations have been made for acceptable levels of pile driving sounds, with particular concern for accumulated exposure over many pile-driving strikes (usually about 1 second apart). While there is considerable controversy, and current rules are often not fully science-based (they tend to be far more conservative sound levels than warranted based on “best available science”), these results may be instructive as a starting point for re-setting the levels allowable for LFA sonar and fish (and considering the poor hearing sensitivity of sharks and marine turtles, for those species as well).

Current levels for pile driving allow for peak exposure of 206 dB re 1 µPa SPL for all sizes of fish (FHWG, 2008). The basis of this criterion is discussed in a memorandum of agreement from the Fisheries Hydroacoustic Working Group (FHWG) (FHWG, 2008). There are several aspects of this peak level that should be noted. First, these levels are for pile driving sounds with sharp onsets and very short signals as compared to LFA sonar with slow rise times and longer signals. Second, the levels agreed to by the FHWG are below those recommended, based on the best available science, in a report to Caltrans by Popper et al. (2006) which was for a 208 dB re 1 µPa SPL peak exposure. Indeed, even the later report is probably too conservative since it was presented before data were available on responses to LFA (Popper et al., 2007) and seismic exposure (Hastings et al., 2008).

4.1.2 POTENTIAL IMPACTS ON FISH (CLASS CHONDRICHTHYES—CARTILAGINOUS FISH) STOCKS

There are only limited new data on the potential effects of low frequency underwater sound on sharks, rays and skates (subclass: Elasmobranchii) (see Subchapter 3.2.2.2). The most recent studies of several species of elasmobranches show hearing ranges that are comparable to earlier studies, but are measured in terms of particle motion, the stimulus parameter that is most likely the most important to animals without a swim bladder, such as elasmobranches (Casper et al., 2003; Casper and Mann, 2006 and 2007). As discussed in the FSEIS (DoN, 2007a), Casper et al. (2003) showed that the little skate, *Raja erinacea,* is able to detect sounds from 100 to over 800 Hz, with best hearing up to and possibly slightly greater than 500 Hz. More recent studies reported similar thresholds and hearing ranges for the nurse shark (*Ginglymostoma cirratum*), the yellow stingray (*Urobatis jamaicensis*) (Casper and Mann, 2006), the horn shark *Heterodontus francisci* and the white-spotted bamboo shark *Chiloscyllium plagiosum* (Casper and Mann, 2007) (see Figure 3-4). These are consistent with elasmobranch species being able to detect sounds up to 1000 Hz, with usable hearing limited to about 500 Hz.

The contents of Subchapter 4.1.2 of the FSEIS (DoN, 2007a) are incorporated herein by reference. The limited additional and updated information on the potential effects on sharks, rays, and skates from LFA sound are included in this SEIS/SOEIS, and are discussed below.

4.1.2.1 Non-Auditory Injury

In the absence of published, peer-reviewed reports on the potential for low frequency underwater sound to cause non-auditory injury to elasmobranches (sharks, rays, and skates), the previous discussions regarding fish non-auditory injury in Subchapter 4.1.1.1 will be considered to also apply here. Recent results from direct studies of the effects of LFA sounds on fish found no damage to tissues either at the gross or cellular levels, and there were no fish mortalities (Popper et al., 2007; Kane et al., 2010) from an LFA sonar source at relative high levels (up to 193 dB re 1 µPa [rms] RL).

4.1.2.2 Permanent Loss of Hearing

Hearing capability in elasmobranches is on a par with, or poorer than, that of hearing non-specialist bony fish, and there is no evidence that any shark is a hearing specialist. Since the FSEIS (DoN, 2007a), there are no additional data on permanent hearing loss in sharks or on damage to the ears. Recent results from direct studies of the effects of LFA sounds on fish examined the long-term effects on sensory hair cells of the ear. In the species studies, even up to 96 hours post-exposure, there was no evidence of damage to sensory cells (Popper et al., 2005a, 2007; Halvorsen et al., 2006) from an LFA sonar source at relative high levels (up to 193 dB re 1 µPa [rms] RL). A very small fraction of any shark stock would be exposed to these levels, even in the absence of mitigation. While extrapolation from bony fish to elasmobranches is something that should be done with caution, since the ears and auditory systems are different, the lack of substantive effects on non-specialist bony fish may also be similar to that for sharks, rays, and skates. Therefore, the utilization of the 180-dB criterion for fish is also applied to elasmobranches (with emphasis that this value is *highly conservative* and protective of fish, sharks, rays, and skates).

4.1.2.3 Temporary Loss of Hearing

Since the FSEIS (DoN, 2007a), there are no scientific data on temporary hearing loss in sharks, rays, and skates. Therefore, because sharks are considered hearing non-specialists and assuming they have similar hearing sensitivities as non-specialist bony fish discussed previously, the potential for TTS to cause substantial deleterious effects on shark stocks due to SURTASS LFA sonar transmissions is probably very small. Moreover, because sharks are considered hearing non-specialists, the Hastings et al. (1996) suggestion, supported by the Smith et al. (2004a and 2004b) studies may potentially apply, indicating that RLs of 220 to 240 dB re 1 µPa (rms) would be required to temporarily affect their hearing capability. However, without additional studies on sharks, this suggestion must be considered speculative, and probably very conservative.

4.1.2.4 Behavioral Change (Attraction/Repulsion)

Since the FSEIS (DoN, 2007a), there are no additional scientific data on behavioral changes in sharks, rays, and skates from anthropogenic underwater sound. Some sharks are attracted to or withdraw from pulsing low frequency sounds, as discussed in Chapter 3. This attraction or repulsion behavioral response is not considered an issue of concern since: 1) the LFA signals are not “pulsed” or structured as are sounds made by struggling marine animals, and 2) the likelihood of a significant portion of any shark stock being in the vicinity of the SURTASS LFA sonar source at any one time should be considered negligible.

4.1.2.5 Behavioral Change (Migration)

As stated in the FSEIS (DoN, 2007a), there is a body of scientific evidence that oceanic sharks make directional migrations. This has been supported by recent research using tags and satellite tracking. Satellite telemetry of tagged white sharks during 1999-2005 has revealed long-distance seasonal migrations from the California coast to offshore focal areas 2,500 km (1,350 nmi) west of the Baja Peninsula, and also the Hawaiian Islands (Weng et al., 2007). Gore et al. (2008) reported transatlantic migration from off the British Isles to off the coast of Newfoundland, Canada.

In assessing the potential for SURTASS LFA sonar signals to affect shark migrations, it is noted that the LFA source frequency is between 100 and 500 Hz, a region of the acoustic spectrum where these species appear to be best able to hear sound, and can detect sounds with intensities below 180 dB re 1 µPa (rms) RL. The issue is whether one or more LFA sonar transmissions could possibly cause displacement of sharks or shark stocks from their migratory path, such that this activity might be disrupted to the extent that the sharks may be unable to re-establish their direction along the migratory path. There are no new data that contradict the conclusion in the FSEIS (DoN, 2007a) that it would be unlikely that significant impacts to shark migration would occur due to SURTASS LFA sonar operations in the open ocean.

4.1.2.6 Masking

Sharks use hearing to detect prey, and this detection ability may potentially be affected by masking. By way of example, Nelson and Johnson (1970) measured a lemon shark’s (*Negaprion brevirostris*) hearing sensitivity to a 300 Hz, 130 dB SPL SL in two different sea states (sea states 1 and 2) and two different levels of vessel traffic (light and heavy). The shark’s auditory threshold was decreased by 2 dB SPL for sea state 2 versus sea state 1, a level of difference that is probably not significant since it is certainly within the variation of the hearing ability of the animal. The difference caused by light versus heavy vessel traffic was 18 dB SPL (measured in sea state 1). This represented differences in masking ranges (distance from the animal that a sound or sounds would be masked) of 45 m (148 ft) for sea state 2 versus 1 (due to sea state alone) and 110 m (360 ft) for heavy versus light boat/ship traffic. Thus, it can be concluded that the masking range for sharks can be elevated by sea state and vessel traffic.

As in bony fish, masking effects could be most significant for sharks with critical bandwidths at the same frequencies as the SURTASS LFA sonar, assuming that masking mechanisms in sharks are similar to that in mammals. However, at a nominal 7.5% duty cycle and an average 60-second transmission window, any masking would probably be temporary since the intermittent nature of the signal reduces the potential impact. In summary, masking effects are not expected to be significant because the SURTASS LFA sonar bandwidth is very limited (approximately 30 Hz), signals do not remain at a single frequency for more than ten seconds, and the system is usually off over 90% of the time.

4.1.2.7 Conclusions for Potential Impacts on Fish (Class Chondrichthyes—Cartilaginous Fish) Stocks

The conclusion in Subchapter 4.1.2.7 of the FSEIS (DoN, 2007a) remains valid. Some sharks in a SURTASS LFA sonar operations area could possibly be affected by LFA sounds, but only if they were very close to the sound source. However, a negligible portion of any shark stock would be exposed to received levels at or above 180 dB re 1 µPa (rms) SPL on an annual basis due to the small size of the LFA mitigation zone (180-dB SPL sound field) relative to the open ocean areas inhabited by shark stocks. Despite the ability of sharks to detect low frequency sound and the possibility of affecting sharks that are migrating or aggregating at seamounts/islands, the potential for the SURTASS LFA sonar to affect shark stocks would not be significant.

4.2 POTENTIAL IMPACTS ON SEA TURTLE SPECIES AND STOCKS

There are very few studies of the potential effects of underwater sound on sea turtles and most of these examined the effects of sounds of much longer duration or of different types (e.g., seismic airgun) than the SURTASS LFA sonar signals. This subchapter will provide summaries of the recent research and update the analysis of the potential effects of the proposed alternatives based on the following SURTASS LFA sonar operational parameters:

- Small number of SURTASS LFA sonar systems to be deployed;
- Geographic restrictions imposed on system employment;
- Narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz);
- Slowly moving ship, coupled with low system duty cycle, would mean that a sea turtle would spend less time in the LFA mitigation zone (180-dB SPL sound field); therefore, with a ship speed of less than 9.3 km/hr (5 kt), the potential for animals being in the sonar transmit beam during the estimated 7.5 to 10% of the time the sonar is actually transmitting is very low; and
- Small size of the LFA mitigation zone (180-dB SPL sound field) relative to open ocean areas.

Due to the lack of more definitive data on sea turtle stock distributions in the open ocean, it is not feasible to estimate the percentage of a stock that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth, during an LFA sound transmission. Data on sea turtle sound production and hearing are very limited. The best available data on sea turtle hearing are presented in Chapter 3 of this document. Further, there are no new data that contradict any of the assumptions or conclusions regarding potential effects to sea turtles in Subchapter 4.2 of the FSEIS (DoN, 2007a), which is incorporated by reference herein.

4.2.1 NON-AUDITORY INJURY

There are no data on the potential for anthropogenic sound to cause non-auditory injury in sea turtles. Although not directly related to SURTASS LFA sonar effects, a review of effects of explosives on turtles was done by Viada et al. (2008). For explosive structure removals in the Gulf of Mexico, NMFS specified that the area within 915 m (3,000 ft) of the platform must be clear of sea turtles. Therefore, using a value of 180-dB SPL injury threshold for sea turtles (within approximately 1,000 m [3,281 ft] of the LFA array) is conservative. The probability of a sea turtle being within the 180-dB mitigation zone is considered negligible because of the active acoustic and visual monitoring mitigation protocols, and the five SURTASS LFA sonar operational parameters listed above.

4.2.2 PERMANENT LOSS OF HEARING

Very little is known about sea turtle hearing and what, if anything, may cause a sea turtle to incur permanent loss of hearing. However, data support the premise that using a value of 180-dB injury threshold for sea turtles is conservative. A sea turtle would have to be within the LFA mitigation zone (≥180 dB re 1 µPa [rms] RL) when the sonar was transmitting to be at risk of injury, including permanent loss of hearing (i.e., PTS).

Despite the lack of scientific data on the potential effects of low frequency sound on sea turtle hearing and on PTS in sea turtles caused by low frequency sound, the potential for SURTASS LFA sonar to cause PTS in sea turtles must be considered negligible.

4.2.3 TEMPORARY LOSS OF HEARING

As with PTS, there are no published scientific data on temporary loss of hearing in sea turtles caused by low frequency sound. As there are no new data that contradict any of the assumptions or conclusions in Subchapter 4.1.2 (Sea Turtles) in the FOEIS/EIS (DoN, 2001), its contents are incorporated by reference herein. Further, the five SURTASS LFA sonar operational parameters listed above support the conclusion that the potential for SURTASS LFA sonar to cause TTS in sea turtles must be considered to be negligible.

4.2.4 BEHAVIORAL CHANGE

Sea turtles can travel many kilometers per day in the open ocean, as shown in tagging studies (Keinath, 1993); and the use of magnetic positional information for long-range navigation has been demonstrated in several diverse animals, including sea turtles (Lohmann et al., 2007). Sea turtles make extensive migrations and movements either for foraging opportunities or to breed. Their migration tracks may extend to thousands of kilometers (Mortimer and Carr, 1987; Bowen et al., 1995; Eckert, 1998 and 1999; Avens and Lohmann, 2004).

This issue relates to the behavior of sea turtle stocks near a high intensity sound source, beyond effects on the animals' ears themselves. A change in behavior that causes prolonged displacement of animals from the site of their normal activities could be considered a deleterious effect. Displacement can occur in two dimensions: vertical and horizontal. For example, a sea turtle could move to the surface, where anthropogenic low frequency sound would be weaker, possibly exposing it to a higher degree of predation. As for horizontal displacement, this is probably of greatest importance for non-pelagic sea turtle species (green [*Chelonia mydas*], olive ridley [*Lepidochelys olivacea*], hawksbill [*Eretmochelys imbricate*], Kemp's ridley [*Lepidochelys kempi*]), for which displacement from preferred benthic habitats could be construed as more serious.

Behavioral responses to human activity have been investigated for only a few species of sea turtles: green and loggerhead (O'Hara and Wilcox, 1990; McCauley et al., 2000); and olive ridley, leatherbacks (*Dermochelys coriacea*), loggerhead, and 160 unidentified turtle (hard-shell species) (Weir, 2007). The work by O'Hara and Wilcox (1990) and McCauley et al. (2000) reported behavioral changes of sea turtles in response to seismic airguns. O'Hara and Wilcox (1990) reported avoidance behaviors by loggerheads in response to airguns with sound levels (RL) of 175 to 176 dB re 1 µPa (peak-to-peak). McCauley et al. (2000) reported noticeable increases in swimming behavior for both green and loggerhead turtles at RLs of 166 dB re 1 µPa (peak-to-peak). At 175 dB re 1 µPa (peak-to-peak) RL, both green and loggerhead sea turtles displayed increasingly erratic behavior (McCauley et al., 2000).

Weir (2007) reported observations on olive ridley, leatherbacks, loggerheads, and additional unidentified animals during a seismic operation off Angola (note, this study has only appeared on the internet, but the author indicates [Popper, 2009] that this was peer reviewed). In this study, observers watched for turtles before and during seismic airgun surveys and reported on the number of animals encountered. In most of the 240 sightings of sea turtles (200 separate animals), it was not possible to comment on actual behavior since the animals were often more than 500 m (1,640 ft) from the observer, and most were just seen and not moving much on the surface. However, when diving behavior was observed, there were no differences between times when airguns were on or off. Similarly, the number of sea turtle sightings within 1,000 m (3,281 ft) of the airguns did not differ between when there was seismic survey activity or not. An important point arose from this study--that observations of sea turtles, much more than marine mammals, are significantly hampered in any but the lowest Beaufort sea state, since the animals are barely visible at the surface.

While the aforementioned studies are of some general interest, it is important to note that airguns used in those studies have an impulsive signal with a large bandwidth, high energy, and a short duration. Therefore, airgun signals cannot be directly compared with SURTASS LFA sonar, since the signal characteristics are very different, and the likelihood of effects on living tissue dissimilar as well.

Based on the hearing data, it is possible that if a sea turtle happened to be in proximity of a SURTASS LFA sonar operations area, it will hear the LF transmissions. Given that the majority of sea turtles encountered would probably be transiting in the open ocean from one site to another, the possibility of significant displacement would be unlikely. Further, the five SURTASS LFA sonar operational parameters listed above support the conclusion that the potential for SURTASS LFA sonar to cause behavioral changes in sea turtles must be considered to be negligible.

4.2.5 MASKING

One critical question to ask is whether there are sufficient anthropogenic sounds in the normal environment of sea turtles to suggest that hearing might be masked. While there have been no masking studies on marine turtles, an indirect study looked at the potential for masking by examining sounds in an area known to be inhabited by turtles. These underwater sound recordings were made in one of the major coastal foraging areas for juvenile sea turtles (mostly loggerhead, Kemp’s ridley and green sea turtles) in the Peconic Bay Estuary system in Long Island, NY (Samuel et al., 2005). The recording season of the underwater environment coincided with the sea turtle activity season in an inshore area where there is considerable boating and recreational activity, especially during the July to September timeframe. During this time period, RLs at the data collection hydrophone system in the 200 to 700 Hz band ranged from 83 dB re 1 µPa (rms) (night) up to 113 dB re 1 µPa (rms) (weekend day). Therefore, during much of the season when sea turtles are actively foraging in New York waters, they are undoubtedly exposed to these levels of noise, most of which is anthropogenic. However, there were no data collected on any behavioral changes in the sea turtles as a consequence of anthropogenic noise or otherwise during this study, so it cannot be stated whether this level of ambient sound would have any physiological and/or behavioral effects on the sea turtles.

Masking effects may occur for sea turtle species that have critical hearing bandwidths at the same frequencies as the SURTASS LFA sonar. However, masking would probably be temporary. The geographical restrictions imposed on all SURTASS LFA sonar operations would limit the potential for masking of sea turtles in the vicinity of their nesting sites. In summary, masking effects are not expected to be significant because of the nominal 7.5% duty cycle[16], the maximum 100-sec signal duration, the fact that the ship is always moving, the limited 30 Hz sonar bandwidth, and the signals not remaining at a single frequency for more than ten seconds.

4.2.6 POTENTIAL IMPACTS ON SEA TURTLES—CONCLUSIONS

The best available sea turtle population estimates (abundances) underestimate the sea turtle populations, as they only represent counts of nesting females and do not account for non-nesting females, males, or juveniles of the species. Few sea turtle density estimates are available worldwide, and those estimates that are available are usually only for nearshore nesting waters that are not representative of the majority of the open ocean. Nearly all species of sea turtles occur in low numbers over most of their ranges, resulting in distributions in the open ocean that are greatly and widely dispersed. Coupled with low numbers dispersed over enormous areas is the additional complexity of some sea turtle species, such as the leatherback and olive ridley turtles, spending their entire lives dispersed widely in pelagic waters, while the early lifestages of other sea turtle species spend the “lost years” drifting around the central ocean gyres. Due to the lack of more definitive data on sea turtle stock distributions in the open ocean, it is not feasible to estimate the percentage of a stock that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth, during an LFA sound transmission.

In this SEIS/SOEIS, the conservative SPL threshold for injury to sea turtles is a received level (RL) of 180 dB re 1 µPa (rms), which is coincident with the LFA mitigation zone. The LFA mitigation zone covers a volume ensonified to a received level ≥180 dB re 1 µPa (rms) around the SURTASS LFA sonar array, which is centered at a nominal depth of 122 m (400 ft) below the water surface. Based on spherical spreading, the LFA mitigation zone will vary between the approximate ranges of 750 to 1,000 m (2,461 to 3,481 ft) from the source array, over a depth of approximately 87 to 157 m (285 to 515 ft).

The small size of the LFA mitigation zone relative to the enormous area and volume of the ocean, as well as the depth of the mitigation zone are important considerations when evaluating the potential for impacts on sea turtles. Most sea turtle species spend a high percentage of their lives in the upper 100 m (328 ft) of the water column, particularly if they are transiting between foraging and nesting grounds in the open ocean. While transiting, their dives are shallower in depth as well as shorter in duration to reduce drag, swimming speed is higher, and generally their responses to resources are suppressed (i.e., no foraging typically occurs during transit) (Godley et al., 2002; Hays et al., 2006). Sea turtles may be found in the open ocean or oceanic environment not only as adults migrating between nesting and foraging habitats but also during early lifestages (post-hatchlings or juveniles) or as foraging adult leatherback and olive ridley turtles. The distribution of sea turtles in the open ocean is greatly and widely dispersed due to the vast area of oceanic waters worldwide over which sea turtles potentially can occur. In shallower continental shelf waters, where most foraging grounds are located, even deep-diving turtles, such as the leatherback, make shallower foraging dives, frequently to less than 60 m (197 ft) due to the constrained water depths (Eckert et al., 1996; Hays et al., 2006). Moreover, turtle foraging grounds do not encompass all available continental shelf waters but are typically in restricted areas of the productive shelf and inshore estuarine waters. Thus, most frequently, sea turtles would occur in the water column above the LFA mitigation zone and, thus, would not encounter LFA received levels ≥180 dB re 1 µPa (rms), the threshold at which they are conservatively considered to be injured.

Additionally, in the shallow, nearshore continental shelf waters where foraging and nesting/breeding turtles would most often occur, SURTASS LFA sonar operations are geographically constrained due to operational depth restrictions and the coastal standoff range (no LFA RLs above 180 dB re 1 µPa (rms) SPL within 22 km [12 nmi] of any coastlines). Also, visual and acoustic monitoring measures are

16 Average duty cycle (ratio of sound “on” time to total time) of the SURTASS LFA sonar active transmission mode is less than 20%. The typical duty cycle, based on historical LFA operational parameters since 2003 is nominally 7.5 to 10%. During the remaining 80 to 92.5% of the time, LFA transmitters would be off, thus adding no sound to the water.

conducted during active LFA sonar transmissions to further reduce the potential for surface animals potentially diving into the LFA mitigation zone. The position of the HF/M3 sonar system above the top of the LFA sonar array means that a sea turtle would have to swim from the surface through the HF/M3 sonar detection zone to enter into the 180-dB LFA mitigation zone, making an acoustic detection of the animal highly likely. While visual monitoring is less effective for sea turtles due to their smaller size and low surface profile, visual sightings of sea turtles have occurred during mitigation monitoring of SURTASS LFA sonar and resulted in the suspension of the sonar to ensure safety of the observed turtle (DoN, 2011).

In addition to the water column usage by sea turtles, the geographic restrictions for LFA sonar use, and the suite of mitigation measures employed during SURTASS LFA sonar transmissions that together result in a reduced potential for injury to sea turtles, other operational parameters of the sonar further reduce the already small likelihood for injury to individual sea turtles. These operational parameters include the small number of SURTASS LFA sonar systems to be deployed (no more than four under the requested five-year Rule), the narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz), the slow speed at which the SURTASS LFA vessels travel (<5 kt), and the low duty cycle of the sonar system (7.5 to 10%). Any masking effects of the sonar would be temporary and not significant. For these reasons, the potential for SURTASS LFA sonar operations to expose individual sea turtles to injurious sound levels or to cause TTS and/or behavioral changes is considered negligible. Due to the small likelihood for injury to individual sea turtles, the potential impact is not significant to sea turtles on a stock level. Therefore, the operation of SURTASS LFA sonar would not adversely impact sea turtle stocks.

4.3 POTENTIAL IMPACTS ON MARINE MAMMAL SPECIES AND STOCKS

Potential effects on marine mammals from SURTASS LFA sonar operations include: 1) non-auditory injury; 2) permanent loss of hearing; 3) temporary loss of hearing; 4) behavioral change; and 5) masking (including communications impairment). Richardson et al. (1995) provided the most comprehensive review of contemporary knowledge on the sources and effects of anthropogenic noise on marine mammals, and Nowacek et al. (2007) provide a more recent review of the effects of anthropogenic noise on cetaceans. Nowacek et al. (2007) included an update on the documented behavioral, acoustic and some physiological responses of cetaceans to man-made noise. They focused on literature that reported quantitatively on the sound field and some indicator of response. Southall et al. (2007) reported on the results from a panel of acoustic research experts in the behavioral, physiological, and physical disciplines. The panel's purpose was to review the expanding literature on marine mammal hearing, and physiological and behavioral responses to anthropogenic sound, with the objective of proposing exposure criteria for certain effects. More recently, Hatch et al. (2008) and Clark et al. (2009) have addressed the issue of acoustic masking and presented metrics for quantifying the influences of anthropogenic noise sources on whales that communicate in the low frequency band.

These papers, additional literature reviews, and research indicate that there are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS (DoN, 2001) and the FSEIS (DoN, 2007a). Thus, the findings presented in the SURTASS LFA sonar FOEIS/EIS and the FSEIS regarding potential impacts on marine mammals remain valid and are incorporated by reference herein. This subchapter provides a summary of the recent literature reviews and the overall potential for impacts of SURTASS LFA sonar operations on marine mammals.

4.3.1 NON-AUDITORY INJURY

Nowacek et al. (2007) and Southall et al. (2007) reviewed potential areas for non-auditory injury to marine mammals from active sonar transmissions. These include direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas. They presented no additional or new data that contradict any of the assumptions or conclusions in the FOEIS/EIS and the FSEIS.

4.3.1.1 Direct Acoustic Impacts

Physical effects, such as direct acoustic trauma or acoustically enhanced bubble growth, require relatively intense received energy that would only occur at short distances from high-powered sonar sources (Nowacek et al., 2007; Zimmer and Tyack, 2007).

As summarized in the FSEIS, the best available scientific information shows that, while resonance can occur in marine animals, this resonance does not necessarily cause injury, and any such injury is not expected to occur below a received sound pressure level (RL) of 180 dB re 1 µPa (rms). Damage to the lungs and large sinus cavities of cetaceans from air space resonance is not regarded as a likely significant non-auditory injury because resonance frequencies of marine mammal lungs are below that of the LFA signal (Finneran, 2003). Further, biological tissues are heavily damped and tissue displacement at resonance is predicted to be exceedingly small. In addition, lung tissue damage is generally uncommon in acoustic-related strandings (Southall et al., 2007).

4.3.1.2 Gas Bubble Formation

Presently, there are discussions among researchers on whether marine mammals can suffer from a form of decompression sickness caused by in vivo nitrogen gas-bubble growth. Jepson et al. (2003, 2005) and Fernandez et al. (2005) reported results of necropsies of stranded beaked whales, some of which coincided with naval sonar exercises, which they interpreted as consistent with a decompression-like syndrome (Nowacek et al., 2007).

Scientists have documented bone lesions (osteonecrosis), which may be a chronic result of nitrogen bubbles, in the rib and chevron bone articulations, nasal bones, and deltoid crests of sperm whale specimens from the Atlantic and Pacific oceans dating from the late 1800s to 2003, (Moore and Early, 2004). This suggests that nonlethal pathologies related to gas bubbles may occur during the normal life span of, at least, the deep-diving sperm whale.

Houser (2007) assessed the potential for nitrogen bubble formation in a trained dolphin. Based on repetitive dives to depths of 10, 30, 50, 70, and 100 m (32.8, 98.4, 164, 230, and 328 ft), ultrasound inspections were completed on the portal and innominate veins (i.e., the left and right brachiocephalic veins). Blood samples were also taken over a 20-min period at the end of each of the 50, 70, and 100 m (164, 230, and 328 ft) dives for the assessment of nitrogen partial pressure. There were no vascular bubbles found in any post-dive ultrasound. Nitrogen partial pressures from blood samples were not significantly elevated from those of the dolphin at rest (20 min post dive). Results suggest that repetitive, prolonged dives up to 100 m (328 ft) accumulate insufficient nitrogen to generate asymptomatic intravascular bubbles in bottlenose dolphins.

Zimmer and Tyack (2007) modeled nitrogen tension and bubble growth in beaked whales during normal diving behavior and for several hypothetical dive profiles to assess the risk of nitrogen bubble formation. They concluded that macroscopic bubbles are unlikely to pose a risk of decompression-like syndrome from a simple interruption of a normal deep foraging dive, even when accompanied by an unrealistic ascent rate. They concluded, contrary to Jepson et al. (2003), that the interruption and rapid ascent from a regular deep foraging dive is unlikely to pose a risk of decompression-like syndromes. They suggested that gas bubble lesions in stranded beaked whales reported by Jepson et al. (2003, 2005) and Fernandez et al. (2005) might be caused by repetitive dives of short to medium surfacing duration without exceeding the depth of alveolar collapse. They stated that the longer the dive time compared to surfacing time, the greater the risk. The Zimmer and Tyack (2007) study suggests the hypothesis that beaked whales have an avoidance response to killer whales and great white sharks, which are their primary near-surface predators, resulting in their swimming at depths of approximately 25 m (82 ft) without exceeding alveolar collapse. These hypotheses require more behavioral and physiological research.

Baird et al. (2008) investigated the variation in diving behavior from time-depth recorders on six Blainville's and two Cuvier's beaked whales. Both species demonstrated ascent rates from dives deeper than 800 m (2,625 ft) that were significantly slower than decent rates, both during the day and at night, suggesting some physiological purpose for the slower ascents. The whales also spent more time in dives to mid-water depths (100 to 600 m [328 to 1,969 ft]) during the day. At night, the whales spent more time in shallow (<100 m) dives. This diel variation[17] in behavior suggests that beaked whales may spend less time in surface waters during the day to avoid visually oriented predators, including sharks and killer whales.

Fahlman et al. (2009) modeled the effects of lung compression and collapse (pulmonary shunt) on the uptake and removal of O_2, CO_2, and N_2 in blood and tissue, and on end-dive nitrogen concentrations for breath-holding marine mammals (e.g., elephant seals, Weddell seals, and beaked whales). Fahlman et al. suggested that repeated dives might result in tissue and blood levels of nitrogen sufficient to cause symptomatic bubble formation.

Based on the current knowledge of gas exchange and physiology of marine mammals, Hooker et al. (2009) developed a mathematical model to predict blood and tissue levels of nitrogen gas for three species of beaked whales: northern bottlenose, Cuvier's, and Blainville's beaked whales. They suggested that deep-diving marine mammals live with, and manage high levels of nitrogen gas in their tissues and blood. Because of differences in dive behavior, predicted nitrogen levels were higher in Cuvier's beaked whales than in northern bottlenose whales and Blainville's beaked whales. The authors state that while the prevalence of Cuvier's beaked whale strandings after naval sonar exercises could be explained by a higher abundance of the species in the area, their results suggest that species differences in behavior and/or physiology may also play a role.

Moore et al. (2009) performed gross histologic and radiographic observations related to the presence of gas bubbles in the tissues and blood of seals and dolphins drowned in gillnets, set at a depth of approximately 80 m (263 ft). The majority (15 of 23) of the seals and dolphins had extensive bubble formation in multiple tissues and blood. In addition, computer tomography (CT), which was performed on four randomly-selected marine mammals, identified gas bubbles in various tissues. Due to the good condition of the carcasses, absence of bacteria and autolytic (self-digestion) changes, the study concluded that peri- or post-mortem phase change of supersaturated blood and tissues was the most likely cause of the bubbles. Overall, Moore et al. (2009) found a high prevalence of vascular and interstitial bubbles in seals and dolphins drowned in gillnets set at a depth of approximately 80 m (263 ft). In contrast, a very low prevalence of bubble lesions was found for beach-stranded marine mammals in this study (one of 41) and in a study by Jepson et al. (2005) (10 of 2,376). The results of the Moore et al. (2009) analyses support the modeling of simulated dive profiles by Zimmer and Tyack (2007), which suggest an increase in risk of bubble formation caused by repetitive dives with short to medium surface durations, without exceeding the depth of alveolar collapse, which is estimated to be about 80 m (263 ft) for dolphins.

Despite the increase in research and literature, there remains scientific disagreement and/or lack of scientific data regarding the evidence for gas bubble formation as a causal mechanism between certain types of acoustic exposures and stranding events. These issues include: 1) received acoustic exposure conditions; 2) pathological interpretation; 3) acoustic exposure conditions required to directly induce physiological trauma; 4) behavioral reactions caused by sound exposure such as atypical dive patterns; and 5) the extent of postmortem artifacts (Southall et al., 2007).

As is shown by the above discussions, the hypothesis for gas bubble formation related to beaked whale strandings is that beaked whales potentially have strong avoidance responses to sounds similar to their main predator, the killer whale (Cox et al., 2006; Southall et al., 2007; Zimmer and Tyack, 2007; Baird et al., 2008; Hooker et al., 2009). Because SURTASS LFA sonar transmissions are lower in frequency (<500 Hz) and dissimilar in characteristics from those of marine mammal predators, the above scientific

---

17 Diel means "in the course of the day". Thus, a "diel variation" is a variation that occurs regularly every day or most days.

studies do not provide additional evidence that SURTASS LFA sonar has caused behavioral reactions, specifically avoidance responses, in beaked whales. Thus, there are no additional or new data to contradict any of the assumptions or conclusions in the FOEIS/EIS and/or the FSEIS, especially the conclusion that SURTASS LFA sonar transmissions are not expected to cause gas bubble formation or beaked whale strandings.

4.3.1.3 Injury Criteria

Southall et al. (2007) proposed injury criteria for individual LF/MF/HF marine mammal groups exposed to non-pulsed sound type, which included discrete acoustic exposures from SURTASS LFA sonar. The proposed injury criteria, which are based on onset of PTS, for LF/MF/HF cetaceans are an SEL of 215 dB re 1 μPa^2-sec and for pinnipeds in water an SEL of 203 dB re 1 μPa^2-sec. These values are then adjusted for the longer LFA signal (nominally 60 seconds) using 10 Log (T/Ti) where T is 60 sec and Ti is 1 sec. An 18-dB adjustment is made, resulting in an injury criterion for SURTASS LFA sonar of an SEL of 197 dB RL for cetaceans. For pinnipeds in water, this adjusted value would be an SEL of 185 dB re 1 μPa^2-sec RL. This provides further scientific support that the SURTASS LFA sonar injury criterion for all marine mammals of 180 dB SPL RL is conservative.

4.3.2 AUDITORY EFFECTS OF SOUND ON MARINE MAMMALS

All studied marine mammals produce sound. They use sound to communicate with conspecifics, to navigate and sense their environment, to locate and capture prey, and to detect and avoid predators (Hofman, 2003; Southall et al., 2007). Marine mammals exposed to natural or man-made sound may experience physical and psychological effects, ranging in magnitude from none to severe (Southall et al., 2007). There are at least four areas of primary concern for marine mammals exposed to elevated noise levels, including: 1) PTS; 2) TTS; 3) behavioral disturbance (Nowacek et al., 2007); and 4) acoustic masking (Clark et al., 2009).

The hearing of marine mammals varies among species and individuals (Richardson et al., 1995). An auditory threshold, estimated by either behavioral or electrophysiological responses, are the levels of the quietest audible sound in a specified percent of trials (i.e., often 50% detection probability) (Southall et al, 2007). Generally, audiograms have been developed for smaller, captive odontocetes and pinnipeds. The absolute threshold is the level of sound that is barely audible when significant ambient noise is absent, which also varies based on the frequency content of the sound. Background noise may mask the sounds that a marine mammal could normally detect; masking can come from both natural and man-made noises (Richardson et al., 1995).

Southall et al. (2007) created five functional hearing groups of marine mammals by combining behavioral and electrophysiological audiograms with comparative anatomy, modeling, and response measured in ear tissues. These are:

- Low-frequency Cetaceans—this group consists of 13 species and subspecies of mysticetes with a collective functional hearing of 7 Hz to 22 kHz.
- Mid-frequency Cetaceans—includes 32 species and subspecies of dolphins, six species of larger toothed whales, and 19 species of beaked and bottlenose whales with functional hearing of approximately 150 Hz to 160 kHz.
- High-frequency Cetaceans—incorporates eight species and subspecies of true porpoises, six species and subspecies of river dolphins, plus the franciscana, *Kogia*, and four species of Cephalorhynchids (genus in the dolphin family Delphinidae) with functional hearing estimated from 200 Hz to 180 kHz.
- Pinnipeds in Water—consists of 16 species and subspecies of sea lions and fur seals, 23 species and subspecies of true seals, and two species of walrus, with functional underwater hearing from 75 Hz to 75 kHz.

- Pinnipeds in Air—includes 16 species and subspecies of sea lions and fur seals, 23 species and subspecies of true seals, and two subspecies of walrus, with functional in air hearing from 75 Hz to 30 kHz (Southall et al., 2007).

Measured sensitivity and frequency ranges of marine mammals are shown by audiograms, which are obtained by either: 1) behavioral testing on captive, trained animals; or 2) by electrophysiological or auditory evoked potential (AEP) methods (Schlundt et al., 2007). Currently, there are no audiograms for low-frequency cetaceans available. However, predictions of their hearing have been made on the basis of cochlear anatomy (Ketten, 1997) and environmental acoustics (Clark and Ellison, 2004). Audiograms, both behavioral and AEP, for mid-frequency cetaceans include those for bottlenose dolphin, common dolphin, killer whale, beluga, false killer whale, Risso's dolphin, tucuxi, Pacific white-sided dolphin, striped dolphin, and Gervais' beaked whale. Audiograms, both behavioral and AEP, for high-frequency cetaceans include those for harbor porpoise, Amazon River dolphin, Chinese river dolphin, and finless porpoise. Audiograms, both behavioral and AEP, for pinnipeds in water, include those for California sea lion, northern fur seal, northern elephant seal, harp seal, harbor seal, gray seal, Hawaiian monk seal, harp seal, and ringed seal. Audiograms, both behavioral and AEP, for pinnipeds in air, include those for northern fur seal, California sea lion, northern elephant seal, harp seal, and harbor seal. The audiograms and supporting technical data are provided in Richardson et al. (1995), Nedwell et al. (2004), Southall et al. (2007), Au and Hastings (2008), Houser et al. (2008), Kastelein et al. (2009), and Mulsow and Reichmuth (2010).

Despite the increased interest in characterizing the auditory system of beaked whales, direct data on their biosonar receiving systems are sparse. Cook et al. (2006) measured AEPs in a stranded juvenile Gervais' beaked whale between 5 and 80 kHz (lowest and highest frequencies tested, respectively). Cook et al. found that the beaked whale was most sensitive to high frequency signals between 40 and 80 kHz. At 5 kHz, there was a detectable evoked potential (EP) at an SPL of 132 dB re 1 µPa (rms) RL, meaning that the behavioral threshold of the Gervais' beaked whale would be lower than 132 dB re 1 µPa (rms) SPL (Cook et al., 2006). Finneran et al. (2009) used AEP measurements to determine the upper cutoff frequency of hearing in a stranded adult Gervais' beaked whale. It was determined to be 80 to 90 kHz, which is substantially lower than that seen in dolphins (~120 to 150 kHz), but similar to killer whales. The hearing sensitivities measured by Cook et al. (2006) at 5 kHz are similar to or less than those of bottlenose dolphins, and do not support the hypothesis that these species have particularly high sensitivity at the frequencies used by MFA sonar.

There has been research into the procedures for audiograms, especially relating to the refinement of techniques for AEP methods and interpretation of results (Houser and Finneran, 2006; Finneran et al., 2007; Finneran, 2008, 2009; Mooney et al., 2009a). The results of updated literature reviews and research information on the hearing capabilities and sound production of marine mammals that potentially could be affected by SURTASS LFA sonar are provided in Chapter 3.

4.3.2.1 Permanent Loss of Hearing

The FOEIS/EIS (DoN, 2001) defined PTS as the deterioration of hearing due to prolonged or repeated exposure to sounds which accelerate the normal process of gradual hearing loss (Kryter, 1985), and the permanent hearing damage from brief exposure to extremely high sound levels (Richardson et al., 1995). PTS results in a permanent elevation in hearing threshold—an unrecoverable reduction in hearing sensitivity (Southall et al., 2007). Therefore, PTS is considered an injury.

In the 2002 Rule for SURTASS LFA sonar (NOAA, 2002b), NMFS stated that TTS is not an injury. Since the boundary line between TTS and PTS is neither clear, definitive, nor predictable for marine mammals, NMFS adopted the standard that 20 dB of threshold shift defines the onset of PTS (i.e., a shift of 20 dB in hearing threshold) (NOAA, 2002b). NMFS used this same standard in the 2007 Rule (NOAA, 2007c). As discussed previously in this chapter, Southall et al. (2007) proposed injury criteria for individual LF/MF/HF marine mammals exposed to non-pulsed sound types, which included discrete acoustic exposures from

SURTASS LFA sonar. The proposed injury criteria for cetaceans and pinnipeds in water are SELs of 215 dB re 1 µPa^2-sec RL and 203 dB re 1 µPa^2-sec RL, respectively. As presented earlier, an 18-dB adjustment must be made for the longer LFA signal (nominally 60 seconds) resulting in injury criteria for SURTASS LFA sonar for LF/MF/HF cetaceans of a SEL of 197 dB re 1 µPa^2-sec RL and for pinnipeds in water an SEL of 185 dB RL. The FOEIS/EIS and FSEIS injury criterion for all marine mammals was an SPL of 180 dB RL, which is noticeably lower and, therefore, more conservative, than the injury criteria proposed by Southall et al. (2007). Thus, the probability of SURTASS LFA sonar transmissions (with mitigation) causing PTS in marine mammals is considered negligible.

4.3.2.2 Temporary Loss of Hearing

In addition to the possibility of causing permanent injury to hearing, sound may cause TTS, a temporary and reversible loss of hearing that may last for minutes to days. The following physiological mechanisms may result in TTS:

1. Reduced sensitivity of the sensory hair cells in the inner ear as a result of their being over-stimulated;
2. Modification of the chemical environment within sensory cells;
3. Displacement of certain inner ear membranes;
4. Increased blood flow; and
5. Post-stimulation reduction in both efferent (impulses traveling from the central nervous system to the peripheral sensory tissue) and sensory output (Kryter, 1994; Ward, 1997; Southall et al., 2007).

In the 2002 and 2007 SURTASS LFA Sonar Final Rules (NOAA, 2002b and 2007c), NMFS stated that TTS is not an injury. The duration of TTS depends on a variety of factors including intensity and duration of the stimulus. Southall et al. (2007) considered that the temporary elevation of a hearing threshold by 6 dB was a sufficient definition for TTS onset. For cetaceans, most of the published TTS data are limited to bottlenose dolphins and belugas (Finneran et al., 2000, 2002, 2005, and 2007; Schlundt et al., 2000; Nachtigall et al., 2003 and 2004).

A study of TTS in harbor porpoises used a seismic airgun as a stimulus (Lucke et al., 2009). Airguns produce an impulsive signal and have a broad frequency range but also have substantial energy in the low frequency region. A small airgun was used in proximity to the animals (between 14 to 150 m), a context that is likely to enhance behavioral responsiveness. The harbor porpoises showed a behavioral response at an SPL RL of 174 dB re 1 µPa (peak-to-peak), which is equivalent to an SEL of 145 dB re 1 µPa^2-sec (Lucke et al., 2009). Harbor porpoise hearing was tested at a frequency of 4 kHz and TTS was detected at an SPL RL of 199.7 dB re 1 µPa (peak-to-peak), which is equivalent to an SEL of 164.3 dB re 1 µPa^2-sec (Lucke et al., 2009). These are the lowest received sound levels that produce TTS yet reported. These data are intriguing and clearly indicate a need for additional research. Unfortunately, only one individual was tested in this study. The applicability of these results to SURTASS LFA sonar is uncertain, given the large differences in source characteristics between airguns and LFA sonar. Furthermore, LFA sonar typically operates in water deeper and further offshore than most harbor porpoise habitats. Indeed, harbor porpoises are found in only one of the SURTASS LFA sonar OPAREAS analyzed, for which zero exposures at levels >180 dB SPL were found. Nevertheless, this study indicates that further study of TTS in porpoises is warranted. Ideally, additional harbor porpoise individuals, as well as additional HF-hearing species would be tested. If this type of results are confirmed for harbor porpoise or found in other HF-hearing species, then the analyses for those species would merit revision.

In a study on the effects of noise level and duration of TTS in a bottlenose dolphin, Mooney et al. (2009a) exposed a bottlenose dolphin to octave-band noise (4 to 8 kHz) of varying durations (2 to 30 minutes) and SPL RLs (130 to 178 dB re 1 µPa). Their results indicated that shorter-duration sound exposures often require greater sound energy to induce TTS than longer-duration exposures. Their results also supported the trend that longer-duration exposures often induce greater amounts of TTS, which concurrently require longer recovery times.

In a controlled exposure experiment, Mooney et al. (2009b) demonstrated that MFA sonar could induce temporary hearing loss in a bottlenose dolphin (*Tursiops truncatus*). Temporary hearing loss was induced by repeated exposure to an SEL of 214 dB re 1 µPa^2-sec. Subtle behavioral alterations were also associated with the sonar exposures. At least with one odontocete species (common bottlenose dolphin), sonar can induce both TTS and mild behavioral effects; but exposures must be prolonged with high exposure levels to generate these effects. The RL used in the Mooney et al. (2009b) experiment was an SPL of 203 dB re 1 µPa (rms), which equates to the RL approximately 40 m (131 ft) from MFA sonar operated at an SPL of 235 dB re 1 µPa at 1 m (rms) (SL). Mooney et al. (2009b) concluded that in order to receive an SEL of near 214 dB re 1 µPa^2-sec, an animal would have to remain in proximity of the moving sonar, which is transmitting for 0.5 sec every 24 sec over an approximately 2 to 2.5 min period, an unlikely situation.

SELs necessary for TTS onset for pinnipeds in water have been measured for harbor seals, California sea lions, and northern elephant seals. As reported by Southall et al. (2007), Kastak et al. (2005) presented comparative analysis of underwater TTS for pinnipeds. This indicated that in harbor seals, a TTS of ~6 dB SPL occurred with a 25-min exposure to 2.5 kHz octave-band noise of 152 dB re 1 µPa (rms) SPL (183 dB re 1 µPa^2-sec SEL); a California sea lion showed TTS-onset under the same conditions at 174 dB re 1 µPa (rms) SPL (206 dB re 1 µPa^2-sec SEL); and a northern elephant seal under the same conditions experienced TTS-onset at 172 dB re 1 µPa (rms) SPL (204 dB re 1 µPa^2-sec SEL). Finneran et al. (2003) exposed two California sea lions to single underwater pulses from an arc-gap transducer and found no measurable TTS following exposures of up to 183 dB re 1 µPa (rms) SPL (215 dB re 1 µPa^2-sec SEL).

Animals suffering from TTS over longer periods of time, such as hours to days, may be considered to have a change in a biologically significant behavior, as they may be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators. Animals that experience repeated occurrences of TTS without sufficient recovery time might develop PTS; but according to Southall et al. (2007) the precise relationship between TTS and PTS is not fully understood and for marine mammals is unknown. As noted by Mooney et al. (2009a), shorter duration sound exposures can require greater sound energy to induce TTS than longer duration exposures, and longer duration exposures can induce greater amounts of TTS. In assessing the potential for LFA sonar transmissions to cause TTS, the much shorter length of the LFA signal (1 min) versus the above studies (2 to 30 min) must be considered. The more recent scientific information presented in this subchapter support the assumptions and findings of the FOEIS/EIS and FSEIS. Therefore, they do not constitute substantial changes to the knowledge or understanding for the potential effects of LFA sonar to cause temporary loss of hearing in marine mammals. The information in the FOEIS/EIS Subchapters 1.4.2 and 4.2.7, taken in the context of temporary loss of hearing (i.e., TTS), remains valid, and the contents are incorporated by reference herein.

4.3.2.3 Behavioral Change

The primary potential deleterious effect from SURTASS LFA sonar is change in a biologically significant behavior[18]. For military readiness activities, such as the use of SURTASS LFA sonar, Level B “harassment” under the MMPA is defined as any act that disturbs or is likely to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or

18 The National Research Council (NRC, 2005) discussed biologically significant behaviors and possible effects, and stated that an action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce. These are the effects on individuals that can have population-level consequences and affect the viability of the species.

significantly altered. Behaviors include migration, surfacing, nursing, breeding, feeding, and sheltering. The National Research Council (NRC, 2005) discussed biologically significant behaviors and possible effects and stated that an action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce. These are the effects on individuals that can have population-level consequences and affect the viability of the species (NRC, 2005).

The Low Frequency Sound Scientific Research Program (LFS SRP) in 1997 to 1998 provided important results on, and insights into, the types of responses of baleen whales to LFA sonar signals and how those responses scaled relative to RL and context. The results of the LFS SRP confirmed that some portion of the total number of whales exposed to LFA sonar responded behaviorally by changing their vocal activity, moving away from the source vessel, or both; but the responses were short-lived (Clark et al., 2001).

In the LFS SRP LFA sonar playback experiment (Phase II), migrating gray whales avoided exposure to LFA signals (source levels of 170 and 178 dB re 1 µPa at 1 m [rms] SPL) when the source was placed in the center of their migration corridor. Responses were similar for the 170-dB re 1 µPa at 1 m (rms) SPL SL LFA stimuli and for the 170-dB re 1 µPa at 1 m (rms) SPL SL 1/3rd-octave, band-limited noise with timing and frequency band similar to the LFA stimulus. However, during the LFA sonar playback experiments, in all cases, whales resumed their normal activities within tens of minutes after the initial exposure to the LFA signal (Clark et al., 2001). Essentially, the whales made minor course changes to go around the source. When the source was relocated within the outer portion of the migration corridor (twice the distance offshore), and the SL was increased to reproduce the same sound field for the central corridor playback condition, the gray whales showed little to no response to the LFA sonar source. This result stresses the importance of context in interpreting the animals' behavioral responses to underwater sounds and demonstrates that RL is not necessarily a good predictor of behavioral impact.

The LFS SRP also conducted field tests to examine the effects of LFA sonar transmissions on foraging fin and blue whales off San Nicolas Island, California (Phase I). Overall, whale encounter rates and dive behavior appeared to be more strongly linked to changes in prey abundance associated with oceanographic parameters rather than LFA sound transmissions (Croll et al., 2001b).

In the final phase of the LFS SRP (Phase III), the effect of LFA sonar on humpback whales during the winter mating season was investigated. Both Miller et al. (2000) and Fristrup et al. (2003) published results from tests conducted with male humpback singers off the Big Island, Hawaii during which they evaluated variation in song length as a function of exposure to LFA sounds. Fristrup et al. (2003) used a larger data set to describe song length variability and to explain song length variation in relation to LFA broadcasts. In spite of methodological and sample size differences, the results of the two analyses were generally in agreement, and both studies indicated that humpback whales might lengthen their songs in response to LF broadcasts.

The Fristrup et al. (2003) results also provided a detailed picture of short-term response as compared to behavioral variation observed in the absence of the stimuli. These responses were relatively brief in duration, with all observed effects occurring within 2 hours of the last LFA source transmission. It should be noted that these effects were not obvious to the acoustic observers on the scene, but were revealed by careful, complex post-test statistical analyses (Fristrup et al*.,* 2003). Aside from the delayed responses, other measures failed to indicate cumulative effects from LFA broadcasts, with song-length response being dependent solely on the most recent LFA transmission, and not the immediate transmission history. The modeled seasonal factors (changes in density of whales sighted near shore) and diurnal factors (changes in surface social activities) did not show trends that could be plausibly explained by cumulative exposure. Increases in song length from early morning to afternoon were the same on days with and without LFA transmissions, and the fraction of variation in song length that could be attributed to LFA broadcast was small (<10%). Fristrup et al. (2003) found high levels of natural variability in humpback song length and interpreted the whales' responses to LFA broadcasts to indicate that exposure to LFA sonar would not impose a risk of dramatic changes in humpback whale singing behavior that would have demographic consequences.

Southall et al. (2007) reviewed the relatively extensive behavioral observations of low frequency cetaceans exposed to non-pulse sources. While there are clearly major areas of uncertainty, they concluded that these papers indicated that there were no (or very limited) responses to RLs of 90 dB to 120 dB re 1 µPa (rms) SPL with an increasing probability of avoidance and other behavioral effects in the 120 to 160 dB re 1 µPa (rms) SPL (RL) range. This is consistent with both the FOEIS/EIS and FSEIS.

4.3.2.4 Masking and Communications Impairment

The obscuring of sounds of interest by interfering sounds, generally at similar frequencies is referred to as masking (Fletcher, 1929; Richardson et al., 1995). In humans, masking has been measured as an increase in detection threshold of the sound of interest in the presence of a masking sound (compared to the detection threshold when there is no masker). Two types of masking have been described: energetic masking and informational masking (Pollack, 1975, Watson, 2005, Kidd et al., 2007). The definitions of energetic and informational masking and their physiological mechanisms, however, continue to be debated. Energetic masking is thought to result from an interfering sound(s) within the same critical band(s) as the signal of interest. It is usually ascribed to peripheral acoustic processing; i.e., the ear itself. A definition for informational masking has been even less forthcoming, and as a default position, informational masking has often been taken to mean masking that is greater than would be predicted by energetic masking alone (Kidd et al., 2007). Informational masking is associated with uncertainty of the signal of interest (Watson, 2005) and is generally assumed to occur as a result of central neural processing that includes analytic (e.g., auditory stream segregation and discrimination) and attentive components (e.g., distraction) (Kidd et al., 2007). As a general statement, the more similar the characteristics (i.e., frequency band, duration) of a masking sound are to the sound of interest, the greater its potential for masking.

Acoustic masking from low frequency ocean noise is increasingly being considered as a threat, especially to low frequency hearing specialists such as baleen whales (Clark et al., 2009). Most underwater low frequency anthropogenic noise is generated by commercial shipping, which has contributed to the increase in oceanic background noise over the past 150 years (Parks et al., 2007a). This is discussed in Chapter 3. Shipping noise is primarily in the 20 to 200 Hz frequency band and is increasing yearly (Ross, 2005). Andrew et al. (2002) demonstrated an increase in oceanic ambient noise of 10 dB SPL since 1963 in the 20 to 80 Hz frequency band as sampled on the continental slope off Point Sur, California, and they ascribed this increase to increased commercial shipping. McDonald et al. (2006a) compared data sets from 1964 to 1966 and 2003 to 2004 for continuous measurements west of San Nicolas Island, California, and found an increase in ambient noise levels of 10 to 12 dB SPL in the 30 to 50 Hz band. This increase in LF background noise is likely having a widespread impact on marine mammal low frequency hearing specialists by reducing their access to acoustic information essential for conspecific communication and other biologically important activities, such as navigation and prey/predator detection. Clark et al. (2009) considered this long-term, large-scale increase in low frequency background noise a chronic impact that results in a reduction in communication space, and the loss of acoustic habitat.

Marine Mammal Behavioral Responses to Masking Sounds

Parks et al. (2007a) provided evidence of behavioral changes in the acoustic behaviors of the endangered North Atlantic right whale, and the South Atlantic right whale, and suggested that these were correlated to increased underwater noise levels. The study indicated that right whales might shift the frequency band of their calls to compensate for increased in-band background noise. The significance of their result is the indication of potential species-wide behavioral change in response to gradual, chronic increases in underwater ambient noise. Di Iorio and Clark (2010) showed that blue whale calling rates vary in association with seismic sparker survey activity, with whales calling more on days with survey than on days without surveys. They suggested that the whales called more during seismic survey periods as a way to compensate for the elevated noise conditions.

Changes in behavior are not limited to low frequency species. Holt et al. (2009) measured killer whale call source levels and background noise levels in the 1 to 40 kHz band. The whales increased their call source levels by 1 dB SPL for every 1 dB SPL increase in background noise level. A similar rate of increase in vocalization activity was reported for St. Lawrence River belugas in response to passing vessels (Scheifele et al., 2005).

SURTASS LFA Sonar Potential for Masking

Masking effects from SURTASS LFA sonar signals will be limited for a number of reasons. First, the bandwidth of any LFA sonar transmitted signal is limited (30 Hz), and the instantaneous bandwidth at any given time of the signal is small, on the order of ≤10 Hz. Therefore, within the frequency range in which masking is possible, the effect will be limited because animals that use this frequency range typically use signals with greater bandwidths. Thus, only a portion of frequency band for the animal's signal is likely to be masked by the LFA sonar transmissions. Furthermore, when LFA is in operation, the LFA source is active only 7.5 to 10% of the time (based on historical LFA operational parameters), which means that for 90 to 92.5% of the time there is no risk that an animal's signal will be masked by LFA sonar. Therefore, within the area in which energetic masking is possible, any effect of LFA sonar transmissions will be minimal because of the limited bandwidth and intermittent nature of the signal, and the fact that animals that use this frequency region typically produce signals with greater bandwidth that are repeated for many hours.

Hildebrand (2005) provided a comparison of anthropogenic underwater sound sources by their annual energy output. On an annual basis, four LFA sonar systems were estimated to have a total energy output of 6.8×10^{11} Joules/yr. Seismic airgun arrays and mid-frequency military sonars were two orders of magnitude greater, with an estimated annual output of 3.9 and 2.6×10^{13} Joules/year, respectively. Super tankers were greater at 3.7×10^{12} Joules/year. Hildebrand (2005) concluded that anthropogenic sources most likely to contribute to increased underwater noise in order of importance are: commercial shipping, offshore oil and gas exploration and drilling, and naval and other uses of sonar. The use of LFA sonar is not scheduled to increase beyond the originally analyzed four systems during the next five-year regulation under the MMPA. The percentage of the total anthropogenic acoustic energy budget added by each LFA source is estimated to be 0.21% per system (or less), when other man-made sources are considered (Hildebrand, 2005). When combined with the naturally occurring and other man-made sources of noise in the oceans, the intermittent LFA signals barely contribute a measurable portion of the total acoustic energy.

Conclusions

The recent research reviewed above provides no substantial changes to the knowledge or understanding for the potential of SURTASS LFA sonar to cause acoustic masking in marine mammals that would change the information and conclusions in Subchapter 4.2.7.7 of the FOEIS/EIS and Subchapters 4.3.5, 4.3.6, and 4.6.1.2 of the FSEIS. In fact, these recent studies provide additional support for the statement in the FOEIS/EIS that broadband low frequency shipping noise is likely to be more detrimental than low duty-cycle SURTASS LFA sonar (Andrew et al., 2002; McDonald et al., 2006a; Parks et al., 2007a; Clark et al., 2009). Therefore, the subchapters noted above of the FOEIS/EIS and FSEIS remain valid, and the contents are incorporated by reference herein; any masking in marine mammals due to narrowband, intermittent (low duty cycle) LFA sonar signal transmissions are expected to be minimal and unlikely.

4.3.2.5 Estimation of the Influence of LFA Signal Waveforms

As presented in Chapter 2, the typical LFA signal is not a constant tone, but rather a transmission of various waveforms that vary in frequency and duration. A complete sequence of sound transmissions is referred to as a wavetrain (also known as a "ping"). LFA wavetrains last between 6 and 100 sec with an average length of 60 sec. Within each wavetrain the duration of each continuous frequency sound transmission is no longer than 10 sec. Questions have been raised concerning the characteristics of the transmitted LFA waveform type (i.e., whether the signal is a continuous wave [CW] that is a single frequency, or a frequency-modulated [FM] waveform--one that sweeps through a range of frequencies), could potentially affect marine mammals differently. To date, no specific scientific investigation has been made into this question, and there are no papers that directly compare the results of various waveforms with potential impacts. A review of the discussion in Subchapter 4.3.2 of this document, or Southall et al. (2007), or the numerous published scientific papers on the subject, in general, show that these studies typically use either a CW waveform or a broadband "pulsed" signal as defined in Southall et al. (2007) (i.e., either an airgun, explosive or a source meant to simulate an airgun or explosive).

Even though there have been no definitive studies comparing the potential impacts of various waveforms, it may be possible to estimate their relative potential for impact in some cases. For example, since most physiological impacts (i.e., physical injury, PTS, and TTS) are understood to be directly related to the amount of acoustic energy received and that the severity of the injury increases with increased levels of exposure, it seems probable that auditory impacts for FM waveforms may occur at higher received levels than for CW waveforms because the FM waveforms distribute their energy over a larger frequency band. Thus, any particular frequency-dependent portion of their hearing (e.g., specific frequency bins/regimes or anatomical devices like ear hairs or bones that detect sound in those frequency regimes) may have received less energy in their operational hearing range and therefore have less impact or damage. However, only future testing will confirm this estimation.

For non-physiological impacts such as behavioral or masking effects, the answer is more complex and less clear. In these cases, many factors like: 1) the frequency range of the signal; 2) how the signal's frequency range overlaps with an animal's hearing and transmitted signal ranges; 3) how directional the animal's hearing is at these frequencies; 4) the degree of similarity between the received signal and possible prey species' transmissions; 5) the physical orientation of the situation; and 6) many other factors, can and will affect the level of behavior or masking impacts. Therefore, there is no simple answer to this question for these cases, and depending on the situation, an FM transmission could cause either more or less impact to a marine mammal than a CW waveform.

The Low Frequency Sound Scientific Research Program (LFS SRP) in 1997 and 1998 utilized the commonly used LFA wavetrains with no discernible differences in behavior attributed to differences in waveforms. The LFA analyses are based on the LFA risk continuum, which was derived from the results of the LFS SRP. Therefore, even though the LFA signals will vary within a wavetrain, any differences in potential effects have been accounted for in the risk assessments.

4.3.3 POTENTIAL FOR MORTALITY: MARINE MAMMAL MASS STRANDING AND UNUSUAL MORTALITY EVENTS[19]

Stranding occurs when marine mammals passively (unintentionally) or purposefully come ashore either alive, but debilitated or disoriented, or dead. Although some species of marine mammals, such as pinnipeds, routinely come ashore during all or part of their life history, stranded marine mammals are differentiated by their helplessness ashore and inability to cope with or survive their stranded situation (i.e., they are outside their natural habitat and survival envelope) (Geraci and Lounsbury, 2005). In the U.S., the MMPA defines a stranding as: a) a marine mammal is dead and is (i) on a beach or shore of the U.S.; or (ii) in waters under the jurisdiction of the U.S. (including any navigable waters); or b) a marine mammal is alive and is (i) on a beach or shore of the U.S. and is unable to return to the water; (ii) on a beach or shore of the U.S. and, although able to return to the water, is in need of apparent medical

19 Unusual mortality events (UMEs) are a type of stranding event(s) in which several to hundreds of marine mammals die under unusual circumstances.

attention; or (iii) in the waters under the jurisdiction of the U.S. (including any navigable waters) but is unable to return to its natural habitat under its own power or without assistance (16 U.S. Code §1421h).

Strandings of multiple marine mammals or mass strandings, however, occur only rarely. A mass stranding of marine mammals is the stranding of two or more unrelated cetaceans (i.e., not a mother-calf pair) of the same species coming ashore at the same time and place (Geraci and Lounsbury, 2005). Mass strandings typically involve pelagic odontocete marine mammal species that occur infrequently in coastal waters and are usually typified by highly developed social bonds. Marine mammal strandings and mortality events are natural events that have been recorded historically from as early as 350 B.C. (Aristotle, ca. 350 B.C.), and such events continue to occur throughout the world's oceans.

While anthropogenic factors are responsible for some marine mammal strandings and mortality, the vast majority of causative factors are natural in origin. Mass strandings can rarely be attributed to one cause; instead, it is usually a complex series of conditions, factors, and behaviors that result in marine mammals coming ashore and dying. However, the causes of unusual mortality events (UMEs) are often attributable to one specific factor, such as an algal bloom of toxic-producing phytoplankton, or malnutrition. Even for UMEs, the likelihood of discerning the cause of a mortality event is not a surety. For instance, of the 45 UMEs that occurred in the U.S. over a 17-year period, causes could only be verified for 24 of those events, with most of the identifiable events being caused by biotoxins or infections (NMFS, 2009c).

Over the last four decades, marine mammal stranding networks have become established, and the reporting of marine mammal stranding and mortality events has become better documented and publicized. This has led to increased public awareness and concern, especially regarding the potential for anthropogenic causes of stranding and mortality events. Underwater noise, particularly sounds generated by military sonar or geophysical and geologic seismic exploration, has increasingly been implicated as the plausible cause for marine mammal mortality and stranding events. However, despite extensive and lengthy investigations and continuing scientific research, definitive causes or links are rarely determined for the vast majority of marine mammal mass strandings and UMEs. It is generally more feasible to exclude causes of strandings or UMEs than to resolve the specific causative factors leading to these events. For instance, although no definitive cause could be identified for the mass stranding and death of 26 common dolphins in the Cornwall region of the United Kingdom during 2008, more than 10 factors were excluded or were considered highly unlikely to have caused the stranding (Jepson and Deaville, 2009). More detail on this stranding event follows.

Given the difficulty in correlating causative factors to marine mammal stranding and mortality events, it is imperative that assumptions not be made about the cause of these events prior to thorough investigations and analyses being conducted on all the physical evidence and associated factors. As a result of such scientific investigations and research over the last decade, especially on beaked whales, the scientific understanding has increased regarding the association between behavioral reactions to natural as well as anthropogenic sources and strandings or deaths of marine mammals. Scientists now understand that for some species, particularly deep-diving marine mammals, behavioral reactions may begin a cascade of physiologic effects, such as gas and fat embolisms, that may result in injury, death, and strandings of marine mammals (Fernández et al., 2005; Cox et al., 2006; Zimmer and Tyack, 2007).

Since strandings of individual marine mammals occur routinely around the world, only the more rarely occurring mass stranding events are documented here, particularly those that potentially could be associated with the use of military active sonar. The SURTASS LFA Sonar FSEIS (DoN, 2007a) covered global mass strandings of marine mammals through 2005, and, as such, stranding data through 2005 is incorporated by reference herein. This document covers those global mass stranding events that have occurred from 2006 through early 2010. Although the documentation process for this analysis has endeavored to be as comprehensive as possible, some mass stranding events may have been missed. No worldwide agency, organization, or group compiles or maintains a database of global mass stranding information and some local or regional mass stranding events are probably not well publicized and may have been missed, especially if they occur in remote geographic locations.

Globally from 2006 through early 2010, at least 27 mass strandings of 11 marine mammal species occurred. For this impact assessment, these 27 mass stranding and mortality events were researched and analyzed to substantiate if any occurred within or near SURTASS LFA sonar operating areas, or if any were potentially associated with the transmission of underwater sound from military sonar. Any mass strandings involving beaked whales were also examined, as strandings of this species group have been shown to have a significant correlation with MFA naval sonar activities in some geographic regions (in the Mediterranean and Caribbean Seas but not off the coasts of Japan or Southern California) (Filadelfo et al., 2009). Additionally, marine mammal stranding records from Japan were analyzed for spatial or temporal correlations to LFA sonar operations.

4.3.3.1 Strandings near SURTASS LFA Sonar Operating Areas

2009 Philippines Stranding Events

Of the 27 global, mass stranding events from 2006 through early 2010, only one event occurred near any of the SURTASS LFA sonar operating areas. In February of 2009, as many as 200 melon-headed whales, live and dead, stranded in the shallow waters of the Bataan Peninsula near the mouth of Manila Bay in the Philippines. Few of the stranded whales died, with most surviving after having been refloated and returned to deeper water. Manila Bay and the stranding site are located on the western or South China Sea side of Luzon Island, Philippines. In March 2009, another mass stranding of 100 to 200 live melon-headed whales occurred in the Philippines, off Odiongan in Romblon. Aragones et al. (2010) attributes these mass strandings in the Philippines possibly to the illegal practice of dynamite fishing or to the strong upwelling and longshore currents produced during the northeast monsoon season. Credible informants confirmed that several fishing operations used dynamite to stun pelagic fishes in the deep waters offshore of the Zambales and Bataan provinces the night prior to the February 2009 mass stranding in Bataan (Aragones et al., 2010). The acoustic trauma associated with being in proximity to dynamite blasts in deep water may have resulted in the stranding of the melon-headed whales. Aragones et al., (2010) also found that strandings over an 11-year period in the Philippines peaked during the northeast monsoon season, which occurs from November through March.

Prior to and during the February and March 2009 stranding events, neither of the LFA sonar vessels, which are stationed in the northwestern Pacific, was actively transmitting. The last active LFA sonar transmission prior to the February stranding event occurred in December 2008 in a body of water isolated from the South China Sea.

Japanese Stranding Records

The Natural Museum of Nature and Science (NMNS) of Tokyo supports a database of marine mammal strandings, which provides marine mammal stranding records (only the species and date of strandings), for all Japanese prefectures through 2008 (NMNS, 2009). Although SURTASS LFA sonar vessels do not operate in proximity to Japanese coastal waters, a review of the stranding records from the coastal prefectures that could have potentially been exposed to LFA sonar transmissions was conducted. Sufficient data were not available to perform a quantitative analysis of the Japanese stranding data in conjunction with the dates of LFA sonar transmissions in the region adjacent to Japanese waters, but a qualitative analysis was conducted. Stranding records from 2006 through 2008 for periods of up to seven days following LFA sonar transmissions offshore from Japan were reviewed. The results of this qualitative analysis indicated that no increase in the stranding rate was associated with the periods when LFA sonar transmissions were occurring offshore from eastern Japan compared to periods when LFA sonar was not transmitting. Strandings that occurred during sonar transmissions to seven days after transmissions ceased were no higher than periods when LFA sonar was not transmitting. There were at least nine periods when LFA sonar was transmitting when no strandings occurred. In addition, in some prefectures, only very shallow water species such as finless porpoises ever stranded. These species occur inshore or in coastal waters and are unlikely to be exposed to LFA sonar transmissions.

4.3.3.2 Strandings Possibly Involving Military Sonar or Beaked Whales

Of the 27 mass stranding events that occurred globally from 2006 through early 2010, only two were possibly linked to military sonar transmissions with just one of those events involving beaked whales.

Spain (2006)

On January 26 through 27, 2006, four Cuvier's beaked whales were reported stranded along the southeast coast of Spain near Almeria in the western Mediterranean Sea. Of the four stranded beaked whales, two live-stranded while the remaining two whales were dead when discovered. All the whales ultimately died. Necropsies were performed on all four of the whales. Although the pathologists that conducted the necropsies concluded that anthropogenic acoustic activities were the likely cause of the whales stranding, no pathological results supporting this conclusion were ever presented, and no further documentation has been published.

A North Atlantic Treaty Organization (NATO) surface ship group (seven ships including one U.S. ship under NATO command) conducted active sonar training against a Spanish submarine target from January 25 through 26, 2006 in the Cartagena Exercise Area, which is located within 93 km (50 nmi) of the stranding sites. Although no definitive pathological or causal linkage between the naval exercises and the mass stranding has been documented, it appears likely that a confluence of factors such as: 1) the water depths in which the naval exercises occurred (1,000 m [3,281 ft] with steeply grading slope); 2) the multiple ships equipped with MFA sonar operating in proximity within the same area for a long duration (~20 hrs); and 3) the topography of the area in which deep water is surrounded by land masses that may have caused sound to be directed toward a channel or embayment, cutting off the whales' egress, may have contributed to the strandings of the Cuvier's beaked whales. As presented in Dolman et al. (2010), Fernandez (2006) concluded that the Almeria strandings were similar to previous atypical mass strandings of beaked whales that were spatially and temporally associated with military naval sonar exercises, such as in the Bahamas (2000) and the Canary Islands (2002).

Cornwall, United Kingdom (2008)

On June 9, 2008, 26 common dolphins died after mass stranding in a small tidal tributary, Porth Creek, of the Fal Estuary in Cornwall, southwestern England. An even larger number of common dolphins were refloated and herded back into deeper water. In the days preceding the mass stranding, a large group(s) of dolphins was observed very close to shore. All of the dead stranded dolphins were necropsied; and detailed pathological, histological, and other diagnostic testing was conducted, as was an investigation of the area, environmental conditions, and interviews with witnesses and responders.

An international naval exercise was conducted in the South Coast Exercise Area, located off the south coast of Cornwall, Devon, and Dorset, from 1 through 9 June, 2008 with peak activity on 4 to 5 June. The naval exercise involved up to 20 Royal Navy (United Kingdom) surface and submarine vessels as well as 11 international ships (Jepson and Deaville, 2009). The joint exercise involved the use of several acoustic sources, including MFA (2 to 8 kHz) sonar, standard echosounders, acoustic modems, sonobuoys, high-frequency (100 kHz) side-scan sonar; the firing of inert and live ammunition and at least one SEAWOLF missile; and helicopter and fixed-wing aircraft flights. No helicopter or fixed-wing flights occurred over the area of the mass stranding. The MFA sonars were employed at least 45 to 50 km (24 to 27 nmi) from the stranding location. Approximately 60 hours lapsed between the end of MFA sonar transmissions and the mass stranding event.

The results of the investigation of this mass stranding event were reported by Jepson and Deaville (2009); the pathological and other analysis results were presented with no finding of significant infectious disease, contaminants, biotoxins, or acute physical injury in the dead dolphins. The ears of all the dolphins were normal with no damaged tissue. Jepson and Deaville (2009) concluded that the following potential causes for the stranding could be excluded or were considered highly unlikely to have caused the mass stranding: infectious disease, fat or gas embolisms (decompression sickness), boat strike, fisheries bycatch, predation, feeding unusually close to shore, ingestion of biotoxins or harmful contaminants, abnormal weather conditions, and high-intensity underwater acoustic sound from airguns or earthquakes. While no definitive cause could be identified for the mass stranding event, the investigation did conclude that an adverse behavioral reaction to some specific trigger or stimuli within a group of healthy dolphins resulted in the mass stranding and death of the 26 common dolphins (Jepson and Deaville, 2009). The investigation also noted that the dolphin's unusual proximity to shore prior to the mass stranding, or a combination of factors including errors in navigation and other natural or anthropogenic factors, could have led to an increased risk of stranding. While the investigators did acknowledge that the use of the MFA sonar could have led to the dolphins being closer to shore than normal, they considered it highly unlikely that the MFA sonar directly triggered the mass stranding event (Jepson and Deaville, 2009).

4.3.3.3 Conclusions—Marine Mammal Mass Stranding and Unusual Mortality Events

The use of SURTASS LFA sonar was not associated with any of the reported 27 mass stranding events or UMEs that occurred globally between 2006 and early 2010. There is no evidence that LFA sonar transmissions resulted in any difference in the stranding rates of marine mammals in Japanese coastal waters adjacent to LFA sonar operating areas. As has been reported previously (DoN, 2001 and 2007a) and has been further documented here, the employment of LFA sonar is not expected to result in any sonar-induced strandings of marine mammals. Given the large number of natural factors that can result in marine mammal mortality, the high occurrence of marine mammal strandings, and the many years of LFA sonar operations without any reported associated stranding events, the likelihood of LFA sonar transmissions causing marine mammals to strand is negligible.

4.3.4 Potential Impacts on Marine Mammals—Conclusions

The potential effects from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) are considered negligible, and the potential effects on the stock of any marine mammal from temporary loss of hearing or behavioral change (significant change in a biologically important behavior) are considered minimal. Any auditory masking in marine mammals due to LFA sonar signal transmissions is not expected to be severe and would be temporary. The likelihood of LFA sonar transmissions causing marine mammals to strand is negligible.

4.4 RISK ASSESSMENT OF POTENTIAL IMPACTS ON MARINE MAMMALS FROM SURTASS LFA SONAR OPERATIONS

The goal of the risk assessment is to analyze the proposed action and alternatives for the employment by the U.S. Navy of up to four SURTASS LFA sonar systems for routine training, testing, and military operations in the oceanic areas (see Figure 1-1). Based on current operational requirements, exercises using these sonar systems could occur in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea. These potential operating areas are the same as those assessed in the SURTASS LFA sonar 2001 FOEIS/EIS and 2007 FSEIS (DoN, 2001 and 2007a), except for additional offshore biologically important areas (OBIA). To reduce potential adverse effects on the marine environment, the Navy will use a suite of mitigation measures including: 1) visual, passive acoustic, and active acoustic monitoring; 2) delay/shutdown protocols for LFA transmissions; 3) geographic restrictions to prevent 180-decibel (dB) sound pressure level (SPL) or greater within 22 kilometers (km) (12 nautical miles [nmi]) of land, and in offshore biologically important areas (OBIA) during biologically important seasons; and 4) geographic restrictions to prevent greater than 145-dB SPL at known recreational and commercial dive sites. Mission planning for annual LOA applications will include the identification of marine areas based on updated scientific data and information for SURTASS LFA sonar routine testing, training, and military operations that contribute to the least practicable adverse impacts on marine mammals while meeting National Security requirements.

Risk assessments must provide decision-makers and regulators results that demonstrate:

- Under the MMPA, the total taking will have a negligible impact on the marine mammal species or stock(s), and will not have an unmitigable adverse impact on the availability of species or stock(s) for subsistence uses, consistent with the permissible methods of taking and requirements pertaining to the mitigation, monitoring, and reporting of such takings are set forth in the regulations. This also includes consideration of personnel safety, practicability of implementation, and impact on the effectiveness of military readiness activities.
- Under the ESA, employment of SURTASS LFA sonar is not likely to jeopardize the continued existence of threatened or endangered marine species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat.

Since it was neither reasonable nor practicable to model all areas of the world's oceans in which SURTASS LFA sonar could operate, the initial risk assessment in the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001) analyzed 31 potential operating sites as discussed below.

This initial analytical process was refined to provide sensitivity and risk analyses sufficient to identify and select potential SURTASS LFA sonar mission areas with minimal marine mammal/animal activity consistent with the Navy's operational readiness requirements. These analyses were used to provide NMFS with reasonable and realistic pre- and post-operational risk estimates for marine mammal stocks in the proposed SURTASS LFA sonar operating areas. This process was documented in the SURTASS LFA Sonar FSEIS (DoN, 2007a).

In this supplemental analysis, 19 additional operating sites have been analyzed. These sites were chosen because they represent, based on today's political climate, areas where SURTASS LFA sonar could potentially test, train, or operate during the 5-year period of the next MMPA Rule.

4.4.1 MARINE MAMMAL IMPACT ANALYSIS

As previously discussed in this chapter, the types of potential effects on marine mammals from SURTASS LFA sonar operations include: 1) non-auditory injury; 2) permanent loss of hearing; 3) temporary loss of hearing; 4) behavioral change; and 5) masking. The details of how these potential effects were analyzed and details of the historical precedence and scientific justifications are provided in this chapter and Appendix C.

The first two potential effects listed above (i.e., non-auditory physical effects and permanent loss of hearing) are typically grouped together and constitute "injury effects" or Level A harassments as defined in the MMPA. Based on Southall et al. (2007), and adjusting for the longer LFA signal, the proposed injury criteria for SURTASS LFA sonar is a sound exposure level (SEL) of 197 dB re 1 μPa^2-sec received level (RL) for cetaceans. For pinnipeds in water, this adjusted value is an SEL of 185 dB re 1 μPa^2-sec RL. Note that due to the long duration of the LFA signal (i.e., nominally 60 seconds), the SEL criteria from Southall et al. (2007) is always the dominant of the dual criteria identified there. Additionally, based on simple spherical spreading (i.e., a transmission loss [TL] based on 20×Log10 [range in meters]) and assuming that the LFA array is a point source, a cetacean would need to approach and remain within approximately 33 m (108 ft) of the LFA source array (while a pinniped would need to be within 130 m [427 ft] of the array) for the complete 60 sec of the transmission to exceed the Southall et al. (2007) injury thresholds. Based on the mitigation procedures used during LFA sonar operations, the chances of this occurring are negligible. Therefore, no Level A harassment under the MMPA is expected.

The next two potential effects listed above (temporary loss of hearing and behavioral change) are also typically grouped together and constitute "non-injury or harassment effects" or Level B harassments as defined in the MMPA. The underlying scientific studies and reports that are documented earlier in this chapter show that the potential impacts to marine mammal hearing varies not only from species to species, but may also vary from animal to animal within a species. Thus, the utilization of a risk continuum to attempt to capture the variability of acoustic impacts to a species, as was first done for U.S. Navy environmental compliance documents in the SURTASS LFA FOEIS/EIS (DoN, 2001), has become the standard approach for the U.S. Navy. A description and application of the risk continuum used in this analysis is included in Appendix C. The risk continuum function is a means of predicting the potential impacts associated with acoustic operations on marine mammal species near the operational area of sonar systems. The inputs to the risk continuum are typically the amount of acoustic exposure an animal is likely to receive during the proposed operation. To estimate the risk to marine mammals in each of the 19 potential operation areas, a list of marine mammals likely to be encountered in each region was developed, and abundance and density estimates calculated for each species at each potential SURTASS LFA sonar operating area. To determine the likely acoustic exposure, the movement of animals in the area is modeled, along with the acoustic field generated by the sonar system. Acoustic impact modeling of 19 potential SURTASS LFA sonar-operating areas was conducted for this SEIS/SOEIS, resulting in estimated percent harassment for each stock (Appendix C). The fifth potential effect on marine mammals from SURTASS LFA sonar operations is masking; this topic has been covered previously in Subchapter 4.3.2.4.

4.4.2 INITIAL RISK ASSESSMENT OF POTENTIAL IMPACTS TO MARINE MAMMALS

The initial risk assessment of potential impacts to marine mammals from the operation of SURTASS LFA sonar was detailed in the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001); this detailed analysis covered the major oceanic regions of the world and analyzed 31 acoustic modeling sites (Figure 4.2-1 and Table 4.2-1 of that document). Marine mammal data were developed from the most recent NMFS stock assessment reports at the time and pertinent multinational scientific literature containing marine mammal distribution, abundance, and/or density datasets. The locations were chosen to represent reasonable sites for each of the three major underwater sound propagation regimes where SURTASS LFA sonar could be employed and included:

- Deep water convergence zone (CZ) propagation;
- Near surface duct propagation; and
- Shallow-water bottom interaction propagation.

These sites were selected to model the highest potential (upper bound) for effects from the use of SURTASS LFA sonar, incorporating the following factors:

- Closest plausible proximity to land (from the standpoint of SURTASS LFA sonar operations) where biological densities were higher, and/or were offshore biologically important areas (particularly for animals most likely to be affected);
- Acoustic propagation conditions that allow minimum propagation loss, or TL (i.e., longest acoustic transmission ranges); and
- Time of year selected for maximum animal abundance.

These sites represented the upper bound of effects (both in terms of possible acoustic propagation conditions, and in terms of marine mammal population and density) that could be expected from operation of the SURTASS LFA sonar system. In other words, the analyses of these 31 sites could be considered “worst-case” scenarios. Thus, if SURTASS LFA sonar operations were conducted in an area that was not acoustically modeled in the FOEIS/EIS and was lower in marine mammal abundances and densities, the potential effects would most likely be less than those obtained from the most similar site in the analyses presented. Effectively, these conservative assumptions of the FOEIS/EIS are still valid. Moreover, since there are no new data that contradict any of the assumptions or conclusions made in

Subchapter 4.2 (Potential Impacts on Marine Mammals) of the FOEIS/EIS (DoN, 2001), its contents are incorporated by reference herein.

4.4.3 Sensitivity/Risk Assessment Approach

Under the 2002 MMPA Rule (NOAA, 2002b) and 2007 MMPA Rule (NOAA, 2007c), the Navy was required to apply for initial LOAs and annual renewals of LOAs. In these applications, the Navy projected where it intended to operate for the period of the next annual LOAs and provided NMFS with reasonable and realistic pre-operational risk estimates for marine mammal stocks in the proposed mission areas. The LOA application analytical process for risk assessment was described in the SURTASS LFA Sonar FSEIS (DoN, 2007a). This risk assessment was developed based on the analyses in the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001), the process utilized for the initial annual applications for LOAs, updated literature reviews, and additional underwater acoustical modeling. This sensitivity/risk process utilized a conservative approach by integrating mission planning needs (Navy's training and operational ASW requirements) and a cautious assessment of the limited data available on specific marine mammal populations, and seasonal habitat and activity. Mission areas were analyzed based on current scientific data to determine the potential sensitivity of marine mammals to SURTASS LFA sonar signals and risks to their stocks. Species-specific density and stock abundance estimates were derived for the selected mission areas from current, available published source documentation.

The process starts with the Navy's ASW requirements to be met by SURTASS LFA sonar based on mission areas proposed by the Chief of Naval Operations (CNO) and fleet commands. These mission areas are then reviewed to determine whether they are within or near OBIAs as defined later in this chapter, or known dive sites. If they are, the proposed mission area is changed or revised, and the process is reinitiated. Then, available published data are collected, collated, reduced and analyzed with respect to marine mammal stocks, marine mammal habitat and seasonal activities, and marine mammal behavioral activities. Utilizing the best available scientific data, estimates are made by highly qualified marine biologists, based on known data for like species and/or geographic areas, and known marine mammal seasonal activity. Next, standard acoustic modeling and risk analyses are performed, taking into account spatial, temporal, and/or operational restrictions. Then, standard mitigation is applied and risk estimates for each marine mammal stocks in the proposed mission area are calculated. Based on these estimates, a decision is made as to whether the proposed mission area meets the conditions of the MMPA regulations and LOAs, as issued, on marine mammal/animal impacts from SURTASS LFA sonar. If not, the proposed mission area is changed or refined, and the process is re-initiated. If the mission area risk estimates are below the required restrictions, then the Navy has identified and selected the potential mission area with minimal marine mammal/animal activity consistent with its operational readiness requirements and restrictions placed on LFA operations by NMFS in the regulatory and consultation processes. This sensitivity/risk assessment approach allows the Navy to determine where and when SURTASS LFA sonar can operate and meet the MMPA condition for the least practicable adverse impacts on marine mammals.

Over the 5-year period of the first MMPA Rule, some of the data gaps were filled, reducing the number of assumptions that necessarily must be made during this analytical process. This type of practical analysis clearly demonstrated that the operation of SURTASS LFA sonar systems under annual LOAs satisfied the regulatory requirement to assess environmental risk to marine mammal stocks for the annual LOAs under the first 5-year Rule (2002 to 2007) and the first three annual LOA periods under the 2007 Rule (2007 to 2012). Under the 2007 Rule and LOAs, NMFS has promulgated regulations with conditions to ensure that the incidental taking of marine mammals resulting from SURTASS LFA sonar operations would have negligible impacts on the affected marine mammal species or stocks. The Navy uses these regulations and conditions as guides in mission planning and annual LOA applications.

The Navy is required under the conditions of the 2007 5-year Rule and LOAs to submit classified quarterly mission reports for each SURTASS LFA sonar vessel for missions completed during the quarter in which active LFA transmissions are employed. The required elements for these reports include estimates of the percentage of marine mammal stocks affected (both for the quarter and cumulative for the year covered by the LOAs) by SURTASS LFA sonar operations based on predictive modeling, and actual operating locations, dates/times of operations, system characteristics, oceanographic environmental conditions, and animal demographics. The total annual risks for potentially affected stocks of marine mammal species are estimated by summing a particular species' risk estimates within each stock, across mission areas, for all vessels combined and are submitted to NMFS in annual unclassified reports (DoN, 2008, 2009b, and 2010). For the first three LOAs under the 2007 rule, these risk estimates have met the regulations and conditions of the LOAs (Tables 4-1, 4-2, and 4-3).

4.4.4 SUPPLEMENTAL RISK ASSESSMENTS

The sensitivity/risk process, discussed above, utilizes a conservative approach by integrating mission planning needs (Navy's training and operational ASW requirements) and a cautious assessment of the limited data available on specific marine mammal populations, and seasonal habitat and activity. In this supplemental analysis, 19 additional operating sites have been analyzed using the most up-to-date marine mammal abundance, density, and behavioral information available (Table 4-4). These sites were chosen because they represent, based on today's political climate, areas where SURTASS LFA sonar could potentially test, train, or operate. This analysis will provide updated modeling for the 11 sites under the current LOAs and eight additional sites, which could be requested for LOAs under the next 5-year Rule because they are in areas of potential strategic importance and/or areas of possible Fleet exercises.

The Navy and NMFS have agreed that the Navy will use the same risk continuum function for estimating acoustic impacts in this document that was used in the Final EIS/OEIS and Final SEIS for SURTASS LFA sonar (DoN, 2001, 2007a). The inputs to the risk continuum are typically the amount of acoustic exposure an animal is likely to receive during the proposed operation. To determine the likely acoustic exposure, the movements of animals in the area are modeled along with the acoustic fields generated by the sonar systems (Appendix C).

The Acoustic Integration Model© (AIM) was used to simulate and integrate potential acoustic effects of SURTASS LFA sonar operations. The sound fields produced by the LFA source in the different areas were modeled based on the system's specifications (i.e., source level, frequency, and location of the sonar system). Details of the physical acoustic environment as well as details of marine species' presence and their movement come from numerous sources (see Appendix C). AIM convolves the sound field data generated by an acoustic model with animal movement data generated from an animal movement engine. The result is an exposure history for each simulated animal (animat); i.e., as if each animal was fitted with an "acoustic dosimeter." These exposure data for individually modeled animats are then scaled and summed to predict the risk of impact for each animal species.

Estimates of the percentage of marine mammal stocks affected by SURTASS LFA sonar operations in the 19 potential operating areas, for the seasons specified, have been derived for this document (Tables 4-5 through 4-23). The estimated stock values support the conclusion that estimates of potential effects to marine mammal stocks are below the conditions delineated by NMFS in the LOAs issued under the 2007 Final Rule.

Table 4-1. Post-operational estimates of marine mammal stocks potentially affected by operation of SURTASS LFA sonar in all mission areas—totals for 1st year LOAs; ESA-listed species indicated by gray highlighting.

LOA 1—R/V *CORY CHOUEST* & USNS IMPECCABLE				
Marine Mammal Species (Seasonal Occurrence)	Stock	Number Animals in Stock	% Stock Affected (w/ MIT[20]) 120 to 180 dB	% Stock Affected (w/ MIT) ≥180 dB
			Annual Total	Annual Total
Fin whale	N. Pacific	9,250	0.57	0.00
Bryde's whale	Western N. Pacific	22,000	0.71	0.00
Common minke whale	Western N. Pacific	25,049	5.17	0.00
North Pacific right whale (Spring/Fall/Winter)	Western N. Pacific	922	0.17	0.00
Humpback whale (Winter only)	Western N. Pacific	394	1.48	0.00
Gray whale (Winter only)	Western N. Pacific	100	0.00	0.00
Sperm whale	N. Pacific	102,112	0.15	0.00
Kogia spp.	N. Pacific	350,553	0.09	0.00
Cuvier's beaked whale	N. Pacific	90,725	0.06	0.00
Blainville's beaked whale	N. Pacific	8,032	1.00	0.00
Ginkgo-toothed beaked whale	N. Pacific	22,799	0.37	0.00
Killer whale	Western N. Pacific	12,256	0.01	0.00
False killer whale	Western N. Pacific	16,668	2.67	0.00
False killer whale	Inshore Archipelago	9,777	0.69	0.00
Pygmy killer whale	Western N. Pacific	30,214	1.28	0.00
Melon-headed whale	Western N. Pacific	36,770	1.30	0.00
Short-finned pilot whale	Western N. Pacific	53,608	2.69	0.00
Risso's dolphin	Western N. Pacific	83,289	3.05	0.00
Common dolphin	Western N. Pacific	3,286,163	0.42	0.00
Bottlenose dolphin	Western N. Pacific	168,791	1.37	0.00
Bottlenose dolphin	Inshore Archipelago	105,138	0.70	0.00
Spinner dolphin	Western N. Pacific	1,015,059	0.01	0.00
Pantropical spotted dolphin	Western N. Pacific	438,064	0.78	0.00
Striped dolphin	Western N. Pacific	570,038	0.64	0.00
Rough-toothed dolphin	Western N. Pacific	145,729	0.84	0.00
Fraser's dolphin	Western N. Pacific	220,789	0.41	0.00
Pacific white-sided dolphin	Western N. Pacific	931,000	0.46	0.00

20 With mitigation measures applied

Table 4-2. Post-operational estimates of marine mammal stocks potentially affected by operation of SURTASS LFA sonar in all mission areas—totals for 2nd year LOAs; ESA-listed species indicated by gray highlighting.

LOA 2—USNS ABLE & USNS IMPECCABLE				
Marine Mammal Species (Seasonal Occurrence	Stock	Number Animals in Stock	% Stock Affected (w/ mit[20]) 120 to 180 dB	% Stock Affected (w/mit) ≥180 dB
			Annual Total	Annual Total
Blue whale	Western N. Pacific	1,548	0.33	0.00
Fin whale	N. Pacific	9,250	0.03	0.00
Fin whale	Hawaii	2,099	0.86	0.00
Bryde's whale	Western N. Pacific	22,000	0.17	0.00
Bryde's whale	Hawaii	469	1.09	0.00
Common minke whale	Western N. Pacific	25,049	1.00	0.00
Common minke whale	Hawaii	25,000	0.02	0.00
N. Pacific right whale (Spring/Fall/Winter)	Western N. Pacific	922	0.05	0.00
Humpback whale (Winter only)	Western N. Pacific	394	0.00	0.00
Gray whale (Winter only)	Western N. Pacific	100	0.00	0.00
Sperm whale	N. Pacific	102,112	0.06	0.00
Sperm whale	Hawaii	6,919	0.54	0.00
Kogia spp.	N. Pacific	350,553	0.01	0.00
Kogia spp.	Hawaii	24,657	0.54	0.00
Cuvier's beaked whale	N. Pacific	90,725	0.15	0.00
Cuvier's beaked whale	Hawaii	15,242	0.54	0.00
Longman's beaked whale	Hawaii	1,007	0.53	0.00
Blainville's beaked whale	N. Pacific	8,032	0.19	0.00
Blainville's beaked whale	Hawaii	2,872	0.54	0.00
Ginkgo-toothed beaked whale	N. Pacific	22,799	0.06	0.00
Killer whale	Western N. Pacific	12,256	0.08	0.00
Killer whale	Hawaii	349	0.56	0.00
False killer whale	Western N. Pacific	16,668	0.53	0.00
False killer whale	Inshore Archipelago	9,777	0.03	0.00
False killer whale	Hawaii	236	0.83	0.00
Pygmy killer whale	Western N. Pacific	30,214	0.22	0.00
Pygmy killer whale	Hawaii	956	0.82	0.00
Melon-headed whale	Western N. Pacific	36,770	0.12	0.00
Melon-headed whale	Hawaii	2,950	0.80	0.00
Short-finned pilot whale	Western N. Pacific	53,608	0.78	0.00
Short-finned pilot whale	Hawaii	8,870	0.80	0.00
Risso's dolphin	Western N. Pacific	83,289	0.51	0.00
Risso's dolphin	Hawaii	2,372	1.06	0.00
Common dolphin	Western N. Pacific	3,286,163	0.06	0.00
Bottlenose dolphin	Western N. Pacific	168,791	0.33	0.00

Table 4-2. Post-operational estimates of marine mammal stocks potentially affected by operation of SURTASS LFA sonar in all mission areas—totals for 2nd year LOAs; ESA-listed species indicated by gray highlighting.

LOA 2—USNS ABLE & USNS IMPECCABLE				
Marine Mammal Species (Seasonal Occurrence	**Stock**	**Number Animals in Stock**	**% Stock Affected (w/ mit[20]) 120 to 180 dB**	**% Stock Affected (w/mit) ≥180 dB**
			Annual Total	**Annual Total**
Bottlenose dolphin	Inshore Archipelago	105,138	0.05	0.00
Bottlenose dolphin	Hawaii	3,215	1.02	0.00
Spinner dolphin	Western N. Pacific	1,015,059	0.09	0.00
Spinner dolphin	Hawaii	3351	0.98	0.00
Pantropical spotted dolphin	Western N. Pacific	438,064	0.12	0.00
Pantropical spotted dolphin	Hawaii	8,978	0.98	0.00
Striped dolphin	Western N. Pacific	570,038	0.18	0.00
Striped dolphin	Hawaii	13,143	0.98	0.00
Rough-toothed dolphin	Western N. Pacific	145,729	0.13	0.00
Rough-toothed dolphin	Hawaii	8,709	0.98	0.00
Fraser's dolphin	Western N. Pacific	220,789	0. 07	0.00
Fraser's dolphin	Hawaii	10,226	0. 99	0.00
Pacific White-sided dolphin	Western N. Pacific	931,000	0.05	0.00
Hawaiian monk seal	Hawaii	1,302	0.24	0.00

Table 4-3. Post-operational estimates of marine mammal stocks potentially affected by the operation of SURTASS LFA sonar in all mission areas—totals for 3rd year LOAs; ESA-listed species indicated by gray highlighting.

LOA 3—USNS ABLE & USNS IMPECCABLE				
Marine Mammal Species (Seasonal Occurrence	**Stock**	**Number Animals in Stock**	**% Stock Affected (w/ mit[20]) 120 to 180 dB**	**% Stock Affected (w/ mit) ≥180 dB**
			Annual Total	**Annual Total**
Blue whale	North (N.) Pacific	9,250	0.03	0.00
Fin whale	N. Pacific	9,250	0.17	0.00
Sei whale	N Pacific	8,600	0.10	0.00
Bryde's whale	Western N. Pacific	22,000	0.30	0.00
Common minke whale	Western N. Pacific	25,049	1.72	0.00
N. Pacific right whale (spring/fall/winter)	Western N. Pacific	922	0.06	0.00
Humpback whale (Winter only)	Western N. Pacific	394	1.78	0.00
Sperm whale	N. Pacific	102,112	0.15	0.00
Kogia spp.	N. Pacific	350,553	0.06	0.00
Baird's beaked whale	Western N. Pacific	8,000	0.26	0.00
Baird's beaked whale	Western N. Pacific	8,000	0.26	0.00
Cuvier's beaked whale	N. Pacific	90,725	0.25	0.00
Blainville's beaked whale	N. Pacific	8,032	0.52	0.00
Ginkgo-toothed beaked whale	N. Pacific	22,799	0.20	0.00
Hubbs' beaked whale	N. Pacific	22,799	0.02	0.00
Killer whale	Western N. Pacific	12,256	0.11	0.00
False killer whale	Western N. Pacific	16,668	1.79	0.00
Pygmy killer whale	Western N. Pacific	30,214	0.71	0.00
Melon-headed whale	Western N. Pacific	36,770	0.30	0.00
Short-finned pilot whale	Western N. Pacific	53,608	2.02	0.00
Risso's dolphin	Western N. Pacific	83,289	1.57	0.00
Common dolphin	Western N. Pacific	3,286,163	0.20	0.00
Bottlenose dolphin	Western N. Pacific	168,791	1.09	0.00
Spinner dolphin	Western N. Pacific	1,015,059	0.00	0.00
Pantropical spotted dolphin	Western N. Pacific	438,064	0.39	0.00
Striped dolphin	Western N. Pacific	570,038	0.43	0.00
Rough-toothed dolphin	Western N. Pacific	145,729	0.47	0.00
Fraser's dolphin	Western N. Pacific	220,789	0. 22	0.00
Pacific white-sided dolphin	Western N. Pacific	931,000	0.24	0.00

Table 4-4. Potential SURTASS LFA sonar operating areas (OPAREAs), location, and representative season that were modeled for this SEIS/OEIS.

OPAREA	SITE	MODELED SEASON	LOCATION (LATITUDE/ LONGITUDE)	REMARKS
1	East of Japan	Summer	38°N/148°E	
2	North Philippine Sea	Fall	29°N/136°E	
3	West Philippine Sea	Fall	22°N/124°E	
4	Offshore Guam	Summer / Fall	11°N/145°E	Mariana Islands Range Complex (outside Mariana Trench)
5	Sea of Japan	Fall	39°N/132°E	
6	East China Sea	Summer	26°N/125°E	
7	South China Sea	Fall	21°N/119°E	
8	NW Pacific 25° to 40°N	Summer	30°N/165°E	
9	NW Pacific 10° to 25°N	Winter	15°N/165°E	
10	Hawaii North	Summer	25°N/158°W	Hawaii Range Complex
11	Hawaii South	Spring/Fall	19.5°N/158.5°W	Hawaii Range Complex
12	Offshore Southern California	Spring	32°N/120°W	SOCAL Range Complex
13	Western Atlantic (off Florida)	Winter	30°N/78°W	AFAST Study Area (Jacksonville OPAREA)
14	Eastern N Atlantic	Summer	56.5°N/10°W	NW Approaches
15	Mediterranean Sea—Ligurian Sea	Summer	43°N/8°E	
16	Arabian Sea	Summer	20°N/65°E	
17	Andaman Sea	Summer	7.5°N/96°E	Approaches to Strait of Malacca
18	Panama Canal	Winter	5°N/81°W	Western Approach
19	Northeast Australian Coast	Spring	23°S/155°E	

Table 4-5. Estimates of the percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 1, East of Japan, summer season; ESA-listed species highlighted.

OPAREA 1—East of Japan			
Marine Mammal Species	**Number Animals in Stock**	**% Stock Affected <180 dB**	**% Stock Affected (with mitigation) ≥180 dB**
Blue whale	9,250	0.0182	0.0000
Fin whale	9,250	0.0221	0.0000
Sei whale	8,600	0.0661	0.0000
Bryde's whale	20,501	0.0277	0.0000
Common minke whale	25,049	0.0566	0.0000
North Pacific right whale (Spring/Fall)	922	< 0.0001	0.0000
Sperm whale	102,112	0.0060	0.0000
Kogia spp.	350,553	0.0079	0.0000
Baird's beaked whale	8,000	0.2603	0.0000
Cuvier's beaked whale	90,725	0.0427	0.0000
Gingko-toothed beaked whale	22,799	0.0157	0.0000
Hubbs' beaked whale	22,799	0.0157	0.0000
False killer whale	16,668	0.1916	0.0000
Pygmy killer whale	30,214	0.0617	0.0000
Short-finned pilot whale	53,608	0.2170	0.0000
Risso's dolphin	83,289	0.1138	0.0000
Common dolphin	3,286,163	0.0212	0.0000
Bottlenose dolphin[21]	168,791	0.0823	0.0000
Spinner dolphin	1,015,059	0.0002	0.0000
Pantropical spotted dolphin	438,064	0.0180	0.0000
Striped dolphin	570,038	0.0059	0.0000
Rough-toothed dolphin	145,729	0.0346	0.0000
Fraser's dolphin	220,789	0.0153	0.0000
Pacific white-sided dolphin	931,000	0.0070	0.0000

21 Until recently, the genus *Tursiops* was considered monospecific, but a second species (the Indo-Pacific bottlenose dolphin, *Tursiops aduncus*) is now also recognized (Rice, 1998). Indo-Pacific bottlenose dolphins generally occur over shallow coastal waters on the continental shelf or around oceanic islands. Their presence has primarily been documented in estuarine and near-coastal waters that are not likely to overlap with SURTASS LFA sonar operations. Without further information on the composition of bottlenose dolphins at the sites modeled for this document, the model results should be considered as potential impacts to *Tursiops* spp. in general.

Table 4-6. Estimates of the percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 2, North Philippine Sea, fall season; ESA-listed species highlighted.

OPAREA 2—NORTH PHILIPPINE SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Bryde's whale	20,501	0.0339	0.0000
Common minke whale	25,049	0.4023	0.0000
North Pacific right whale (Spring/Fall/Winter)	922	0.0055	0.0000
Sperm whale	102,112	0.0454	0.0000
Kogia spp.	350,553	0.0265	0.0000
Cuvier's beaked whale	90,725	0.0534	0.0000
Blainville's beaked whale	8,032	0.0559	0.0000
Gingko-toothed beaked whale	22,799	0.0197	0.0000
Killer whale	12,256	0.0379	0.0000
False killer whale	16,668	0.2123	0.0000
Pygmy killer whale	30,214	0.0848	0.0000
Melon-headed whale	36,770	0.0398	0.0000
Short-finned pilot whale	53,608	0.5137	0.0000
Risso's dolphin	83,289	0.3337	0.0000
Common dolphin	3,286,163	0.0168	0.0000
Bottlenose dolphin[21]	168,791	0.0548	0.0000
Spinner dolphin	1,015,059	0.0007	0.0000
Pantropical spotted dolphin	438,064	0.0429	0.0000
Striped dolphin	570,038	0.0792	0.0000
Rough-toothed dolphin	145,729	0.1109	0.0000
Fraser's dolphin	220,789	0.0411	0.0000
Pacific white-sided dolphin	931,000	0.0176	0.0000

Table 4-7. Estimates of the percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 3, West Philippine Sea, fall season; ESA-listed species highlighted.

OPAREA 3—WEST PHILIPPINE SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Fin whale	9,250	0.0492	0.0000
Bryde's whale	20,501	0.0653	0.0000
Common minke whale	25,049	0.1880	0.0000
Humpback whale (Winter only)	1,107	< 0.0001	0.0000
Sperm whale	102,112	0.0105	0.0000
Kogia spp.	350,553	0.0099	0.0000
Cuvier's beaked whale	90,725	0.0042	0.0000
Blainville's beaked whale	8,032	0.0797	0.0000
Gingko-toothed beaked whale	22,799	0.0281	0.0000
False killer whale	16,668	0.2610	0.0000
Pygmy killer whale	30,214	0.1043	0.0000
Melon-headed whale	36,770	0.0490	0.0000
Short-finned pilot whale	53,608	0.1348	0.0000
Risso's dolphin	83,289	0.2284	0.0000
Common dolphin	3,286,163	0.0325	0.0000
Bottlenose dolphin[21]	168,791	0.0927	0.0000
Spinner dolphin	1,015,059	0.0004	0.0000
Pantropical spotted dolphin	438,064	0.0230	0.0000
Striped dolphin	570,038	0.0212	0.0000
Rough-toothed dolphin	145,729	0.0769	0.0000
Fraser's dolphin	220,789	0.0284	0.0000
Pacific white-sided dolphin	931,000	0.0211	0.0000

Table 4-8. Estimates of the percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 4, Offshore Guam, summer and fall seasons; ESA-listed species highlighted.

OPAREA 4—OFFSHORE GUAM					
		SUMMER	SUMMER	FALL	FALL
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (W/ MITIGATION) ≥180 DB	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (W/ MITIGATION) ≥180 DB
Blue whale	2,842	0.0377	0.0000	0.0338	0.0000
Fin whale	9,250	0.0376	0.0000	0.0354	0.0000
Sei whale	8,600	0.0331	0.0000	0.0330	0.0000
Bryde's whale	20,501	0.0183	0.0000	0.0197	0.0000
Common minke whale	25,049	0.0110	0.0000	0.0104	0.0000
Humpback whale (October to May)	10,103	<0.0001	0.0000	<0.0001	0.0000
Sperm whale	102,112	0.0105	0.0000	0.0104	0.0000
Kogia spp.	350,553	0.0373	0.0000	0.0315	0.0000
Cuvier's beaked whale	90,725	0.0690	0.0000	0.0679	0.0000
Longman's beaked whale	1,007	0.4112	0.0000	0.4043	0.0000
Blainville's beaked whale	8,032	0.1471	0.0000	0.1446	0.0000
Ginkgo-toothed beaked whale	22,799	0.0222	0.0000	0.0218	0.0000
Killer whale	349	0.4894	0.0000	0.4372	0.0000
False killer whale	16,668	0.0699	0.0000	0.0440	0.0000
Pygmy killer whale	30,214	0.0049	0.0000	0.0031	0.0000
Melon-headed whale	36,770	0.1222	0.0000	0.0769	0.0000
Short-finned pilot whale	53,608	0.0350	0.0000	0.0205	0.0000
Risso's dolphin	83,289	0.0141	0.0000	0.0125	0.0000
Common dolphin	3,286,163	0.0007	0.0000	0.0006	0.0000
Bottlenose dolphin[21]	168,791	0.0013	0.0000	0.0009	0.0000
Spinner dolphin	1,015,059	0.0027	0.0000	0.0025	0.0000
Pantropical spotted dolphin	438,064	0.0444	0.0000	0.0417	0.0000
Striped dolphin	570,038	0.0093	0.0000	0.0087	0.0000
Rough-toothed dolphin	145729	0.0022	0.0000	0.0021	0.0000
Fraser's dolphin	10,226	0.411	0.0000	0.3780	0.0000

Table 4-9. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 5, Sea of Japan, fall season; ESA-listed species highlighted.

OPAREA 5—SEA OF JAPAN			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Fin whale	9,250	0.2345	0.0000
Bryde's whale	20,501	0.0104	0.0000
Common minke whale	25,049	0.0291	0.0000
Common minke whale—J Stock	893	0.3261	0.0000
North Pacific right whale (Spring/Fall/Winter)	922	0.0255	0.0000
Gray whale	121	0.0011	0.0000
Sperm whale	102,112	0.0206	0.0000
Stejneger's beaked whale	8,000	0.5023	0.0000
Baird's beaked Whale	8,000	0.1076	0.0000
Cuvier's beaked Whale	90,725	0.1360	0.0000
Gingko-toothed beaked whale	22,799	0.0629	0.0000
False killer whale	9,777	0.8202	0.0000
Melon-headed whale	36,770	0.0008	0.0000
Short-finned pilot whale	53,608	0.0303	0.0000
Risso's dolphin	83,289	0.2121	0.0000
Common dolphin	3,286,163	0.0529	0.0000
Bottlenose dolphin[21]	105,138	0.0134	0.0000
Spinner dolphin	1,015,059	< 0.0001	0.0000
Pantropical spotted dolphin	219,032	0.0632	0.0000
Pacific white-sided dolphin	931,000	0.0040	0.0000
Dall's porpoise	76,720	0.9218	0.0000

Table 4-10. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 6, East China Sea, summer season; ESA-listed species highlighted.

OPAREA 6—EAST CHINA SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 dB	% STOCK AFFECTED (WITH MITIGATION) ≥180 dB
Fin whale	500	0.6200	0.0000
Bryde's whale	20,501	0.0357	0.0000
Common minke whale	25,049	0.2284	0.0000
Common minke whale—J Stock	893	2.6204	0.0000
North Pacific right whale (Winter)	922	< 0.0001	0.0000
Gray whale (Winter only)	121	< 0.0001	0.0000
Sperm whale	102,112	0.0092	0.0000
Kogia spp.	350,553	0.0056	0.0000
Cuvier's beaked whale	90,725	0.0719	0.0000
Blainville's beaked	8,032	0.1530	0.0000
Ginkgo-toothed beaked whale	22,799	0.0230	0.0000
False killer whale	9,777	0.1703	0.0000
Pygmy killer whale	30,214	0.0070	0.0000
Melon-headed whale	36,770	0.1746	0.0000
Short-finned pilot whale	53,608	0.0498	0.0000
Risso's dolphin	83,289	0.1833	0.0000
Common dolphin	3,286,163	0.0202	0.0000
Bottlenose dolphin[21]	105,138	0.0967	0.0000
Spinner dolphin	1,015,059	0.0036	0.0000
Pantropical spotted dolphin	219,032	0.0728	0.0000
Striped dolphin	570,038	0.0334	0.0000
Rough-toothed dolphin	145,729	0.0518	0.0000
Fraser's dolphin	220,789	0.0252	0.0000
Pacific white-sided dolphin	931,000	0.0041	0.0000

Table 4-11. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 7, South China Sea, fall season; ESA-listed species highlighted.

OPAREA 7—SOUTH CHINA SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Fin whale	9,250	0.0352	0.0000
Bryde's whale	20,501	0.0416	0.0000
Common minke whale	25,049	0.1713	0.0000
North Pacific right whale (Winter)	922	<0.0001	0.0000
Gray whale (Winter only)	121	<0.0001	0.0000
Sperm whale	102,112	0.0125	0.0000
Kogia spp.	350,553	0.0087	0.0000
Cuvier's beaked whale	90,725	0.0042	0.0000
Blainville's beaked whale	8,032	0.0782	0.0000
Gingko-toothed beaked whale	22,799	0.0276	0.0000
False killer whale	9,777	0.1873	0.0000
Pygmy killer whale	30,214	0.0076	0.0000
Melon-headed whale	36,770	0.1921	0.0000
Short-finned pilot whale	53,608	0.0415	0.0000
Risso's dolphin	83,289	0.2074	0.0000
Common dolphin	3,286,163	0.0210	0.0000
Bottlenose dolphin[21]	105,138	0.0796	0.0000
Spinner dolphin	1,015,059	0.3186	0.0000
Pantropical spotted dolphin	219,032	0.0646	0.0000
Striped dolphin	570,038	0.0296	0.0000
Rough-toothed dolphin	145,729	0.0467	0.0000
Fraser's dolphin	220,789	0.0257	0.0000

Table 4-12. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 8, northwest Pacific Ocean (from 25ºN to 40ºN), summer season; ESA-listed species highlighted.

OPAREA 8—NW PACIFIC (25ºN TO 40ºN)			
MARINE MAMMAL SPECIES	**NUMBER ANIMALS IN STOCK**	**% STOCK AFFECTED <180 DB**	**% STOCK AFFECTED (WITH MITIGATION) ≥180 DB**
Blue whale	9,250	0.1064	0.0000
Fin whale	9,250	0.0532	0.0000
Sei whale	37,000	0.0400	0.0000
Bryde's whale	20,501	0.1020	0.0000
Common minke whale	25,049	0.0465	0.0000
Sperm whale	102,112	0.0054	0.0000
Kogia spp.	350,553	0.0587	0.0000
Baird's beaked whale	8,000	0.0283	0.0000
Cuvier's beaked whale	90,725	0.0423	0.0000
Mesoplodon spp	22,799	0.0711	0.0000
False killer whale	16,668	0.6998	0.0000
Pygmy killer whale	30,214	0.0150	0.0000
Melon-headed whale	36,770	0.1057	0.0000
Short-finned pilot whale	53,608	0.0014	0.0000
Risso's dolphin	83,289	0.0418	0.0000
Common dolphin	3,286,163	0.1140	0.0000
Bottlenose dolphin	168,791	0.0086	0.0000
Spinner dolphin	1,015,059	< 0.0001	0.0000
Pantropical spotted dolphin	438,064	0.0696	0.0000
Striped dolphin	570,038	0.1477	0.0000
Rough-toothed dolphin	145,729	0.0076	0.0000
Pacific white-sided dolphin	67,769	0.1544	0.0000
Hawaiian monk seal	1,129	0.0278	0.0000

Table 4-13. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 9, northwest Pacific Ocean, summer season; ESA-listed species highlighted.

OPAREA 9—NW PACIFIC (10°N TO 25°N)			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 dB	% STOCK AFFECTED (WITH MITIGATION) ≥180 dB
Bryde's whale	20,501	0.0309	0.0000
Sperm whale	102,112	0.0034	0.0000
Kogia spp.	350,553	0.0044	0.0000
Cuvier's beaked whale	90,725	0.0197	0.0000
False killer whale	16,668	0.1965	0.0000
Melon-headed whale	36,770	0.0509	0.0000
Short-finned pilot whale	53,608	0.0373	0.0000
Risso's dolphin	83,289	0.0478	0.0000
Common dolphin	3,286,163	0.0475	0.0000
Bottlenose dolphin[21]	168,791	0.0074	0.0000
Spinner dolphin	1,015,059	0.0054	0.0000
Pantropical spotted dolphin	438,064	0.0908	0.0000
Striped dolphin	570,038	0.0340	0.0000
Rough-toothed dolphin	145,729	0.0027	0.0000

Table 4-14. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 10, Hawaii North, summer season; ESA-listed species highlighted.

OPAREA 10—Hawaii North (25°N, 158° W)			
Marine Mammal Species	**Number Animals in Stock**	**% Stock Affected <180 dB**	**% Stock Affected (with mitigation) ≥180 dB**
Blue whale	1,548	0.2295	0.0000
Fin whale	2,099	0.9338	0.0000
Bryde's whale	469	1.1855	0.0000
Common minke whale	25,000	0.0128	0.0000
Humpback whale (Summer)	10,103	< 0.0001	0.0000
Sperm whale	6,919	0.5258	0.0000
Kogia spp.	24,657	1.0271	0.0000
Cuvier's beaked whale	15,242	0.6698	0.0000
Longman's beaked whale	1,007	0.6530	0.0000
Blainville's beaked	2,872	0.6697	0.0000
Killer whale	349	0.7851	0.0000
False killer whale (pelagic)	484	0.8760	0.0000
False killer whale (insular)	123	3.4472	0.0000
Pygmy killer whale	956	0.8870	0.0000
Melon-headed whale	2,950	0.8624	0.0000
Short-finned pilot whale	8,870	0.3718	0.0000
Risso's dolphin	2,372	0.9106	0.0000
Bottlenose dolphin	3,215	0.5087	0.0000
Spinner dolphin	3,351	0.2347	0.0000
Pantropical spotted dolphin	8,978	0.2340	0.0000
Striped dolphin	13,143	0.2341	0.0000
Rough-toothed dolphin	8,709	0.9375	0.0000
Fraser's dolphin	10,226	0.7590	0.0000
Hawaiian monk seal	1,129	0.1435	0.0000

Table 4-15. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 11, Hawaii South, spring and fall seasons; ESA-listed species highlighted.

OPAREA 11—HAWAII SOUTH (19.5°N 158.5°W)			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Blue whale	1548	0.1288	0.0000
Fin whale	2099	0.4369	0.0000
Bryde's whale	469	0.5544	0.0000
Common minke whale	25000	0.0078	0.0000
Humpback whale (not summer)	10103	0.0003	0.0000
Sperm whale	6919	0.3391	0.0000
Kogia spp.	24657	0.5217	0.0000
Cuvier's beaked whale	15242	0.3985	0.0000
Longman's beaked whale	1007	0.3885	0.0000
Blainville's beaked	2872	0.3984	0.0000
Killer whale	349	0.3811	0.0000
False killer whale (pelagic)	484	0.4628	0.0000
False killer whale (insular)	123	1.8211	0.0000
Pygmy killer whale	956	0.4686	0.0000
Melon-headed whale	2950	0.4556	0.0000
Short-finned pilot whale	8870	0.3527	0.0000
Risso's dolphin	2372	0.4764	0.0000
Bottlenose dolphin	3215	0.3514	0.0000
Spinner dolphin	3351	0.2935	0.0000
Pantropical spotted dolphin	8978	0.2927	0.0000
Striped dolphin	13143	0.2928	0.0000
Rough-toothed dolphin	8709	0.4932	0.0000
Fraser's dolphin	10226	0.4037	0.0000
Hawaiian monk seal	1129	0.1010	0.0000

Table 4-16. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 12, Offshore Southern California, spring season; ESA-listed species highlighted.

OPAREA 12—Offshore Southern California			
MARINE MAMMAL SPECIES	**NUMBER ANIMALS IN STOCK**	**% STOCK AFFECTED <180 DB**	**% STOCK AFFECTED (WITH MITIGATION) ≥180 DB**
Blue whale	2,842	0.8374	0.0000
Fin whale	2,099	2.2178	0.0000
Sei whale	98	1.9876	0.0000
Bryde's whale	13,000	0.0013	0.0000
Common minke whale	823	1.2685	0.0000
Humpback whale	942	1.0485	0.0000
Gray whale	18,813	0.0352	0.0000
Sperm whale	1,934	1.9354	0.0000
Stejneger's beaked whale	1,177	1.9427	0.0000
Baird's beaked whale	1,005	1.9439	0.0000
Cuvier's beaked whale	4,342	1.9531	0.0000
Longman's beaked whale	1,177	1.9427	0.0000
Blainville's beaked whale	1,177	1.9427	0.0000
Ginkgo-toothed beaked whale	1,177	1.9427	0.0000
Hubb's beaked whale	1,177	1.9427	0.0000
Perrin's beaked whale	1,177	1.9427	0.0000
Pygmy beaked whale	1,177	1.9427	0.0000
Killer whale	810	1.9898	0.0000
Pygmy sperm whale	1,237	2.5818	0.0000
Short-finned pilot whale	350	1.5433	0.0000
Risso's dolphin	11,910	2.3572	0.0000
Long-beaked common dolphin	21,902	1.8887	0.0000
Short-beaked common dolphin	352,069	1.8891	0.0000
Bottlenose dolphin	2,026	1.4497	0.0000
Striped dolphin	18,976	1.0087	0.0000
Pacific white-sided dolphin	23,817	1.0370	0.0000
Northern right whale dolphin	11,097	2.4777	0.0000
Dall's porpoise	85,955	0.9666	0.0000
Guadalupe fur seal	7,408	0.7172	0.0000
Northern fur seal	9,424	<0.0001	0.0000
California sea lion (on shelf)	238,000	0.9507	0.0000
California sea lion (offshore)	238,000	<0.0001	0.0000
Northern elephant seal (on shelf)	124,000	0.0191	0.0000
Northern elephant seal (offshore)	124,000	<0.0001	<0.0001
Harbor seal	34,233	0.2559	0.0000

Table 4-17. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 13, Western Atlantic/Jacksonville OPAREA, winter season; ESA-listed species highlighted.

OPAREA 13—WESTERN ATLANTIC, JACKSONVILLE OPAREA (OFF FLORIDA)			
MARINE MAMMAL SPECIES	**NUMBER ANIMALS IN STOCK**	**% STOCK AFFECTED <180 DB**	**% STOCK AFFECTED (WITH MITIGATION) ≥180 DB**
North Atlantic right whale (on shelf)	438	0.1217	0.0000
Humpback whale	11,570	0.0663	0.0000
Sperm whale (on shelf)	4,804	< 0.0001	0.0000
Sperm whale (off shelf)	4,804	0.1691	0.0000
Short-finned pilot whale (on shelf)	31,139	0.0001	0.0000
Short-finned pilot whale (off shelf)	31,139	2.2997	0.0000
Pygmy sperm whale	580	4.4579	0.0000
Dwarf sperm whale	580	4.4579	0.0000
Beaked whales (on shelf)	3,513	< 0.0001	0.0000
Cuvier's beaked whale (off shelf)	3,513	0.3642	0.0000
Blainville's beaked whale (off shelf)	3,513	0.3642	0.0000
Gervais' beaked whale (off shelf)	3,513	0.3642	0.0000
True's beaked whale (off shelf)	3,513	0.3642	0.0000
Sowerby's beaked whale (off shelf)	3,513	0.3642	0.0000
Risso's dolphin (on shelf)	20,479	0.0054	0.0000
Risso's dolphin (off shelf)	20,479	1.9744	0.0000
Common dolphin	120,743	0.0003	0.0000
Coastal Bottlenose dolphin (on shelf) Southern migratory coast Northern FL coast Central FL coast	12,482 3,064 6,318	0.7515 3.0615 1.4847	0.0000 0.0000 0.0000
Bottlenose dolphin (off shelf)	81,588	2.8506	0.0000
Pantropical spotted dolphin	12,747	2.8452	0.0000
Striped dolphin	94,462	0.0006	0.0000
Rough-toothed dolphin	274	2.5226	0.0000
Clymene dolphin	6,086	2.8470	0.0000
Atlantic spotted dolphin (on shelf)	50,978	0.4089	0.0000
Atlantic spotted dolphin (off shelf)	50,978	0.1311	0.0000

Table 4-18. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 14, Eastern North Atlantic, summer season; ESA-listed species highlighted.

OPAREA 14—Eastern North Atlantic (NW Approaches)			
Marine Mammal Species	**Number Animals in Stock**	**% Stock Affected <180 dB**	**% Stock Affected (with mitigation) ≥180 dB**
Blue whale	100	0.7726	0.0000
Fin whale	10,369	3.4018	0.0000
Sei whale	14,152	9.2473	0.0000
Common minke whale	107,205	0.6518	0.0000
Humpback whale	4,695	1.1710	0.0000
Sperm whale	6,375	2.3498	0.0000
Pygmy sperm whale	580	1.3386	0.0000
Dwarf sperm whale	580	1.3386	0.0000
Cuvier's beaked whale	3,513	1.3685	0.0000
Blainville's beaked whale	3,513	1.3685	0.0000
Sowerby's beaked whale	3,513	1.3685	0.0000
North Atlantic bottlenose whale	5,827	0.1654	0.0000
Killer whale	6,618	0.1607	0.0000
False killer whale	484	1.2615	0.0000
Long-finned pilot whale	778,000	0.0857	0.0000
Risso's dolphin	20,479	2.1137	0.0000
Common dolphin	273,150	9.1833	0.0000
Bottlenose dolphin	81,588	1.0419	0.0000
Striped dolphin	94,462	4.8839	0.0000
Atlantic white-sided dolphin	11,760	1.4759	0.0000
White-beaked dolphin	11,760	1.4759	0.0000
Harbor porpoise	341,366	1.4294	0.0000
Harbor seal	23,500	3.2031	0.0000
Gray seal	113,300	3.7559	0.0000

Table 4-19. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA potential sonar OPAREA 15, Mediterranean Sea/Ligurian Sea, summer season; ESA-listed species highlighted.

OPAREA 15—MEDITERRANEAN SEA, LIGURIAN SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Fin whale	3,583	7.0332	0.0000
Sperm whale	6,375	1.7525	0.0000
Cuvier's beaked whale	3,513	1.0139	0.0000
Long-finned pilot whale	778,000	0.0754	0.0000
Risso's dolphin	5,320	6.7105	0.0000
Common dolphin	19,428	4.4472	0.0000
Bottlenose dolphin	23,304	10.3802	0.0000
Striped dolphin	117,880	8.8565	0.0000

Table 4-20. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 16, Arabian Sea, summer season; ESA-listed species highlighted.

OPAREA 16—ARABIAN SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Bryde's whale	9,176	0.0134	0.0000
Humpback whale	200	1.5275	0.0000
Sperm whale	24,446	0.4530	0.0000
Dwarf sperm whale	10,541	4.1267	0.0000
Cuvier's beaked whale	27,272	0.0073	0.0000
Longman's beaked whale	16,887	0.1880	0.0000
Blainville's beaked whale	16,887	0.1880	0.0000
Ginkgo-toothed beaked whale	16,887	0.1880	0.0000
False killer whale	144,188	0.0056	0.0000
Pygmy killer whale	22,029	0.3187	0.0000
Melon-headed whale	64,600	2.7627	0.0000
Short-finned pilot whale	268,751	0.0078	0.0000
Risso's dolphin	452,125	0.0357	0.0000
Common dolphin	1,819,882	0.0373	0.0000
Bottlenose dolphin[21]	785,585	0.0393	0.0000
Spinner dolphin	634,108	0.0066	0.0000
Pantropical spotted dolphin	736,575	0.0072	0.0000
Striped dolphin	674,578	0.0437	0.0000
Rough-toothed dolphin	156,690	0.0663	0.0000

Table 4-21. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 17, Andaman Sea, summer season; ESA-listed species highlighted.

OPAREA 17—ANDAMAN SEA			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Bryde's whale	9,176	0.0094	0.0000
Sperm whale	24,446	0.5369	0.0000
Dwarf sperm whale	10,541	1.5682	0.0000
Cuvier's beaked whale	16,867	0.1214	0.0000
Longman's beaked whale	16,867	0.1214	0.0000
Blainville's beaked whale	16,867	0.1214	0.0000
Ginkgo-toothed beaked whale	16,867	0.1214	0.0000
Killer whale	12,593	0.0079	0.0000
False killer whale	144,188	0.0017	0.0000
Pygmy killer whale	22,029	0.0970	0.0000
Melon-headed whale	64,600	0.8411	0.0000
Short-finned pilot whale	268,751	0.0079	0.0000
Risso's dolphin	452,125	0.0337	0.0000
Common dolphin	1,819,882	0.0130	0.0000
Bottlenose dolphin[21]	785,585	0.0122	0.0000
Spinner dolphin	634,108	0.0095	0.0000
Pantropical spotted dolphin	736,575	0.0104	0.0000
Striped dolphin	674,578	0.0632	0.0000
Rough-toothed dolphin	156,690	0.0724	0.0000

Table 4-22. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 18, Panama Canal, winter season; ESA-listed species highlighted.

OPAREA 18—Panama Canal (Western Approaches)			
Marine Mammal Species	**Number Animals in Stock**	**% Stock Affected <180 dB**	**% Stock Affected (with mitigation) ≥180 dB**
Blue whale	2,842	0.0287	0.0000
Bryde's whale	13,000	0.0197	0.0000
Humpback whale	1,391	0.0034	0.0000
Sperm whale	22,700	0.1604	0.0000
Dwarf sperm whale	11,200	1.711	0.0000
Cuvier's beaked whale	20,000	0.1204	0.0000
Longman's beaked whale	25,300	0.0112	0.0000
Blainville's beaked whale	25,300	0.0502	0.0000
Ginkgo-toothed beaked whale	25,300	0.0617	0.0000
Pygmy beaked whale	25,300	0.0617	0.0000
Killer whale	8,500	0.0116	0.0000
False killer whale	39,800	0.0082	0.0000
Pygmy killer whale	38,900	0.0316	0.0000
Melon-headed whale	45,400	0.3324	0.0000
Short-finned pilot whale	160,200	0.0288	0.0000
Risso's dolphin	110,457	0.1724	0.0000
Common dolphin	3,127,203	0.0153	0.0000
Bottlenose dolphin	335,834	0.0363	0.0000
Spinner dolphin	450,000	0.0082	0.0000
Pantropical spotted dolphin	640,000	0.0549	0.0000
Striped dolphin	964,362	0.0653	0.0000
Rough-toothed dolphin	107,633	0.1744	0.0000
Fraser's dolphin	289,300	0.0030	0.0000

1

Table 4-23. Estimates of percentage of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 19, Northeast Australia Coast, spring season; ESA-listed species highlighted.

OPAREA 19—NORTHEAST AUSTRALIA COAST			
MARINE MAMMAL SPECIES	NUMBER ANIMALS IN STOCK	% STOCK AFFECTED <180 DB	% STOCK AFFECTED (WITH MITIGATION) ≥180 DB
Blue whale	9,250	0.0311	0.0000
Fin whale	9,250	0.0392	0.0000
Bryde's whale	22,000	0.0389	0.0000
Common minke whale	25,000	0.2466	0.0000
Humpback whale inshore (<200 m)	3,500	7.1143	0.0000
Humpback whale offshore (>200 m)	3,500	0.1990	0.0000
Sperm whale	102,112	0.0367	0.0000
Pygmy sperm whale	350,553	0.0187	0.0000
Dwarf sperm whale	350,553	0.0187	0.0000
Cuvier's beaked whale	3,286,163	0.0265	0.0000
Longman's beaked whale	22,799	0.0375	0.0000
Blainville's beaked whale	8,032	0.1065	0.0000
Ginkgo-toothed beaked whale	22,799	0.0375	0.0000
Arnoux's beaked whale	90,725	0.1018	0.0000
Southern bottlenose whale	22,799	0.0375	0.0000
Killer whale	12,256	0.0594	0.0000
Pygmy killer whale	30,214	0.1768	0.0000
False killer whale	16,668	0.4427	0.0000
Melon-headed whale	36,770	0.0830	0.0000
Short-finned pilot whale	53,608	0.5580	0.0000
Long-finned pilot whale	53,608	0.5580	0.0000
Risso's dolphin	220,789	0.0280	0.0000
Common dolphin	83,289	0.2586	0.0000
Spinner dolphin	145,729	0.0837	0.0000
Pantropical spotted dolphin	570,038	0.0738	0.0000
Striped dolphin	1,015,059	0.0006	0.0000
Rough-toothed dolphin	168,791	0.1438	0.0000
Fraser's dolphin	12,626	0.0228	0.0000
Dusky dolphin	438,064	0.0400	0.0000

4.5 OFFSHORE BIOLOGICALLY IMPORTANT AREAS FOR SURTASS LFA SONAR OPERATIONS

The U.S. Navy plans to operate up to four SURTASS LFA sonar systems for routine training, testing, and military operations. These systems have the potential to adversely affect marine animals. In the past, the Navy has applied for, and NMFS has issued, MMPA regulations and LOAs that allow for the incidental taking of marine mammals, while ensuring a negligible impact on the affected species or stock, an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and prescribing measures to minimize impacts. Under the Endangered Species Act (ESA), consultation was required on the Navy's operation of SURTASS LFA sonar and the issuance of MMPA regulations and LOAs. NMFS' rulemaking for the next five-year period of authorizations will be required.[22]

To meet the least practicable adverse impacts to marine mammals under the MMPA, NMFS and the Navy developed a suite of mitigation measures including visual, passive acoustic, and active acoustic monitoring for marine mammals, with shutdown protocols, as well as geographic restrictions, to reduce the potential for adverse impacts. Given the unique operational characteristics of SURTASS LFA sonar, Navy and NMFS were able to develop as part of the geographic restrictions a systematic process for designating "offshore biologically important areas" (OBIA) for SURTASS LFA sonar in the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001). Because the majority of areas of biological importance to marine mammals and sea turtles are in coastal areas, the Navy determined it would not ensonify areas within 22 km (12 nmi) of any coastline with SURTASS LFA sonar pursuant to the FOEIS/EIS at levels at or above 180 dB dB re 1 µPa (rms). Since the Navy recognized, however, that certain areas of biological importance lie outside of these coastal areas, the Navy and NMFS developed the concept of OBIAs. OBIAs are part of a comprehensive suite of mitigation measures used in previous authorizations to minimize impacts and adverse effects to marine mammals. OBIAs were defined in the 2001 SURTASS LFA Sonar FOEIS/EIS Subchapter 2.3.2.1 as those areas of the world's oceans outside of the geographic stand-off distance (greater than 22 km [12 nmi]) from a coastline (including islands) where marine animals of concern (those animals listed under the ESA and/or marine mammals) carry out biologically important activities, including migration, foraging, breeding, and calving. For this SEIS/SOEIS, NMFS revised the criteria for designation of OBIAs discussed in Subchapter 4.5.2.1. The concept of OBIAs is unique to SURTASS LFA operations due to the unique operating characteristics of SURTASS LFA sonar, including frequency range, bandwidth, source depth, pulse length, pulse repetition rate, and duty cycle. As NMFS noted in the 2007 Final Rule for SURTASS LFA sonar (NOAA, 2007c), "OBIAs are not intended to apply to other Navy activities and sonar operations, but rather as a mitigation measure to reduce incidental takings by SURTASS LFA sonar."

4.5.1 MARINE SPECIES CONSIDERED

In addition to considering OBIAs for marine mammals, the Navy considered whether it was appropriate to establish OBIAs for listed marine species other than marine mammals, assuming those species occur within the same ocean region and during the same time of year as the SURTASS LFA sonar operation and possess some sensory mechanism that allows it to perceive the LF sounds or possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. Species that do not meet these criteria were excluded from consideration. Thus, many organisms would be unaffected, even if they were

22 Under the MMPA, the Secretary (Commerce) must issue regulations setting forth the permissible methods of taking and of other means of effecting the least practicable adverse impact on marine mammal species or stock and their habitat and on the availability of the species or stock for subsistence uses. These regulations must provide a determination that the operation of SURTASS LFA sonar would have no more than a negligible impact on the affected marine mammal stocks or habitats and would not have an unmitigable adverse impact on subsistence uses, including a consideration of personnel safety, the practicality of implementation of any mitigation, the impact on the effectiveness of the subject military readiness activity, and the requirements pertaining to the monitoring and reporting of such taking.

in areas of LF sound, because they do not have an organ or tissue with acoustic impedance different from water. Based on these factors, virtually all other species were eliminated from further consideration except for listed fish and sea turtles.

The potential impacts to fish stocks were discussed previously in this chapter, where results from recent direct studies of the effects of LFA sounds on fish (Popper et al., 2005a, 2007; Halvorsen et al., 2006; Kane et al., 2010) were presented that provided evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB re 1 µPa [rms] RL) had minimal effects on at least the species of fish that were studied. Based on examinations by an expert fish pathologist, there was no damage to fish tissues, either at the gross or cellular levels with exposures to LFA sounds up to 193 dB re 1 µPa (rms) RL, and there were no fish mortalities due to sound exposure (Popper et al. 2007; Kane et al., 2010).

The potential impacts to sea turtles are also discussed previously in this chapter. There are limited hearing data for sea turtle species (loggerhead, green, and Kemp's ridley) that demonstrate that these species can hear LF sound (Ketten and Bartol, 2006). The data suggest that the best hearing sensitivities of the studied sea turtles were in the LF range between 100 and 900 Hz, but the data also showed that their hearing thresholds in the LFA range (100 to 500 Hz) were from 81 to 92 dB re 1 µPa, which is similar to the hearing thresholds of marine mammals with poor LF hearing sensitivity, such as odontocetes and pinnipeds. Sea turtles would have to be well inside of the LFA mitigation zone (180-dB sound field) during a SURTASS LFA sonar transmission to be affected. Therefore, the potential impacts to fish stocks and sea turtles are considered negligible, and there is no basis for establishing OBIAs for these species.

For the purposes of initial the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001), 180-dB dB re 1 µPa (rms) received level (RL) was considered as the point above which some potentially serious problems in the hearing capability of marine mammals could start to occur from exposure to an LFA signal. This value was determined based on the best, but sparse, scientific data available at the time. This conservative value was above the estimated values for onset TTS, but below the values for onset PTS, which was and is considered injury. As has already been detailed, the probability of SURTASS LFA sonar transmissions (with mitigation) causing injury in marine mammals is considered negligible. A part of the mitigation strategy to achieve this negligible impact is the establishment of OBIAs for marine mammals.

4.5.2 LFA Offshore Biologically Important Areas for Marine Mammals

The process of identifying potential marine mammal (MM) OBIAs involved an assessment by both NMFS and the Navy to identify the areas that met the biological criteria for an OBIA. To assist in the process of identifying potential LFA OBIAs for marine mammals, NMFS convened an expert review panel of independent scientists knowledgeable about potentially affected marine mammal habitats. This panel consisted of eight subject matter experts (SMEs), each with specific expertise in geographic regions including the Atlantic Ocean, Pacific Ocean, Mediterranean Sea, Indian Ocean/Southeast Asia, and East Africa. The SMEs provided analysis of potential OBIAs in regions of the world where the Navy potentially could use the SURTASS LFA sonar systems. The initial step in the identification of LFA OBIAs for marine mammals was the development of standardized screening criteria to identify preliminary OBIA nominees (Table 4-24). More details about the delineation of marine mammal OBIAs are provided in Appendix D. For those areas that were determined to meet at least one biological criterion, a practicability assessment was performed by the Navy.

4.5.2.1 Screening Criteria for OBIA Nominees for Marine Mammals

NMFS developed the following screening criteria to determine an area's eligibility to be considered as a nominee for an OBIA for marine mammals. These OBIA criteria differ from the criteria in the FOEIS/EIS (as continued in the 2007 SEIS) and the 2007 MMPA Final Rule in two respects. First, under the 2001 FOEIS/EIS, 2007 SEIS, and the 2007 Final Rule, an area could be designated as an OBIA only if it met a conjunctive test of being an area where: (a) marine mammals congregate in high densities, and (b) for a biologically important purpose. Under the new NMFS criteria, either of these criteria alone can be sufficient. Second, the new criteria include an additional criterion that, standing alone, could be a basis for designation; i.e., "Small, distinct populations with limited distributions."

Table 4-24. NMFS' classification methodology for OBIA recommendations for marine mammals.

RANK	LEVEL DESCRIPTION FOR HIGH DENSITY, FORAGING, BREEDING/CALVING, MIGRATION, CRITICAL HABITAT, OR SMALL DISTINCT POPULATIONS	LEVEL DESCRIPTION BOUNDARY CONSIDERATION
0	Information not provided or information presented does not meet NMFS' definition of the corresponding MM OBIA criteria or the MM OBIA criteria are not applicable.	SME did not provide boundary information.
1	Clear justification (qualitative or quantitative) for corresponding MM OBIA criteria is not available; or the SME did not provide sufficient detail to NMFS for criteria evaluation; or for high density specifically, the SME provided strong abundance/presence information, but without the comparative information that supports *high* density.	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.
2	Designation inferred from analyses conducted for purposes other than quantifying the corresponding MM OBIA criteria. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.	Proposed boundary inferred from analyses conducted for purposes other than quantifying the boundary. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.
3	Designation inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the corresponding MM OBIA criteria. Information presented from a single source or is generally imprecise (e.g., coefficient of variation [CV] ≥30%).	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the proposed boundary.
4	Designation inferred from peer-reviewed analyses or surveys specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented is from multiple sources or is generally precise (e.g., CV <30%).	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. ESA of 1973).

<u>Criterion 1: Outside of Coastal Standoff Distance and Non-Operational Areas</u>

The Navy will not operate SURTASS LFA sonar pursuant to the SEIS/SOEIS in certain areas of the world as shown in Figure 1-1 (Chapter 1). Therefore, MM OBIAs will not be designated if they lie solely within these areas:

- Coastal Standoff Zone—the area within 22 km (12 nmi) of any coastline including islands and island systems.
- Non-Operational Areas:

- Arctic—Portions of the Norwegian, Greenland, and Barents Seas north of 72°N latitude, plus Baffin Bay, Hudson Bay, the Bering Sea, and the Gulf of St. Lawrence.
- Antarctic—South of 60°S latitude.

Criterion 2: Biologically Important

To be considered an MM OBIA nominee, an area must meet at least one of the below sub-criterion.

- **Sub-criterion 2a—High densities**

An area that represents a region of high density for one or more species of marine mammals will be considered. In addition to survey data, predictive habitat or density modeling may be used to identify areas of high density. The exact definition of "high density" may differ across species and should generally be treated and justified on a stock-by-stock or species-by-species basis, although combining species or stocks may be appropriate in some situations, if well justified.

In identifying high-density areas:

1. For locations/regions and species for which adequate density information is available (e.g., most waters off the U.S.), high density areas should be defined as those areas where density measurably, within a definable and justifiable area, meaningfully exceeds the average density of the species or stock in that location/region regularly or regularly within a designated time period of the year.
2. For locations/regions and species and stocks for which density information is limited or not available, high density areas should be defined (if appropriate) using some combination of the following: available data, regional expertise, and/or habitat suitability models utilizing static and/or predictable dynamic oceanographic features and other factors that have been shown to be associated with high marine mammal densities.

- **Sub-criterion 2b—Known area for breeding/calving grounds, foraging grounds, and migration routes**

The area representing a location of known biologically important activities including defined breeding or calving areas, foraging grounds, concentrated migration routes, and any ESA-designated critical habitat will be considered. Although such areas may not qualify as areas of "high density" as set forth in sub-criterion 2a above, potential designation under this sub-criterion denotes that these areas are concentrated areas for the biologically important activity in question. For the purpose of this SEIS/SOEIS, "concentrated" means that more of the animals are engaged in the particular behavior at the location (and perhaps time) than are typically engaged in that behavior elsewhere.

- **Sub-criterion 2c—Small, distinct populations with limited distributions**

Such an area represents a location that contains a small, distinct population of marine mammals with limited distribution.

4.5.2.2 Application of Screening Criteria by SMEs and NMFS

NMFS used the screening criteria to review existing and potential marine protected areas based on the World Database on Protected Areas (WDPA) (WDPA, 2009), Hoyt (2005), and prior SURTASS LFA sonar OBIAs to produce a preliminary list of LFA MM OBIA nominees. Of the 403 worldwide marine protected areas derived from these sources, NMFS compiled a preliminary listing of 27 MM OBIA nominees.

Although NMFS did not consider this list of 27 nominees to be comprehensive, it was provided to the SMEs to illustrate some of the more well-known important marine mammal areas and to lay out the format for the SME review process. NMFS asked the SMEs to review the OBIA nominations; to identify less well-known areas; to use peer-reviewed literature, technical reports, and their own specific expertise and professional experience, in addition to other data sources, to justify their additions, modifications, or deletions to the list of preliminary MM OBIA nominees (Appendix D). Based on the specific criteria provided by NMFS, the SMEs provided a list of 73 recommendations to NMFS for MM OBIA nominees (Table 4-25).

NMFS reviewed the SMEs' recommendations and ranked them based on the quality of the data that supported the selection of the given area based on the screening criteria (Table 4-25). To ensure that the nominated areas were ranked consistently, NMFS assigned a rank of zero to four (i.e., 0 = lowest, 4 = highest) to reflect the robustness of the supporting documentation for each criterion for which the area was nominated. These ranking categories are:

- Rank 0: Not Eligible, not applicable
- Rank 1: Not Eligible, insufficient data
- Rank 2: Eligible for consideration, requires more data
- Rank 3: Eligible for consideration, adequate justification
- Rank 4: Eligible for consideration, strong justification.

NMFS also assigned a rank for the robustness of the supporting documentation for each proposed MM OBIA boundary (Appendix D). These ranking categories are:

- Rank 0: SME did not provide boundary information.
- Rank 1: Clear justification (qualitative or quantitative) for boundary consideration is not available.
- Rank 2: Proposed boundary inferred from analyses conducted for purposes other than quantifying the boundary.
- Rank 3: Proposed boundary inferred from peer-reviewed analyses.
- Rank 4: Proposed boundary is well documented and/or codified by national law or regulation.

Nominee areas that received a ranking of 2 or higher for any criterion were eligible for continued consideration as an MM OBIA nominee. As a result of this process, 45 areas were ranked 2 or higher.

The frequencies of the signal produced by the SURTASS LFA sonar (frequency range 100 to 500 Hz) are much lower than the frequencies of best hearing sensitivity for HF and MF marine mammal hearing groups (as defined in Southall et al., 2007). There are few known documented responses of these marine mammal hearing groups to SURTASS LFA sonar. In the initial stage and in the subsequent SME reviews, the experts identified all potential OBIA nominees that met the screening criteria, regardless of the best hearing sensitivity of the species for which the area was considered important. Further assessments were performed to eliminate areas that only met the screening criteria for HF and/or MF hearing species. Subchapter 4.5.2.3 provides a more detailed discussion.

4.5.2.3 Further Analysis by NMFS and the Navy

The list of 45 potential MM OBIAs was analyzed further by NMFS and the Navy. This included further analysis of the biological evidence's strength for each OBIA and further review of the proposed OBIA boundaries and, where appropriate, consideration of seasonality. It also includes a practicability assessment performed by the Navy. Portions of this analysis are discussed in more detail below, including reasons for excluding some of the recommended OBIAs from further consideration. Additional analysis included screening criterion which considered marine mammal OBIAs only for those species whose best hearing sensitivity is in the LF range.

Table 4-25. NMFS' ranking of the SMEs' list of OBIA recommendations for marine mammals.

NAME	HIGH DENSITY	FORAGING	BREEDING/ CALVING	MIGRATING	CRITICAL HABITAT	SMALL DISTINCT POPULATION	LF SPECIALIST
Georges Bank	3	4	0	4	0	0	4
Roseway Basin Right Whale Conservation Area	0	4	0	0	0	0	4
Great South Channel	0	3	0	0	4	0	4
The Gully MPA	4	3	0	0	0	0	0
Southeastern U.S. Right Whale Seasonal Habitat	0	0	4	0	4	0	4
Silver Bank and Navidad Bank[23]	4	0	4	0	0	0	4
Coastal Waters of Gabon, Congo and Equatorial Guinea	1	1	4	4	0	2	4
Patagonian Shelf Break	0	4	0	0	0	0	4
Southern Right Whale Seasonal Habitat	0	0	4	0	0	0	4
Northern Bay of Bengal and Swatch-of-No-Ground	1	2	2	0	0	4	2
Coastal Waters off Madagascar	1	1	4	1	0	0	4
Madagascar Plateau, Madagascar Ridge, Walters Shoal	1	3	4	3	0	2	3
Central California National Marine Sanctuaries	4	4	0	4	0	0	4
Vaquita Habitat in the Northern Gulf of California	0	0	0	0	0	4	0
Southern California Bight	0	4	0	4	0	0	4
Gulf of Alaska Steller Sea Lion Critical Habitat	0	0	0	0	4	0	0

23 In addition to their importance as breeding and calving areas, NMFS notes that these banks are also areas of high whale concentration.

Table 4-25. NMFS' ranking of the SMEs' list of OBIA recommendations for marine mammals.

Name	High Density	Foraging	Breeding/ Calving	Migrating	Critical Habitat	Small Distinct Population	LF Specialist
Okhotsk Sea	0	4	0	2	0	0	4
Piltun and Chayvo Offshore Feeding Grounds	0	3	0	1	0	0	3
Area around Ischia Island and Regno di Nettuno MPA	1	1	3	0	0	0	0
Area in the Northern Adriatic Sea	1	2	3	0	0	0	0
Northeast Slope in the Ligurian-Corsican-Provençal Basin	0	3	0	0	0	0	3
Harbor Porpoise Take Reduction Management Areas	3	3	0	3	0	0	0
Cape Hatteras Special Research Area	3	3	0	0	0	0	0
Shortland Canyon and Haldimand Canyon	3	3	0	0	0	0	0
Gulf of Thailand	1	0	1	0	0	3	0
Penguin Bank	3	0	3	0	0	0	3
Costa Rica Dome	0	3	0	0	0	0	3
Cross Seamount	0	3	0	0	0	0	0
Great Barrier Reef Between 16°S and 21°S	0	0	3	0	0	0	3
Bonney Upwelling	0	3	0	0	0	0	3
Southwest Mediterranean	1	2	2	0	0	0	0
North Alboran Sea, Gulf of Vera, Southern Almeria	1	2	2	0	0	0	0
Avenzar Bank, Câbliers Bank, and El Mansour Seamount	1	2	2	0	0	0	0
Djibouti Bank, Ville de Djibouti Bank, and Alborán Channel	1	2	2	0	0	0	0

Table 4-25. NMFS' ranking of the SMEs' list of OBIA recommendations for marine mammals.

NAME	HIGH DENSITY	FORAGING	BREEDING/ CALVING	MIGRATING	CRITICAL HABITAT	SMALL DISTINCT POPULATION	LF SPECIALIST
Barcelona Canyon, Tarragona Canyon, Mallorca Chanel, Pituisas Canyon	1	2	2	0	0	0	1
Southern Almería, Seco de los Olivos Seamount, Alborán Island, Águilas Seamount	1	2	2	0	0	0	0
Felibres Hills, Calypso Hills, Spinola Spur, and Montpelier Canyon	1	2	2	0	0	0	2
Marseille Canyon, Cassis Canyon, Felibres Hill, Alabe Hill, Barcelona Canyon	1	2	0	0	0	0	0
Area off of Southwest Greece and Crete, Ptolemy Mountains, Cretan-Rhodes Ridge	1	2	2	0	0	0	0
Northwest of Challenger Bank	0	2	0	1	0	0	2
Sylt Outer Reef	1	0	2	0	0	0	0
Pommeranian Bay, Adler Ground, and Western Ronne Bank	0	0	2	0	0	0	0
Buenos Aires Province Coastal Area	1	2	2	0	0	2	0
Area in the Ombai Strait in the Savu Sea MPA	0	2	0	2	0	0	2
Fairweather Grounds, Southeast Alaska	0	2	0	0	0	0	2
Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon	0	2	0	0	0	0	2

Table 4-25. NMFS' ranking of the SMEs' list of OBIA recommendations for marine mammals.

NAME	HIGH DENSITY	FORAGING	BREEDING/ CALVING	MIGRATING	CRITICAL HABITAT	SMALL DISTINCT POPULATION	LF SPECIALIST
Sardinian Seamount, Comino Trough, Sardinia, Corsica Trough	1	0	0	0	0	0	1
Peñiscola Canyon, Valencia Basin, Benidorm Canyon, Alicante Canyon, Águilas Seamount	1	0	0	0	0	0	1
Mediterranean Sea West of 10° E Ligurian Sea to Gibraltar Strait	1	0	0	0	0	0	1
Pelagos Cetacean Sanctuary	1	0	0	0	0	0	1
Caprera Canyon, Giglio Ridge, Oblia Terrace—Southeast of Pelagos Sanctuary	1	0	0	0	0	0	1
Area off Eastern Sicily, East of Messina Canyon	1	0	0	0	0	0	0
Area off the Gaza Strip and the Western Coast of Israel	1	0	0	0	0	0	0
Song of the Whale Surveys - Eastern Mediterranean	1	0	0	0	0	0	1
Dogger Bank	1	0	0	0	0	0	0
Continental Slope of the Northern Gulf of Mexico	1	1	0	0	0	0	0
Canary Islands Cetacean Marine Sanctuary	1	0	0	0	0	0	0
Tristan da Cunha Cetacean Sanctuary	1	0	0	0	0	0	0
Komodo National Park, Biosphere Reserve	1	0	0	0	0	0	0

Table 4-25. NMFS' ranking of the SMEs' list of OBIA recommendations for marine mammals.

NAME	HIGH DENSITY	FORAGING	BREEDING/ CALVING	MIGRATING	CRITICAL HABITAT	SMALL DISTINCT POPULATION	LF SPECIALIST
Beaked Whale Habitat in the Coastal Waters off California, Washington, and Oregon	1	0	0	0	0	0	0
Southern Gulf of California	1	0	0	0	0	0	1
Exclusion around Japan and the Ryukyu Islands	1	0	0	0	0	0	0
The Sea of Japan	1	0	0	0	0	0	0
Exclusion in the South China Sea	1	0	0	0	0	0	0
Exclusion for the West Philippine Sea	1	0	0	0	0	0	1
Area around Quarqannah Island	0	0	0	0	0	0	0
Area Malta Island and Malta Plateau	0	0	0	0	0	0	0
Total Exclusion within the Yellow Sea / East China Sea	0	0	0	0	0	0	0
Exclusion around Taiwan	0	0	0	0	0	0	0
Total Exclusion in the Gulf of Tonkin	0	0	0	0	0	0	0
Exclusion around Wake Island	0	0	0	0	0	0	0
Exclusion for the North Philippine Sea	0	0	0	0	0	0	0
Exclusion for the East China Sea	0	0	0	0	0	0	1

Southern California Bight

An area in the Southern California Bight (SCB), specifically an area including Tanner and Cortes Banks (Figure 4-6), meets the biological criteria described above for designation as a SURTASS LFA sonar OBIA as a concentrated area for blue whales based on predictive modeling or as a foraging area based on a 2000 to 2004 study of blue whale calls. In both cases, the underlying data cover a short time period. Over a longer period, the dynamic nature of blue whale distribution and the variability of prey abundance make it difficult to assign any permanence to this area as one of biological importance for blue whales.

Figure 4-6. Southern California Bight (SCB) OBIA boundary.

Moreover, based upon operational considerations, avoiding this area is impracticable. Much of this area lies within the existing Southern California (SOCAL) Range Complex, which plays a vital part in ensuring the readiness of our naval forces. The region surrounding San Diego, California, is home to the largest concentration of U.S. naval forces in the world, and the SOCAL Range Complex is the most capable and active Navy range complex in the eastern Pacific region. The Navy has used this area for over 70 years to provide a safe and realistic training and testing environment for U.S. naval forces charged with the defense of the nation. The vital year-round training that occurs in the SOCAL Range Complex includes pre-deployment training for Carrier Strike Groups (CSG), Surface Strike Groups (SSG), and Expeditionary Strike Groups (ESG). Antisubmarine warfare (ASW) training, including possibly SURTASS LFA sonar, is a critical component of the pre-deployment training. The SOCAL Range Complex provides the uneven, mountainous underwater topography that is essential to such training, because it is similar to the kind of underwater topography that submarines use to hide or mask their presence. Therefore, it is not practicable to designate this area as an OBIA.

The Navy is not currently planning to use SURTASS LFA sonar in the SCB. If the Navy were to plan use of SURTASS LFA sonar pursuant to the SEIS/SOEIS, the Navy would include the details of that plan in the LOA application for the applicable year. At that time, the Navy and NMFS can discuss what, if any, other measures are appropriate for the projected use of LFA sonar and relevant current information available for the species potentially affected by that use.

Stellwagen Bank NMS and the Gulf of Maine

The Gulf of Maine and adjacent waters, including the Stellwagen Bank NMS, are some of the most important areas of marine mammal prey abundance in U.S. Atlantic waters. The waters of the sanctuary, the Great South Channel, and Gulf of Maine (which includes Cape Cod and Massachusetts Bays) support key prey species of cetaceans, including sand lance (small semi-pelagic fish), herring, copepods, and euphausid zooplankton. Seasonally, the prey-dense waters of the Gulf of Maine are essential North Atlantic foraging grounds for such ESA-listed cetacean species as the North Atlantic right, humpback, fin, and sei whales. Also, the northern section of North Atlantic right whale critical habitat is located in these waters off New England.

Four feeding areas of the North Atlantic right whale are located in the greater Gulf of Maine: Cape Cod Bay, Great South Channel, Bay of Fundy, and Roseway Basin. Right whales occupy these feeding grounds from late winter (January) through fall (November) while the other cetacean species are found in greatest feeding abundances in late spring through early fall. Due to this region's importance as a seasonal baleen whale feeding ground and the location of right whale critical habitat, the portions of the U.S. Gulf of Maine including Stellwagen Bank NMS, as shown in Figure 4-7, that are located outside of the 22 km (12 nmi) coastal standoff distance are eligible for inclusion as an LFA OBIA for marine mammals. For these reasons, the Great South Channel OBIA has been expanded to encompass the waters of the U.S. Gulf of Maine, the Great South Channel, and the Stellwagen Bank NMS; and has been designated as OBIA #3 (Figure 4-7). OBIA #3 includes the northern portion of the North Atlantic right whale's critical habitat and together with the Georges Bank and Roseway Basin OBIAs, provides full coverage of seasonal baleen whale feeding grounds in the northwestern Atlantic Ocean.

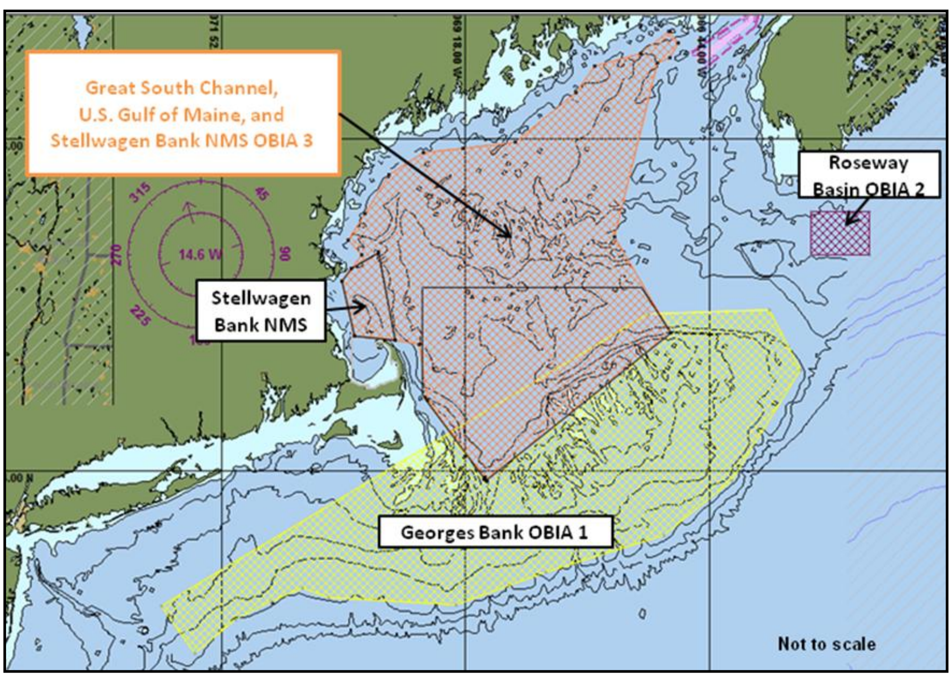


Figure 4-7. LFA OBIA MM #3 boundary including the U.S. Gulf of Maine, Great South Channel, and Stellwagen National Marine Sanctuary.

Challenger Bank (off Bermuda)

An area northwest of Challenger Bank, located just west of Bermuda, was proposed as a marine mammal OBIA for SURTASS LFA sonar due its use by humpback whales as a foraging area and migration route. Humpback whales occur in and around Bermuda in the late winter and spring as they migrate northward between their North Atlantic calving and feeding grounds. Humpbacks have been sighted principally in the waters near Challenger, Plantagenet, and Sally Tucker Banks off western Bermuda and in the coastal waters off Bermuda's southern shore during their spring northward migration, although they have also been observed elsewhere in Bermudian waters (Stone et al., 1987; Clapham and Mattila, 1990; Reeves et al., 2006). Recent photographic surveys by the Humpback Whale Research Project of Bermuda have verified that humpback whales occur from late February through mid-May on the Sally Tucker and Challenger Banks and along Bermuda's south shore (Whales Bermuda, 2008). In 2000, the Bermudian government established a marine mammal sanctuary encompassing all its territorial waters but placed no emphasis on specific areas within Bermuda's waters (Hoyt, 2005).

During the OBIA selection process, Challenger Bank was considered under the criteria of biological importance (known, defined breeding/calving grounds, foraging grounds, and/or migration route) and under the criteria for marine mammal species whose best hearing sensitivity is in the LF range. As humpback whales are believed to have best hearing in the LF range (Southall et al., 2007), these criteria apply for the Challenger Bank area. Ecologically and biologically, Challenger Bank is not a breeding/calving ground for humpbacks, and although located in waters used by some migrating humpbacks, the waters off the bank do not constitute a "migration route." Thus, the only remaining consideration is that Challenger Bank is a foraging ground for seasonally-occurring humpback whales. Although humpback whales unquestionably have been observed in the waters surrounding Challenger Bank in spring, there is no direct evidence that humpback whales are indeed feeding in the waters off Challenger Bank. Stone et al. (1987) only hypothesized that humpback whales were feeding in Bermudian water and only "suggest the possibility that humpback whales feed at Bermuda on their way north." Other researchers (Clapham and Mattila, 1990; Baraff et al., 1991) have merely repeated the suggestions of Stone et al. (1987) that humpbacks may be feeding in Bermudian waters. Evidence to definitely demonstrate that humpbacks are feeding in the waters of Bermuda, let alone Challenger Bank, in spring does not exist. Therefore, at this time, Challenger Bank does not meet the criteria to be nominated as an LFA OBIA for marine mammals as its biological importance as a feeding ground cannot be justified.

Fairweather Grounds (Southeast Alaska)

Fairweather Grounds was recommended as a LFA OBIA for humpback whale foraging. The nomination was based on limited sighting data of humpback whale aggregations collected during the summer of 2004 by NMFS as part of the SPLASH (Structure of Populations, Levels of Abundance and Status of Humpback whales) project. Fairweather Grounds, located in the continental shelf waters of southeastern Alaska and offshore from Glacier Bay, was a former whaling ground. This area is currently an important habitat for corals, demersal fishes, and some pelagic fishes, with EFH having been designated at Fairweather Grounds for more than 10 species (NMFS, 2005), while only one of these fish species is preyed upon by humpback whales. The 15 July 2004 weekly NMFS cruise reported high densities (value undefined) of humpback whales in the area of Fairweather Grounds for three days in the summer of 2004. No humpbacks were reported for the fall 2004 survey in the same area. In the Final SPLASH report (Calambokidis, et al., 2008), no mention is made of the Fairweather Grounds as a location to be further studied or of particular relevance for humpback whales in the northeastern Pacific. Further, the stock assessment reports for Alaskan waters do not mention Fairweather Grounds as a feeding area for humpback whales (Angliss and Allen, 2009). The limited sighting data for only one season are not adequate scientific support to warrant setting aside Fairweather Grounds as an LFA OBIA for marine mammals.

Ombai Strait in the Savu Sea/Savu Sea National Marine Park

An area near the center of the Ombai Strait in the Savu Sea of Indonesia was nominated as a marine mammal LFA OBIA for blue and sperm whale foraging grounds and migration routes. Sperm whales have been both historically and presently observed in this region of Indonesia, with subsistence whaling of sperm whales continuing in small scale in villages surrounding the Savu Sea (Rudolph et al., 1997; Mustika, 2006). While there is no doubt that both sperm and blue whales occur in the Ombai Strait region of the Savu Sea and nearby island passages (Rudolph et al., 1997; Pet-Soede, 2002, Kahn and Pet, 2003), the available data, however, do not adequately support the location or seasonality proposed for the OBIA nor do the data sufficiently show what biological activities these species are performing while occupying the waters of the Savu Sea region. Sightings of both sperm and blue whales are concentrated near to shore, likely a bias of the survey collection methodology, with no sightings in the center of the Ombai Strait (Pet-Soede, 2002, Kahn and Pet, 2003). Also, the data collected in the most recent surveys from 2001 to 2003 of the region's waters were collected principally in May with some sparse records collected in October; these data do not support the seasonality of June through September proposed for this OBIA (Pet-Soede, 2002, Kahn and Pet, 2003). For these reasons, the Ombai Strait did not meet the criteria to be nominated as a marine mammal LFA OBIA.

Designation of OBIAs for LF Sensitive Species

The further analysis by NMFS and the Navy included establishment of a further screening criterion, i.e., that it was appropriate to consider marine mammal OBIAs only for those species whose best hearing sensitivity is in the LF range. The LFA source is well below the range of best hearing sensitivity for odontocetes and most pinnipeds, based on the fairly extensive body of laboratory measurements (Richardson et al., 1995; Nedwell et al., 2004; Southall et al., 2007; Au and Hastings, 2008; Houser et al., 2008; Kastelein et al., 2009; and Mulsow and Reichmuth, 2010).

Observations of marine mammal responses to other types of anthropogenic sounds, such as pile driving or seismic airguns, provide little insight to the discussion here. These types of activities produce impulsive sounds which contain both a rapid onset and a broad band of frequencies, including some in the MF and HF bands, and which have been observed to elicit a behavioral response from marine mammal species. LFA sonar is not impulsive but consists of narrowband tonals that resemble some of the sounds produced by certain LF whales, such as humpback and right whales. Therefore, an LFA sonar sound presents a fundamentally different context compared to impulsive anthropogenic sound sources. LFA sonar signals sound like the communication sounds produced by LF whales and are not the kind of sounds that would be expected to, or that have been observed to, evoke behavioral responses in MF or HF animals.

This finding is further supported by the 1997 to 1998 SURTASS LFA Sonar Low Frequency Sound Scientific Research Program (LFS SRP) which consisted of three phases, each conducted in an area where baleen whales were engaged in a biologically important behavior (blue and fin whales feeding in Southern California Bight, gray whales migrating off the central California coast, and humpback whales mating off the Big Island, Hawaii) (Clark et al., 2001). Results from that scientific research program demonstrated that under certain conditions, some of the focal individuals (LF species) within a limited range of the LFA sources would respond to LFA sonar, but they returned to their normal activities within a short period of time (Miller et al., 2000; Croll et al., 2001a; Fristrup et al., 2003). The conclusion from these observed responses was that the probability of LFA signals affecting a significant biological behavior of the focal baleen whales was minimal. During the LFS SRP, there were numerous non-focal marine mammals (MF and HF hearing species) sighted in the vicinity of the sea tests, including short-finned pilot whales, pygmy and dwarf sperm whales, melon-headed whales, false killer whales, Cuvier's beaked whales, common dolphins, bottlenose dolphins, spinner dolphins, Risso's dolphins, and California sea lions. There were no immediately obvious responses observed from these odontocetes and pinnipeds and no immediately obvious changes in sighting rates for these species as a function of LFA source conditions during the LFS SRP. Consequently, none of these species had any obvious behavioral reaction to LFA signals at received levels similar to those that produced only minor, short-term behavioral responses in the baleen whales.

There may be some possibility that a marine mammal MF and/or HF species could detect, either acoustically or vibrotactally, and possibly respond to LFA sonar. However, the chances of injury and/or significant behavioral responses to SURTASS LFA sonar are very low to negligible, given the following:

- The MF/HF frequencies these animals are adapted to hear and produce;
- Their natural acoustic ecologies;
- Their observed lack of response to LFA sounds during the LFS SRP; and
- The kinds of sounds to which they do or do not respond.

Continuing OBIA Analysis by NMFS

To continue the assessment of potential OBIAs for SURTASS LFA sonar, NMFS reviewed Hoyt (2011), which is an update and revision of Hoyt's (2005) earlier work on marine protected areas for marine mammals, and areas recommended during the public comments on the DSEIS/SOEIS. NMFS analyzed those areas presented in Hoyt (2011) and the public comments that meet the geographic and biological selection criteria for SURTASS LFA sonar OBIAs (Appendix F).

4.5.3 SURTASS LFA Sonar Offshore Biologically Important Areas

As a result of this further analysis, the NMFS and the Navy concluded that there was adequate basis to designate 21 OBIAs (Table 4-26). The Navy also reviewed the potential OBIAs to assess personnel safety, practicality of implementation, and impacts of the effectiveness on military readiness activities to include testing, training, and military operations. No issues were found that would affect the practical implementation of the LFA OBIA geographic restrictions as part of the overall mitigation and monitoring program. These OBIAs, as part of the overall mitigation measures, will reduce incidental takings by SURTASS LFA sonar and, consistent with the 2007 Rule, are not intended to apply to other Navy activities and sonar operations.

4.5.4 Comparison with Current OBIAS

In the SURTASS LFA Sonar FSEIS (DoN, 2007a), nine OBIAs were identified (Table 2-4). During the 2007 rulemaking process under the MMPA, NMFS designated The Gully as the tenth OBIA for LFA (Table 4-27). OBIAs designated under the 2007 Final Rule that have maintained status as LFA OBIAs include the Costa Rica Dome, Antarctic Convergence Zone, and Penguin Bank of the Hawaiian Island Humpback Whale NMS. Also, the Cordell Bank NMS, Gulf of the Farallones NMS, and Monterey Bay NMS, including the Davidson Seamount Management Zone, were combined into the Central California NMSs based on NMFS' Final Rule revisions of November 20, 2008 (15 CFR 922; NOAA, 2008). The Olympic Coast NMS OBIA was expanded to include the offshore areas known as The Prairie, Barkley Canyon, and Nitnat Canyon.

Two current OBIAs were evaluated and found not to meet the screening criteria for designation as an LFA OBIA–Flower Garden Bank NMS and The Gully. Flower Garden Bank NMS lies approximately 185 km (100 nmi) off the coasts of Texas and Louisiana in the Gulf of Mexico. It was evaluated in NMFS' initial screening of OBIAs for marine mammals and was found ineligible because it did not meet Criterion 2. The Gully was removed from further consideration because the marine mammal of concern (northern bottlenose whale) does not have its best hearing sensitivity in the LF range.

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
1	Georges Bank	40°00'N, 72°30'W 39°37 N, 72°09'W 39°54'N, 71°43'W 40°02 N, 71°20'W 40°08'N, 71°01'W 40°04'N, 70°44'W 40°00'N, 69°24'W 40°16'N, 68°27'W 40°34'N, 67°13'W 41°00'N, 66°24'W 41°52'N, 65°47'W 42°20'N, 66°06'W 42°18'N, 67°23'W	Northwest Atlantic Ocean	North Atlantic right whale	Year-round
2	Roseway Basin Right Whale Conservation Area	43°05'N, 65°40'W 43°05'N, 65°03'W 42°45'N, 65°40'W 42°45'N, 65°03'W	Northwest Atlantic Ocean	North Atlantic right whale	Canadian Restriction is June through December
3	Great South Channel, U.S. Gulf of Maine, and Stellwagen Bank NMS[24]	41°00.000'N, 69°05.000'W 42°09.000'N, 67°08.400'W 42°53.436'N, 67°43.873'W 44°12.541'N, 67°16.847'W 44°14.911'N, 67°08.936'W 44°21.538'N, 67°03.663'W 44°26.736'N, 67°09.596'W 44°16.805'N, 67°27.394'W 44°11.118'N, 67°56.398'W 43°59.240'N, 68°08.263'W 43°36.800'N, 68°46.496'W 43°33.925'N, 69°19.455'W 43°32.008'N, 69°44.504'W 43°21.922'N, 70°06.257'W 43°04.084'N, 70°21.418'W 42°51.982'N, 70°31.965'W	Northwest Atlantic Ocean/ Gulf of Maine	North Atlantic right whale	January 1 to November 14

24 The expanded boundaries of OBIA #3 encompass the northern critical habitats of the North Atlantic right whale, Stellwagen Bank NMS, and areas within the Gulf of Maine.

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
		42°45.187'N, 70°23.396'W 42°39.068'N, 70°30.188'W 42°32.892'N, 70°35.873'W 42°07.748'N, 70°28.257'W 42°05.592'N, 70°02.136'W 42°03.664'N, 69°44.000'W 41°40.000'N, 69°45.000'W			
4	Southeastern U.S. Right Whale Seasonal Habitat	Critical Habitat Boundaries are coastal waters between 31°15' N and 30°15' N from the coast out 28 km (15 nmi); and the coastal waters between 30°15' N and 28°00' N from the coast out 9 km (5 nmi) (NOAA, 1994). OBIA Boundaries are coastal waters from 31°15' N and 30°15' N from 22 to 28 km (12 to 15 nmi).	Northwest Atlantic Ocean	North Atlantic right whale	15 November to 15 April
5	North Pacific Right Whale Critical Habitat[25]	57°03'N, 153°00'W 57°18'N, 151°30'W 57°00'N, 151°30'W 56°45'N, 153°00'W (NOAA, 2008)	Northeastern Pacific Ocean/Gulf of Alaska	North Pacific right whale	March through August
6	Silver Bank and Navidad Bank	Silver Bank: 20° 38.899'N, 69° 23.640'W 20° 55.706'N, 69° 57.984'W 20° 25.221'N, 70° 00.387'W 20° 12.833'N, 69° 40.604'W 20° 13.918'N, 69° 31.518'W 20° 28.680'N, 69° 31.900'W Navidad Bank: 20° 15.596'N, 68° 47.967'W 20° 11.971'N, 68° 54.810'W 19° 52.514'N, 69° 00.443'W 19° 54.957'N, 68° 51.430'W 19° 51.513'N, 68° 41.399'W	Northwestern Atlantic Ocean/Caribbean Sea	Humpback whale	December through April

25 OBIA added after NMFS and SME initial reviews. Effective 8 May 2008, NMFS designated critical habitat for the North Pacific Right Whale in the western Gulf of Alaska off of Kodiak Island (NOAA, 2008).

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
7	Coastal Waters of Gabon, Congo and Equatorial Guinea	An exclusion zone following the 500-m isobath extending from 3°31.055'N, 9°12.226'E in the north offshore of Malabo southward to 8°57.470'S, 12°55.873'E offshore of Luanda	Southeastern Atlantic Ocean	Humpback whale and Blue whale	June through October
8	Patagonian Shelf Break	Between 200- and 2000-m isobaths and the following latitudes: 35°00'S, 39°00'S, 40°40'S, 42°30'S, 46°00'S, 48°50'S	Southwestern Atlantic Ocean	Southern elephant seal	Year-round
9	Southern Right Whale Seasonal Habitat	Coastal waters between 42°00'S and 43°00'S from 12 to 15 nmi including the enclosed bays of Golfo Nuevo, Golfo San Jose and San Matias. Golfos San Jose and San Nuevo are within 22 km (12 nmi) coastal exclusion zone.	Southwestern Atlantic Ocean	Southern right whale	May through December
10	Central California National Marine Sanctuaries	Single stratum boundary created from the Cordell Bank, Gulf of the Farallones, and Monterey Bay legal boundaries. Includes Davidson Seamount Management Zone. Boundaries (NOAA, 2008a).	Northeastern Pacific Ocean	Blue whale and Humpback whale	June thru November
11	Antarctic Convergence Zone[26]	30°E to 80°E, 45°S 80°E to 150°E, 55°S 150°E to 50°W, 60°S 50°W to 30°E, 50°S	Southern Ocean	Blue whale, Fin whale, Sei whale, Minke whale, Humpback whale, and Southern right whale	October through March
12	Piltun and Chayvo Offshore Feeding Grounds—Sea of Okhotsk	54°09.436'N, 143°47.408'W 54°09.436'N, 143°17.354'W 54°01.161'N, 143°17.354'W 53°53.580'N, 143°13.398'W 53°26.963'N, 143°28.230'W	Northwestern Pacific Ocean/Sea of Okhotsk	Western Pacific gray whale	June through November

26 OBIA added after NMFS and SME initial reviews. The Antarctic Convergence Zone has been an OBIA since 2001 as required by the 2002 and 2007 SURTASS LFA Sonar 5-Year Rules (NOAA, 2002b and 2007c). There are no additional scientific data that would change this status.

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
		53°07.013'N, 143°35.481'W 52°48.705'N, 143°38.447'W 52°32.077'N, 143°37.788'W 52°21.605'N, 143°34.163'W 52°09.470'N, 143°26.582'W 51°57.686'N, 143°30.208'W 51°36.033'N, 143°42.794'W 51°08.082'N, 143°51.301'W 51°08.082'N, 144°16.742'W 51°24.514'N, 144°11.139'W 51°48.116'N, 144°10.809'W 52°03.194'N, 144°20.363'W 52°23.235'N, 144°10.150'W 52°28.674'N, 144°12.787'W 52°42.523'N, 144°10.150'W 53°12.972'N, 143°55.648'W 53°18.505'N, 143°56.637'W 53°23.041'N, 143°53.011'W 53°28.250'N, 143°53.341'W 53°44.039'N, 143°49.056'W 53°53.207'N, 143°50.045'W 53°59.819'N, 143°48.067'W			
13	Coastal Waters off Madagascar	16°03'55.04"S, 50°27'12.59"E 16°12'23.03"S, 51°03'37.38"E 24°30'45.06"S, 48°26'00.94"E 24°15'28.07"S, 47°46'51.16"E 22°18'00.74"S, 48°14'13.52"E 20°52'24.12"S, 48°43'13.49"E 19°22'33.24"S, 49°15'45.47"E 18°29'46.08"S, 49°37'32.25"E 17°38'27.89"S, 49°44'27.17"E 17°24'39.12"S, 49°39'17.03"E 17°19'35.34"S, 49°54'23.82"E 16°45'41.71"S, 50°15'56.35"E	Western Indian Ocean	Humpback whale and Blue whale	July through September for humpback whale breeding November through December for migrating blue whales
14	Madagascar Plateau, Madagascar Ridge, and	25°55'20.00"S, 44°05'15.45"E 25°46'31.36"S, 47°22'35.90"E	Western Indian	Pygmy blue whale, Humpback	November through

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
	Walters Shoal	27°02'37.71"S, 48°03'31.08"E 35°13'51.37"S, 46°26'19.98"E 35°14'28.59"S, 42°35'49.20"E 31°36'57.96"S, 42°37'49.35"E 27°41'11.21"S, 44°30'11.01"E	Ocean	whale, and Bryde's whale	December
15	Ligurian-Corsican-Provençal Basin and Western Pelagos Sanctuary	42°50.271'N, 06°31.883E 42°55.603'N, 06°43.418E 43°04.374'N, 06°52.165E 43°12.600'N, 07°10.440E 43°21.720'N, 07°19.380E 43°30.600'N, 07°32.220E 43°33.900'N, 07°49.920E 43°36.420'N, 08°05.580E 43°42.600'N, 08°22.140E 43°50.880'N, 08°34.500E 43°58.560'N, 08°47.700E 43°59.040'N, 08°56.040E 43°57.047'N, 09°03.540E 43°52.260'N, 09°08.520E 43°47.580'N, 09°13.500E 43°36.060'N, 09°16.620E 43°28.440'N, 09°05.820E 43°21.360'N, 09°02.100E 43°16.020'N, 08°57.240E 43°04.440'N, 08°47.580E 42°54.900'N, 08°35.400E 42°45.900'N, 08°27.540'E 42°36.060'N, 08°22.020'E 42°22.620'N, 08°15.849'E 42°07.202'N, 08°17.174'E 41°52.800'N, 08°15.720'E 41°39.780'N, 08°05.280'E 41°28.200'N, 08°51.600'E 42°57.060'N, 06°19.860'E	Northern Mediterranean Sea	Fin whale	July to August

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
16	Hawaiian Islands Humpback Whale NMS—Penguin Bank	21°10'02.179"N, 157°30'58.217"W 21°09'46.815"N, 157°30'22.367"W 21°06'39.882"N, 157°31'00.778"W 21°02'51.976"N, 157°30'30.049"W 20°59'52.725"N, 157°29'28.591"W 20°58'05.174"N, 157°27'35.919"W 20°55'49.456"N, 157°30'58.217"W 20°50'44.729"N, 157°42'42.418"W 20°51'02.654"N, 157°44'45.333"W 20°53'56.784"N, 157°46'04.716"W 20°56'32.988"N, 157°45'33.987"W 21°01'27.472"N, 157°43'10.586"W 21°05'20.499"N, 157°39'27.802"W 21°10'02.179"N, 157°30'58.217"W	North-Central Pacific Ocean	Humpback whale	November through April
17	Costa Rica Dome	Centered at 9°N and 88°W	Eastern Tropical Pacific Ocean	Blue whale and Humpback whale	Year-round
18	Great Barrier Reef Between 16°S and 21°S	16°01.829'S, 145°38.783'E 15°52.215'S, 146°20.936'E 17°28.354'S, 146°59.392'E 20°16.228'S, 151°39.674'E 20°58.381'S, 150°30.897'E 20°17.007'S, 149°38.247'E 20°10.941'S, 149°18.247'E 20°02.403'S, 149°12.623'E 19°53.287'S, 149°03.986'E 19°49.866'S, 148°52.135'E 19°53.287'S, 148°44.302'E 19°47.965'S, 148°36.870'E 19°47.205'S, 148°26.024'E 19°19.978'S, 147°39.626'E 19°14.065'S, 147°37.014'E 19°08.913'S, 147°31.993'E 19°05.667'S, 147°24.160'E 19°07.576'S, 147°18.134'E 18°51.718'S, 146°51.219'E 18°44.258'S, 146°54.031'E 18°37.175'S, 146°51.420'E	Coral Sea/Southwestern Pacific Ocean	Humpback whale and Dwarf minke whale	May through September

Table 4-26. Potential SURTASS LFA sonar OBIAs revised for this document.

OBIA Number	Name of Area	Location of OBIA	Water Body	Significant Species	Seasonal Restrictions
		18°31.620'S, 146°43.385'E 18°27.595'S, 146°40.573'E 17°36.676'S, 146°20.488'E 17°20.484'S, 146°16.671'E 17°07.745'S, 146°13.056'E 16°49.769'S, 146°11.047'E 16°41.835'S, 146°03.817'E 16°39.706'S, 145°54.979'E			
19	Bonney Upwelling	37°12'20.036"S, 139°31'17.703"E 37°37'33.815"S, 139°42'42.508"E 38°10'36.144"S, 140°22'57.345"E 38°44'50.558"S, 141°33'50.342"E 39°07'04.125"S, 141°11'00.733"E 37°28'33.179"S, 139°10'52.263"E	Eastern Indian Ocean	Blue whale, Pygmy blue whale, and Southern right whale	December through May
20	Northern Bay of Bengal and Head of Swatch-of-No-Ground (SoNG)	20°59.735'N, 89°07.675'E 20°55.494'N, 89°09.484'E 20°52.883'N, 89°12.704'E 20°55.275'N, 89°18.133'E 21°04.558'N, 89°25.294'E 21°12.655'N, 89°25.354'E 21°13.279'N, 89°16.833'E 21°06.347'N, 89°15.011'E	Bay of Bengal/Northern Indian Ocean	Bryde's whale (small form)	Year-round
21	Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon	48°30'01.995"N, 125°58'38.786"W 48°16'55.605"N, 125°38'52.052"W 48°23'07.353"N, 125°17'10.935"W 48°12'38.241"N, 125°16'42.339"W 47°58'20.361"N, 125°31'14.517"W 47°58'20.361"N, 126°06'16.322"W 48°09'46.665"N, 126°25'48.758"W Existing OBIA boundaries as defined in the 2007 Rule (50 CFR §216.184(f)).	Northeastern Pacific Ocean	Humpback whale	Existing OBIA: December, January, March, and May The Prairie, Barkley Canyon, and Nitnat Canyon June to September

Table 4-27. OBIAs for SURTASS LFA sonar designated under the 2007 Final MMPA Rule (NOAA, 2007c)[27].

Area Number	Name of Area	Location of Area	Months of Importance
1	200 m isobath of North American East Coast[28]	From 28°N to 50°N west of 40°W	Year-round
2	Costa Rica Dome	Centered at 9°N and 88°W	Year-round
3	Antarctic Convergence Zone	30°E to 80°E, 45°S. 80°E to 150°E, 55°S 150°E to 50°W, 60°S 50°W to 30°E, 50°S	October through March
4	Hawaiian Island Humpback Whale NMS—Penguin Bank[29]	Centered at 21°N and 157°30'W	November 1 through May 1
5	Cordell Bank NMS[29]	Boundaries IAW 15 CFR 922.110	Year-round
6	Gulf of the Farallones NMS[29]	Boundaries IAW 15 CFR 922.80	Year-round
7	Monterey Bay NMS[29]	Boundaries IAW 15 CFR 922.130	Year-round
8	Olympic Coast NMS[29]	Within 23 nm of coast from 47°07'N to 48°30'N latitude	December, January, March and May
9	Flower Garden Banks (NMS)[29]29	Boundaries IAW 15 CFR 922.120	Year-round
10	The Gully[30]	44°13'N, 59°06'W to 43°47'N, 58°35'W to 43°35'N, 58°35'W to 43°35'N, 59°08'W to 44°06'N, 59°20'W	Year-round

OBIA #1 (200-m isobath of North American East Coast) under the 2007 Rule was re-designated as LFA OBIAs #1 to #4, which include:

- Georges Bank (LFA OBIA #1);
- Roseway Basin Right Whale Conservation Area (LFA OBIA #2);
- Southeastern U.S. Right Whale Seasonal Habitat (NARW Critical Habitat) (LFA OBIA #4); and

---

27 The SURTASS LFA Sonar FSEIS (DoN, 2007a) identified nine OBIAs but the NMFS 2007 Final Rule designated an additional OBIA, The Gully, as the tenth LFA OBIA.

28 OBIA boundaries encompass the critical habitats of the North Atlantic right whale, Stellwagen Bank NMS, Monitor NMS, and Gray's Reef NMS.

29 Letter from the Office of National Marine Sanctuaries, National Ocean Service, NOAA, dated 15 May 2001.

30 In the 2007 FSEIS (DoN, 2007a), the Navy's alternatives analyses included nine OBIAs. During the rulemaking process, NMFS added The Gully as the tenth OBIA.

- Great South Channel (LFA OBIA #3) including North Atlantic Right Whale (NARW) Critical Habitat, Stellwagen Bank NMS, and areas within the Gulf of Maine.

This approach meets NMFS' biological criteria with seasonal restrictions (where appropriate) and establishes these OBIAs based on the best available science in lieu of geographic restrictions from arbitrarily established distances from shore or bathymetric features.

4.5.5 Operational Exception

The Navy reserves the right to create sound fields from SURTASS LFA transmissions at or above 180 dB dB re 1 µPa (rms) within the boundaries of the designated SURTASS LFA sonar OBIAs pursuant to the FSEIS/SOEIS, including operating within an OBIA when: 1) operationally necessary to continue tracking an existing underwater contact; or 2) operationally necessary to detect a new underwater contact within the OBIA. This exception will not apply to routine training and testing with the SURTASS LFA sonar systems.

4.5.6 Dual Criteria for Coastal Exclusion Zones

The Navy also used the OBIA analysis to consider whether dual criteria to determine the coastal exclusion zones in some locations where the shelf (≤200 m [656 ft] depth) extends farther than the current 22 km (12 nmi) coastal standoff range, is necessary based on the best available scientific information and operational practicability. This analysis was a part of the OBIA analysis (Subchapter 4.5 above and Appendix D), because NMFS and the Navy considered the biological importance of coastal areas outside the current 22 km (12 nmi) coastal standoff range as well as their practicability for SURTASS LFA sonar operations. For example, of the initial listing of 73 recommended LFA MM OBIAs by NMFS' expert panelists, 32 were either completely or partially within shelf waters and outside of the coastal standoff range. After analyses and rankings, NMFS and the Navy agreed on the proposed final 21 SURTASS LFA sonar OBIAs. Of the 21 OBIAs, 17 included important areas for coastal protection, such as continental shelf/slope areas and similar coastal areas. It should also be noted that the east coast continental shelf area previously designated as an OBIA was considered by the SMEs and NMFS. It was determined that the entire eastern seaboard out to the 200-m isobath did not meet the criteria, but that certain more defined areas did, which included:

- Georges Bank (LFA OBIA #1);
- Roseway Basin Right Whale Conservation Area (LFA OBIA #2);
- Southeastern U.S. Right Whale Seasonal Habitat (North Atlantic Right Whale [NARW] Critical Habitat) (LFA OBIA #4); and
- Great South Channel (LFA OBIA #3) including NARW Critical Habitat, Stellwagen Bank NMS, and areas within the Gulf of Maine.

In light of these comprehensive efforts to identify and analyze areas of biological concern outside the 22 km (12 nmi) coastal standoff range and the need for broad operational flexibility, dual criteria for coastal exclusion zones was considered in the overall OBIA analysis process.

4.6 POTENTIAL IMPACTS TO SOCIOECONOMIC RESOURCES

This subchapter addresses the potential impact to commercial and recreational fisheries, other recreational activities, and research and exploration activities that could result from implementation of the alternatives under consideration.

4.6.1 Commercial and Recreational Fisheries

SURTASS LFA sonar operations are geographically restricted such that SURTASS LFA sonar RLs are less than 180 dB dB re 1 µPa (rms) RL within 22 km (12 nmi) from coastlines and at the boundaries of offshore biologically important areas during biologically important seasons, where fisheries productivity is generally high. If SURTASS LFA sonar operations occur in proximity to fish stocks, members of some fish species could potentially be affected by LF sounds. Even then, the impact on fish is likely to be minimal to negligible since only an inconsequential portion of any fish stock would be present within the 180-dB sound field at any given time. Moreover, recent results from direct studies of the effects of LFA sounds on fish (Halvorsen et al., 2006; Popper et al., 2007; Kane et al., 2010) provide evidence that SURTASS LFA sonar sounds at relatively high received levels (up to 193 dB dB re 1 µPa [rms] SPL) have minimal impact on at least the species of fish that were studied. Nevertheless, the 180-dB criterion has been maintained for the analyses presented in this SEIS/SOEIS, with emphasis that this value is *highly conservative* and protective of fish. Therefore, SURTASS LFA sonar operations are not likely to affect fish populations and, thus, are not likely to affect commercial and recreational fishing.

4.6.2 SUBSISTENCE USE

If SURTASS LFA sonar were to be operated in the Gulf of Alaska or off the coast of Washington and Oregon, sonar operation would adhere to the suite of mitigation measures including visual, passive acoustic, and active acoustic monitoring for marine mammals, delay/shutdown protocols, and established geographic restrictions, which includes the coastal standoff range (i.e., the sound field produced by the sonar must be below 180 dB SPL within 22 km (12 nmi) of any coastline and within designated OBIAs). Two OBIAs are included in these regions: one in the Gulf of Alaska encompassing the portion of the North Pacific right whale's critical habitat in the gulf (Appendix D, Figure D-3) with the second OBIA located off the Olympic Coast of Washington State, which encompasses The Prairie, Barkley Canyon, and Nitnat Canyon (see Appendix D, Figure D-20).

While it is impossible to predict the future timing of possible employment of SURTASS LFA sonar in the Gulf of Alaska, regardless of the time of year the sonar may be employed, there should be no overlap in time or space with subsistence hunts of marine mammals due to the geographic restrictions on the sonar (i.e., coastal standoff range and OBIA restrictions). These restrictions prevent the sonar use or sound transmission >180 dB SPL from reaching the shallow coastal and inshore areas of the Gulf of Alaska where subsistence harvest of two pinniped species occurs. The Olympic Coast OBIA provides protection well outside of the 22 km (12 nmi) standoff distance and minimizes potential impacts on the subsistence harvest of gray whales.

Subchapter 4.3.4 concluded that the potential effects from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) are considered negligible, and the potential effects on the stock of any marine mammal from temporary loss of hearing or behavioral change (significant change in a biologically important behavior) are considered minimal. Any auditory masking in marine mammals due to LFA sonar signal transmissions is not expected to be severe and would be temporary. The likelihood of LFA sonar transmissions causing marine mammals to strand is negligible.

The Navy is not currently planning to use SURTASS LFA sonar in the Gulf of Alaska or offshore of the coasts of Washington or Oregon. Nevertheless, the possible employment of SURTASS LFA sonar in the Gulf of Alaska or off the coast of Washington or Oregon will not cause abandonment of any subsistence harvest/hunting locations, will not displace any subsistence users, and will not place physical barriers between marine mammals and the hunters. No mortalities of marine mammals have been associated with the employment of SURTASS LFA sonar, and the Navy undertakes a suite of proven mitigation measures whenever SURTASS LFA sonar is actively transmitting, as detailed in Subchapter 2.5 and Chapter 5.0. Therefore, although there are no current plans to do so, the possible future employment of SURTASS LFA sonar would not lead to unmitigable adverse impacts on the availability of marine mammal species or stocks for subsistence uses in the Gulf of Alaska or off the coast of Washington and Oregon.

4.6.3 OTHER RECREATIONAL ACTIVITIES

There are no new data that contradict any of the assumptions or conclusions regarding Subchapter 4.3.2 (Other Recreational Activities) in the FOEIS/EIS (DoN, 2001) regarding recreational swimming, snorkeling, and diving; hence, the contents of the FOEIS/EIS section are incorporated by reference herein. Whale watching typically takes places during times of year and in geographic locations where the probability of observing cetaceans will be greatest; probability of occurrence is higher because cetaceans have aggregated in specific areas to participate in some biologically important activity such as feeding or migrating. Due to the water depth and accessibility, the vast majority of recreational swimming, snorkeling, and diving occurs within 22 km (12 nmi) of shore. Since SURTASS LFA sonar operations are restricted from transmitting ≥180 dB dB re 1 µPa (rms) SPL RL within 22 km (12 nmi) from shore, more than 145 dB dB re 1 µPa (rms) SPL RL near known recreational and commercial dive sites, and in OBIAs during biologically important seasons, there is no reasonably foreseeable likelihood that operation of the sonar will affect recreational diving, snorkeling, swimming, or whale watching.

4.6.4 RESEARCH AND EXPLORATION ACTIVITIES

There are no new data that contradict any of the assumptions or conclusions regarding Subchapter 4.3.3 in the FOEIS/EIS (DoN, 2001) and Subchapter 4.5.3 in the FSEIS (DoN, 2007a) regarding research and exploration activities; hence, their contents are incorporated by reference herein. SURTASS LFA sonar operations are highly unlikely to affect oceanographic research that utilize submersibles (remotely operated vehicles [ROVs], autonomous undersea vehicles [AUVs], or manned submersibles) but could potentially affect other types of oceanographic research or oil and gas exploration activities that employ underwater acoustic equipment or instruments such as air guns, hydrophones, and ocean-bottom seismometers. If transmitted near oceanographic or exploration activities using underwater acoustic instrument, SURTASS LFA sonar could possibly interfere with the acoustic instruments or saturate the hydrophones. Conversely, research and exploration activities using underwater acoustic instruments or sources could likewise interfere with SURTASS LFA sonar operations. For these reasons, SURTASS LFA sonar operations will not operate in the vicinity of known oceanographic or oil and gas exploratory operations and thus will not have an effect on these activities.

4.7 POTENTIAL CUMULATIVE EFFECTS

Cumulative effects have been defined by the Council on Environmental Quality (CEQ) as:

> "Cumulative impacts is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR 1508.7, 1978)

Four areas were evaluated for the incremental cumulative effects of SURTASS LFA sonar operations with "past, present, and reasonably foreseeable future actions." These include:

- Anthropogenic oceanic noise levels;
- Injury and lethal takes from anthropogenic causes;
- Socioeconomics; and
- Concurrent SURTASS LFA sonar and mid-frequency active (MFA) sonar operations.

4.7.1 CUMULATIVE EFFECTS FROM ANTHROPOGENIC OCEANIC NOISE

The potential cumulative effects issue associated with SURTASS LFA sonar operations is the addition of underwater sound to oceanic ambient noise levels, which in turn could affect marine animals.

Anthropogenic sources of ambient noise that are most likely to have contributed to increases in ambient noise levels are commercial shipping, offshore oil and gas exploration and drilling, and naval and other use of sonar (ICES, 2005; MMC, 2007).

A report of the Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science & Technology (JSOST) states that the Marine Mammal Commission (MMC), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (USFWS) are:

> "…broadening their focus and expertise, based on the increasing realization that sound sources such as large vessels, pile driving, offshore energy development, navigational and/or imaging sonars, and oceanographic research sources may be of concern in addition to the naval and geophysical sound sources currently receiving the greatest attention. While some of these sources may lack the instantaneous output power of some of the powerful active sonars and seismic airgun sources, many of them occur in far greater numbers and cover much greater geographical ranges and deployment times than more intense, acute sounds. The potential for impact from certain lower-power but more ubiquitous sources is increasingly being considered and scientific measurements are required to inform these considerations." (Southall et al., 2009)

The potential effects that up to four SURTASS LFA sonars may have on the overall oceanic ambient noise level are reviewed in the following contexts:

- Recent reports on ambient sound levels in the world's oceans;
- Operational parameters of the SURTASS LFA sonar system, including proposed mitigation;
- Contribution of SURTASS LFA sonar to oceanic noise levels relative to other human-generated sources of oceanic noise; and
- Cumulative effects from concurrent LFA/MFA sonar operations.

4.7.1.1 Oceanic Noise Levels

Ambient noise is the typical or persistent environmental background noise that is present throughout the ocean; it is generated by both natural and anthropogenic sources. The U.S. Marine Mammal Commission, in a recently published document on underwater sound in the marine environment, classifies ambient noise into three broad categories: natural biotic, which can include marine animals, fish, and invertebrates; natural abiotic, such as seismic disturbances; and anthropogenic, which includes noise from shipping vessels and seismic surveying (Bradley and Stern, 2008). Thus, any potential for cumulative effects should be put into the context of recent changes to ambient sound levels in the world's oceans. Sources of oceanic ambient noise, both natural and man-made are presented in the SURTASS LFA sonar FOEIS/EIS Subchapter 3.1.1 as well as in Subchapter 3.1.1 of this document. Research and statements made regarding changes in oceanic noise levels before 2001 can be found in the FOEIS/EIS, Subchapter 4.4.1. The SURTASS LFA sonar FSEIS, Subchapter 4.6.1.1, complements those data with information from 2001 through 2005. These subchapters are incorporated by reference herein to this SEIS/SOEIS.

Andrew et al. (2002) compared ocean ambient sound from the 1960s with the 1990s for a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 dB SPL in the frequency range of 20 to 80 Hz and 200 and 300 Hz, and about 3 dB SPL at 100 Hz over a 33-year period. A possible explanation for the rise in ambient noise is the increase in shipping noise. More recently, McDonald et al. (2006a) compared northeast Pacific Ocean ambient noise levels over the past four decades, from continuous measurements west of San Nicolas Island, California. Ambient noise levels at 30 to 50 Hz were 10 to 12 dB SPL higher in 2003 to 2004 than in 1964 to 1966, suggesting an increase in the rate of average noise of 2.5 to 3 dB SPL per decade. Above 50 Hz, the noise level differences between recording periods gradually diminished to a rise of 1 to 3 dB SPL at 100 to 300 Hz. McDonald et al. (2006a) cite commercial shipping as the most plausible explanation for the measured increases.

Commercial Shipping and Vessel Noise Sources

Subchapter 4.6.1.1 from the SURTASS LFA sonar FSEIS (DoN, 2007a) dealing with commercial shipping and vessel noise sources, remains valid and is incorporated by reference herein to this SEIS/SOEIS, except as noted below. The number of commercial vessels plying the world's oceans approximately doubled between 1965 and 2003, and the gross tonnage quadrupled, with a corresponding increase in horsepower (McDonald et al., 2006a). Clark et al. (2009) demonstrated that acoustic communications space for the highly endangered North Atlantic right whale is seriously compromised by anthropogenic noise from commercial shipping traffic.

Oil and Gas Industry

Subchapter 4.6.1.1 from the SURTASS LFA sonar FSEIS, dealing with the oil and gas industry, remains valid and is incorporated by reference herein to this SEIS/SOEIS. In a recent study, Di Iorio and Clark (2009) found that blue whales increase their rate of social calling in the presence of seismic exploration sparkers (plasma sound sources), which presumably represented a compensatory behavior to elevated ambient noise levels from seismic surveys.

Military and Commercial Sonar

Subchapter 4.6.1.1 from the SURTASS LFA sonar FSEIS, dealing with military and commercial sonar, remains valid and is incorporated by reference herein to this SEIS/SOEIS. The statement excerpted from Southall et al. (2009) above also applies here—that even though naval and geophysical sound sources are currently receiving the greatest attention, other lower-power but more ubiquitous sound sources occur in far greater numbers and cover much greater geographical ranges and deployment times.

Effects of Ambient Noise Increase

As noted above, oceanic ambient noise levels are increasing due to the global escalation in numbers of anthropogenic sources. There is increasing scientific evidence indicating effects on marine mammals from this escalation. In a study by Parks et al. (2007a), evidence was provided of a behavioral change in sound production of the North and South Atlantic right whales, which was correlated with increased underwater ambient noise levels. This indicated that right whales might shift their call frequency to compensate for the increasing band-limitations caused by background noise. Holt et al. (2009) studied the effects of anthropogenic sound exposure on the endangered Southern Resident killer whales in Puget Sound, reporting that these whales increased their call amplitude by 1 dB for every 1 dB increase in background noise (1 to 40 kHz).

4.7.1.2 SURTASS LFA Sonar Combined with Other Human-Generated Sources of Oceanic Noise

The potential for cumulative effects from SURTASS LFA transmissions is analyzed in relation to overall oceanic ambient noise levels, including the potential for LFA sound to add to overall ambient levels of anthropogenic noise. Increases in ambient noise levels have the potential to cause masking and decrease the distances that underwater sound can be detected by marine animals. These effects have the potential to cause a long-term decrease in a marine mammal's efficiency at foraging, navigating, or communicating (ICES, 2005). NRC (2003) discussed acoustically-induced stress in marine mammals. NRC stated that sounds resulting from one-time exposure are less likely to have population-level effects than sounds that animals are exposed to repeatedly over extended periods of time. NRC (2005) proposed an alternative terminology for what "stress" refers to, which considers energy budgets and life-history events, based on McEwen and Wingfield (2003). It focuses on the concept of allostatic[31] load, which was adapted from the cardiovascular field and was introduced for more broad application in McEwen and Stellar (1993).

Ambient Noise Levels and Masking

Subchapter 4.6.1.2 from the SURTASS LFA sonar FSEIS, dealing with ambient noise levels and masking, remains valid and is incorporated by reference herein to this SEIS/SOEIS except as noted below. Broadband, continuous low-frequency ambient noise is more likely to affect marine mammals than narrowband, low duty cycle SURTASS LFA sonar. Moreover, the bandwidth of any SURTASS LFA sonar transmitted signal is limited (approximately 30 Hz), the average maximum pulse length is 60 seconds, signals do not remain at a single frequency for more than 10 seconds, and during an operation the system is off nominally 90 to 92.5% of the time. Most mysticete vocalizations are in the low frequency band below 1 kHz, and it is generally believed that their frequency band of best hearing is below 1 kHz, where their calls have the greatest energy (Clark, 1990; Edds-Walton, 2000; Ketten, 2000). However, with the nominal duty cycle of 7.5 to 10%, masking by LFA would only occur over a very small spatial and temporal scale. For these reasons, any masking effects from SURTASS LFA sonar are expected to be negligible.

As presented in Subchapter 4.6.1.2 of the FSEIS, Hildebrand (2005) concluded that increases in anthropogenic oceanic sound sources most likely to contribute to increased noise in order of importance are: commercial shipping, offshore oil and gas exploration and drilling, and naval and other uses of sonar. This is supported by the findings of Andrew et al. (2002) and McDonald et al. (2006a) discussed above. Both the SURTASS LFA Sonar FOEIS/EIS and FSEIS analyzed the potential effects of four SURTASS LFA sonar systems. The use of SURTASS LFA sonar is not scheduled to increase past the originally analyzed four systems during the next five–year regulation under the MMPA. Therefore, LFA transmissions will not significantly increase anthropogenic oceanic noise in the next five years over that of the previous analyses. The findings in the SURTASS LFA Sonar FSEIS remain valid, and the cumulative effects related to the potential for masking from the proposed four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine animals.

Stress

Subchapter 4.6.1.2 from the SURTASS LFA Sonar FSEIS, dealing with stress, remains valid and is incorporated by reference herein to this SEIS/SOEIS. Even though there are scientific data gaps concerning stress and marine animals, a sufficient understanding exists to make an informed decision regarding the proposed action. Because LFA transmissions will not significantly increase anthropogenic oceanic noise and the potential for masking is negligible, cumulative effects related to the potential for inducing stress from the proposed four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine animals.

Synergistic Effects with Other Oceanic Noise Sources

Subchapter 4.6.1.2 from the SURTASS LFA Sonar FSEIS, dealing with synergistic effects with other oceanic noise sources, remains valid. Since the FSEIS was published in 2007, a comprehensive scientific analysis has been undertaken and is highlighted below to address the potential for cumulative effects from concurrent LFA/MFA sonar operations; this study validates the earlier FSEIS assessment of SURTASS LFA sonar operations concurrent with other military and commercial sonar systems.

---

31 Allostasis refers to the physiological and behavioral mechanisms used by an organism to support homeostasis (the stability of the physiological systems that maintain life) in the face of normal and relatively predictable life-history events, such as migration, mating, rearing young, and seasonal changes in resource availability; and unpredictable events such as decreases in oceanic productivity and increases in human disturbances; and more permanent handicaps, such as injuries, parasites, and contaminant loads.

4.7.2 CUMULATIVE EFFECTS TO MARINE MAMMALS DUE TO INJURY AND LETHAL TAKES

The second area for potential cumulative effects to marine mammal populations is through injury and lethal takes. In order to evaluate the effects of SURTASS LFA sonar operations, it is necessary to place it in perspective with other anthropogenic impacts on marine resources. Subchapter 4.6.2 from the SURTASS LFA Sonar FSEIS, dealing with bycatch and ship strikes, remains valid and is incorporated by reference herein to this SEIS/SOEIS.

4.7.2.1 Bycatch

Culik (2010) stated in his report compiled for the United Nations Environmental Programme (UNEP) Convention on Migratory Species that the major threat faced by odontocetes is by-catch in fisheries operations, which is affecting 86% of toothed whale species. Read et al. (2006) estimated the annual global bycatch for the period 1990 to 1994 to be 653,365 marine mammals (307,753 cetaceans and 345,611 pinnipeds). They also reported that the mean annual marine mammal bycatch in U.S. fisheries between 1990 and 1999 was 6,215, with the number trending downward throughout the decade due to the implementation of bycatch mitigation measures and, coincidentally, due to measures put in place to protect fisheries stocks.

Increases in underwater ambient noise levels have the potential to mask an animal's ability to detect objects, such as fishing gear, thus increasing their susceptibility to bycatch. However, because LFA transmissions are intermittent and will not significantly increase anthropogenic oceanic noise, cumulative effects from masking by LFA signals are not a reasonably foreseeable significant adverse effect on marine animals.

4.7.2.2 Ship Strikes

NMFS convened a workshop to identify and assess technologies to reduce ship strikes of large whales 8 to 10 July 2008, in Providence, RI. The workshop objectives were to: 1) identify existing or emerging technologies that might be useful in reducing ship strikes; 2) assess the feasibility of each in reducing ship strikes; and 3) identify research and development timelines needed to make a given technology useful in reducing the threat.

The outcome of the workshop was a report that stated:

> "…the problem of ship strikes is a complex one; there are no easy technological "fixes;" no technology exists, or is expected to be developed in the foreseeable future that will completely ameliorate, or reduce to zero the chances of, ship strikes of large whales; and no single technology will fit all situations. Reducing the co-occurrence of whales and vessels is likely the only sure means of reducing ship strikes, but it is not possible in many locations…Technologies applicable to reducing ship strikes are limited almost entirely to those that enhance whale detection…Depending on systems used, costs can be relatively high and false positives could be problematic…In all cases, studies are needed to confirm that any technology developed and used for this purpose are clearly capable of reducing strikes and to ensure that added environmental impacts are not introduced." (Silber et al., 2009)

A review of ship strike data found that the probability of injury or death increased with speed and generally occurred when ships were travelling at 14 kts or faster (Laist et al., 2001). Ship strikes are generally not an issue for SURTASS LFA sonar vessels because of their slow operational speed (nominally 3 kts) and transit speed (10 to 12 kts).

4.7.2.3 Lethal Whale Takes

As discussed in Chapter 3 of this document, lethal takes of whales for other activities have been authorized, including those for scientific research and subsistence whaling. Based on extensive evaluation in this document, the FOEIS/EIS, and the FSEIS, the operation of SURTASS LFA sonar with monitoring and mitigation will result in no lethal takes. This is supported by the fact that SURTASS LFA sonar has been operating since 2003 in the northwestern Pacific Ocean with no reported Level A (MMPA) harassment takes or strandings associated with its operations (DoN, 2008; 2009b; 2010). Moreover, there has been no new information or data that contradict the FOEIS/EIS and FSEIS findings that the potential effects from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) are considered not more than negligible. Since there are no reasonably foreseeable effects from LFA operations that would lead to injury or lethal takes of marine animals, there are no cumulative effects in this area due to SURTASS LFA sonar operations.

4.7.3 Cumulative Effects to Socioeconomic Resources

Earlier in this chapter the potential effects on commercial and recreational fisheries, other recreational activities, and research and exploration activities that could result from implementation of the alternatives under consideration were addressed. The conclusion was that these activities would not be substantially affected. Therefore, the potential for cumulative effects from LFA effects on socioeconomic activities are not a reasonably foreseeable significant adverse impact.

4.7.4 Cumulative Effects from Concurrent LFA and MFA Sonar Operations

In 2007, the SURTASS LFA Sonar FSEIS stated:

> "If SURTASS LFA sonar operations were to occur concurrent with other military and commercial sonar systems, synergistic effects are not probable because of differences between these systems. In order for the sound fields to converge, the multiple sources would have to transmit exactly in phase (at the same time), requiring similar signal characteristics, such as time of transmissions, depth, frequency, bandwidth, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, and duty cycle. The potential for this occurring is small." (DoN, 2007a)."

This subchapter provides further analysis regarding the potential for impacts when SURTASS LFA sonar and MFA sonar are used simultaneously or in rapid succession during the same naval exercise/operation.

4.7.4.1 Potential for Combined Effects from LFA and MFA Sonar Transmissions

Although the SURTASS LFA and MFA (AN/SQS 53C and AN/SQS 56) sonars are similar in the underlying transmission types, specifically frequency-modulated (FM) sweeps and continuous wave (CW) transmissions, LFA and MFA sonars are dissimilar in other respects (Table 4-28). In addition to the dissimilarities apparent in the table, the standard MFA duty cycle, (i.e., the amount of time *during sonar operations* that the sonar is actually transmitting), is different for SURTASS LFA sonar as opposed to MFA sonar. During SURTASS LFA sonar operations, LFA sonar transmits approximately 10% of the time (1 minute out of 10). During MFA sonar operations, MFA sonar transmits approximately 1.7% of the time (1 second out of 60)[32]. This means that for any given period of time that both SURTASS LFA and MFA sonars are operating concurrently, the LFA 60-sec transmission will be overlapped by 1. sec of MFA transmission, or 1.7% of the 60-sec LFA ping (1 sec/60 sec) (Figure 4-8). During the 10-min LFA transmission cycle, the most an animal could be simultaneously exposed from both transmissions is 1 sec for every 600 sec, or about 0.17%[33] of the time that both sonars are operating.

---

32 MFA standard sonar operating characteristics are based on the Navy's AN/SQS 53C sonar. The nominal sonar ping is approximately 1 second every 60 to 90 seconds (Nissen, 2011). For analysis, 1 sec/60 sec was used as it is the most conservative.

33 MFA overlaps 1 sec for every 10 min (600 sec) of LFA duty cycle (1 sec/600 sec = 0.0017).

Table 4-28. Comparison of LFA and MFA sonar underwater acoustic source properties (D'Spain et al., 2006; DoN 2007a and 2008b).

	SURTASS LFA SONAR	AN/SQS 53C MFA SONAR	AN/SQS 56 MFA SONAR
Waveform[34]	FM/CW	FM/CW	FM/CW
Source Level[35]	215 dB re 1 µPa at 1 m (rms) per element	235 dB re 1 µPa at 1 m (rms)	223 dB re 1 µPa at 1 m (rms)
Pulse Length	Variable 6 to 100 sec, average 60 sec; never longer than 10 sec at a single frequency	1 to 2 sec	1 to 2 sec
Inter-pulse Time	6 to 15 min	60 to 90 sec	60 sec
Center Frequency	100-500 Hz	2.6 and 3.3 kHz	6.8, 7.5, and 8.2 kHz
Bandwidth	30 Hz	100 Hz	100 Hz
Source Depth	Array 87 to 157 m (285 to 515 ft), center 122 m (400 ft)	8 m (26.2 ft)	6 m (19.7 ft)

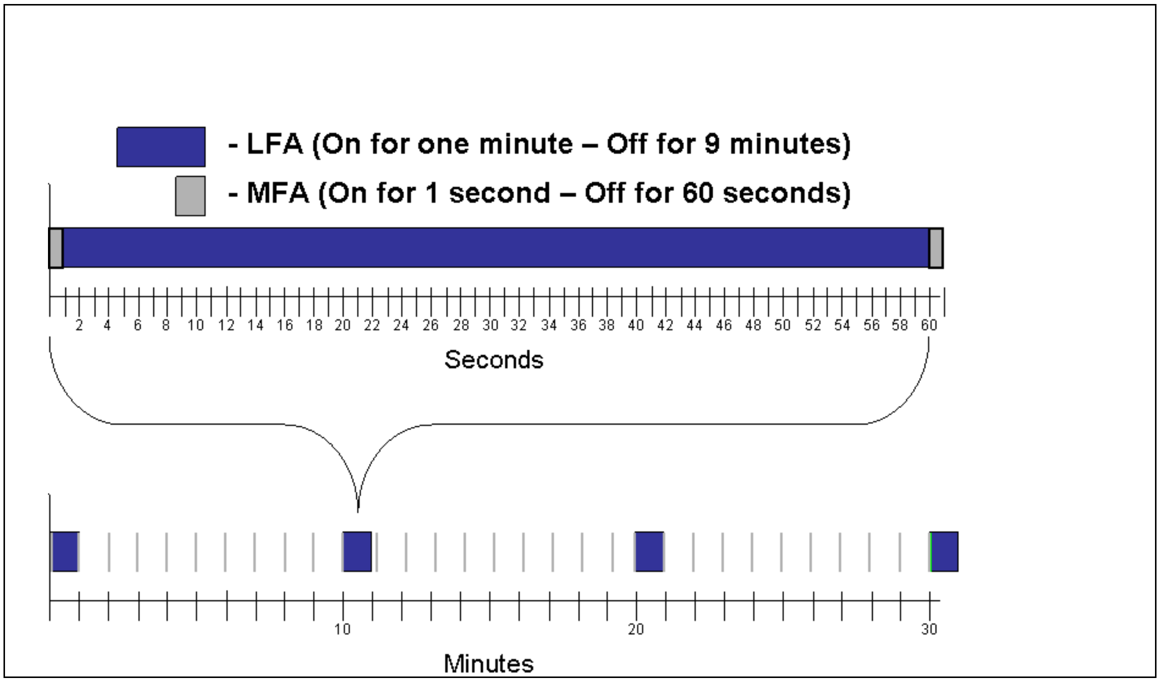


Figure 4-8. Potential for LFA and MFA sonar transmissions to overlap.

34 Frequency modulated (FM), continuous wave (CW).

35 Source levels are rms for sonars in units of dB re 1 µPa @ 1m.

The previous SURTASS LFA Sonar FEIS/FOEIS and FSEIS did not attempt to quantify potential impacts from concurrent SURTASS LFA and MFA sonar operations. The simplest way to attempt such quantification would be to calculate the risk to marine mammals/animals independently for each sonar and then add the results. To address the issue of whether the combined risk from concurrent SURTASS LFA and MFA sonar operations could be more than the sum of the impacts of both systems due to potential synergistic[36] effects, the Navy has conducted additional, more sophisticated analyses (Appendix E).

<u>Potential for MMPA Level A Impacts from Combined Effects</u>

The ocean volume potentially affected by Level A received levels (RLs) for each source are relatively small, being 1 km (0.54 nmi) radius or less, based on NMFS-published Rules (NOAA, 2007c, 2009d, 2009e, and 2009f). For a variety of tactical and safety reasons, however, it is not reasonably foreseeable that SURTASS LFA and MFA sonars would operate at distances closer than 9.3 km (5 nmi) to each other. It is therefore not reasonably foreseeable that the Level A volumes for SURTASS LFA and MFA sonars would ever overlap. The statistical probability of an MFA Level B RL intensifying to a Level A RL when combined simultaneously with a SURTASS LFA sonar Level B RL is also exceedingly low (Appendix E).

Sequential, as opposed to simultaneous, exposures of a single marine mammal to a SURTASS LFA sonar transmission at a RL immediately below Level A and then an MFA transmission at a RL immediately below Level A (or vice versa), could hypothetically result in exposure above 180 dB re 1 µPa (rms) (RL). However, this hypothetical possibility is exceedingly small, given: 1) the low probability that SURTASS LFA and MFA sonars would be operating concurrently in the first place; 2) the low duty cycles of each source, even when such concurrent operations are occurring (0.17% of the time); 3) the fact that both systems would have to be operating close enough to each other for the animal to swim to both exposure points in a short enough period to have experienced, but not recovered from, the impact of the first exposure before experiencing the second exposure; 4) the fact that both the SURTASS LFA and MFA vessels are moving in two dimensions and the animal is moving in three dimensions; and 5) the fact that the exposed animal would have to elude detection by the multiple mitigation regimes for both SURTASS LFA and MFA sonars to be near enough to the Level A volumes of both sonars to experience near-Level A exposures.

<u>Potential for MMPA Level B Effects from Combined Effects</u>

To analyze the possibility for Level B effects of the improbable scenario (simultaneous, or near-simultaneous, MFA and LFA transmissions) occurring, the Navy used two separate methodologies, a parametric analysis and an Acoustic Integration Model© (AIM) analysis, which use the previously established risk continuum for SURTASS LFA sonar (DoN, 2001 and 2007a). The risk continuum methodology for SURTASS LFA sonar was applied here to facilitate a complex analytic process with two dissimilar sonar systems.

The risk continuum for SURTASS LFA sonar was initially developed for determining the risk from SURTASS LFA sonar (DoN, 2001). An exposure of 165 dB SPL (re 1 µPa) returns an associated risk of 0.5 (50%) from the risk continuum function; whereas 150 and 180 dB SPL (re 1 µPa) return 0.025 (2.5%) and 0.95 (95%) risk, respectively (Figure 4-9).

36 Synergism, in general, may be defined as two or more agents working together to produce a result not obtainable by any of the agents independently.

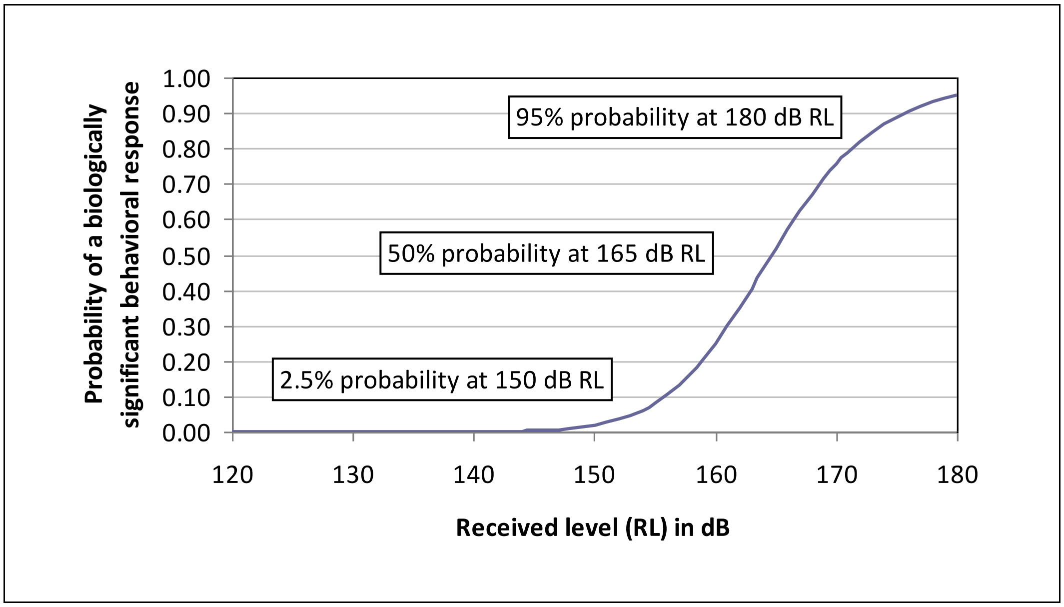


Figure 4-9. The SURTASS LFA sonar risk continuum function.

- **Parametric analysis**

Parametric analysis is a methodology to describe and examine the relationship between different parameters (e.g., in this case acoustic transmission loss as a function of range and depth) and the variable (e.g., potential acoustic effect on marine mammals) that it/they influence or affect. Parametric analysis is derived from “dimensional analysis,”, which is defined as:

> “…the mathematics of dimensions and quantities and provides procedural techniques whereby the variables that are assumed to be significant in a problem can be formed into dimensionless parameters, the number of parameters being less than the number of variables.” (Avallone and Baumeister, 1987)

The advantage of this type of analysis is the reduction of a large number of variables into a smaller, more manageable, number of parameters. This kind of analysis has been in use for over 100 years and is well accepted in the scientific community. One example is the use of a properly scaled ship model to identify the force needed to propel the actual full-size ship through the water, including the size of the engines needed to do so. One of the key inputs is the ratio of inertia and viscous forces using the “Reynolds Number[37],” a key dimensionless number used in naval architecture, aeronautics, and anywhere fluid flow is important.

This analysis identified appropriate metrics for each of the important parameters (e.g., difference in source level [SL], distance between sources, different propagation conditions, Level B harassment criteria, etc.). Then, using such metrics, the risk for multiple animal depths and a variety of sonar separation ranges in static conditions (i.e., a series of “snapshots” of single ping risk for each source, and for the combined sources, with the source vessels in specific locations, was examined. The analysis assumed a convergence zone (CZ) propagation condition (where sound waves in the ocean refract downward and then rise back to the surface at regular intervals known as convergence zones) because it is the most probable sound propagation path that would be encountered with concurrent SURTASS LFA

37 In fluid mechanics, the Reynolds number (Re) is a dimensionless number that gives a measure of the ratio of inertial forces to viscous forces and consequently quantifies the relative importance of these two types of forces for given flow conditions.

and MFA sonar operations. Details of this analysis are provided in Appendix E, along with discussions of other propagation conditions (i.e., bottom bounce, surface duct). In summary, this parametric analysis demonstrates that concurrent MFA/SURTASS LFA sonar operations produce a zero increase in risk over that from summing the risk of the two sources operating independently.

- **Acoustic Integration Model© (AIM) analysis**

This approach (similar to that used for specific operations of SURTASS LFA sonar) used AIM to develop the sound-source exposure history for individual animals in a multiple-source exposure scenario. To estimate the acoustic exposure an animal is likely to receive while the sources are transmitting, the 3-dimensional movement of animals and the acoustic fields to which they would be exposed were modeled based on nominal transmissions of the MFA and SURTASS LFA sonars. The sound fields around each source were estimated based on: 1) acoustic parameters of the SURTASS LFA sonar; 2) acoustic parameters of the MFA sonar; and 3) underwater acoustic propagation models to predict underwater sound transmissions for CZ and surface duct scenarios[38]. To estimate the risk of MMPA Level B harassment from each acoustic source, the acoustic exposures an animal receives were used to calculate a single ping equivalent, which is input into the SURTASS LFA sonar risk continuum to estimate Level B harassment (Figure 4-9). The single ping equivalent RLs were then evaluated for each source separately, and combined (Appendix E). In summary, the model analysis demonstrated that the result of concurrent MFA/SURTASS LFA sonar operations produces a zero increase in risk over that from summing the risk of the two sources operating independently.

- **Conclusion**

The results of the parametric analysis and the model analysis are consistent—concurrent MFA/SURTASS LFA sonar operations produce no risk greater than that obtained by simply adding the risks from the individual sources. Therefore, two separate analytic approaches have concluded that there is no potential increase in risk for Level B harassment from concurrent MFA/SURTASS LFA sonar operations.

4.7.4.2 Overall Risk from Concurrent MFA/SURTASS LFA Sonar Operations

Analyses of the potential impacts associated with the concurrent operation of SURTASS LFA and MFA sonars during naval exercises/operations demonstrate that the overall risks of Level A and Level B impacts are no greater than the risks obtained by simply adding the risks from the individual SURTASS LFA and MFA sources. Thus, the conclusion in the SURTASS LFA Sonar FSEIS (DoN, 2007a) that the potential for this occurring is small remains valid, and should be considered very conservative.

4.7.5 SUMMARY OF CUMULATIVE EFFECTS

The operations of up to four SURTASS LFA sonars were evaluated for the potential for cumulative effects in the following foreseeable areas:

- Anthropogenic oceanic noise levels;
- Injury and lethal takes from anthropogenic causes;
- Socioeconomics; and
- Cumulative effects from concurrent LFA and MFA sonar operations.

Given the information provided in this subchapter, the potential for cumulative effects from the operations of up to four SURTASS LFA sonars has been addressed by limitations proposed for employment of the

38 See Appendix E for the technical details of the model analysis. The bottom bounce sound propagation scenario was not modeled because the potential for SURTASS LFA sonar to conduct operations in water depths that would support bottom bounce propagation as the primary sound transmission path is minimal. Moreover, for SURTASS LFA sonar operations, the bottom bounce propagation scenario would always yield higher transmission loss values (and hence shorter RL ranges) than the surface duct propagation scenario.

system (i.e., geographical restrictions and monitoring mitigation). Even if considered in combination with other underwater sounds, such as commercial shipping, other operational, research, and exploration activities (e.g., acoustic thermometry, hydrocarbon exploration and production), recreational water activities, commercial and military sonars, and naturally-occurring sounds (e.g., storms, lightning strikes, subsea earthquakes, underwater volcanoes, whale vocalizations, etc.), the proposed four SURTASS LFA sonar systems do not add appreciably to the underwater sounds to which fish, sea turtles and marine mammal stocks are exposed. Moreover, SURTASS LFA sonar will cause no lethal takes of marine mammals or other marine animals. Analysis of the potential impacts from concurrent LFA and MFA sonar operations demonstrates that the overall risks for Level A and Level B impacts are no greater than the risks obtained by simply adding the risks from individual LFA and MFA sources. Therefore, cumulative effects from the operation of up to four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine animals.

4.8 EVALUATION OF ALTERNATIVES

NEPA requires federal agencies to prepare an EIS that discusses the environmental effects of a reasonable range of alternatives (including the No Action Alternative). Reasonable alternatives are those that will accomplish the purpose and meet the need of the proposed action, and are practical and feasible from a technical and economic standpoint.

This SEIS/SOEIS is the third environmental impact statement for SURTASS LFA prepared under NEPA and Executive Order 12114. Previous to this document, a final environmental impact statement (under NEPA) and final overseas environmental impact statement (under Executive Order 12114) were prepared in 2001 (DoN, 2001) and supplemented in 2007 (DoN, 2007a). In these documents, numerous potential alternatives have been analyzed including: acoustic and non-acoustic detection methods such as radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, biological technologies, passive sonar and high- or mid-frequency active sonar; monitoring and mitigation for fish; the use of small boats and aircraft for pre-operational surveys; and an extended coastal standoff range of 46 km (25 nmi) vice 22 km (12 nmi). It has been concluded in the FOEIS/EIS (DoN, 2001) and the FSEIS (DoN, 2007a) that none of these potential alternatives met the purpose and need of the proposed action to provide Naval forces with reliable long-range detection and, thus, did not provide adequate reaction time to counter potential threats. Furthermore, they were not considered practical and/or feasible for technical and economic reasons.

4.8.1 ALTERNATIVES PREVIOUSLY CONSIDERED

4.8.1.1 SURTASS LFA Sonar Offshore Biologically Important Areas (OBIAs)

SURTASS LFA Sonar OBIAs were introduced in the 2001 FOEIS/EIS as a geographic restriction to provide protection for offshore areas that were outside of the 22 km (12 nmi) coastal standoff, where species of concern (ESA listed species and/or marine mammals) congregated in high density to carry out biologically important activities. Under the 2002 5-Year Rule, there were four designated OBIAs. In the 2007 SEIS and 5-Year Rule, there were ten OBIAs designated.

The current process for the identification of OBIAs is provided in Subchapter 4.5. The resulting 21 OBIAs (Table 4-26) reflect a thorough review of potential areas where SURTASS LFA sonar may be restricted from operating without significantly impacting the Navy's required ASW readiness and training evolutions.

4.8.1.2 Monitoring and Mitigation for Fish

The FSEIS (2007) examined the potential for SURTASS LFA sonar operations to affect fish stocks based on scientific results from fish controlled exposure experiments (CEEs), which exposed fish to LFA signals. These scientific results from independent scientists indicate that there were no injuries to auditory and non-auditory tissues at received levels of 193 dB re 1 µPa at 1 m (rms). The opportunity for a fish or a school of fish to be exposed to sound pressure levels from SURTASS LFA sonar transmissions that could cause injury was considered negligible. Therefore, based on scientific research, it was determined in the FSEIS (2007) that mitigation protocols for fish were not required. Thus, these protocols were not considered in the alternatives for this document.

4.8.1.3 Coastal Standoff Range

The FSEIS (2007) analyzed the differences in potential impacts from increasing the coastal standoff from 22 km (12 nmi) to 46 km (25 nmi) (a difference of 24 km [13 nmi]). Based on the analysis of the risk areas and the potential impacts to marine animals, it was concluded that increasing the coastal standoff range does decrease exposure to higher received levels for the concentrations of marine animals closest to shore (shelf species) but does so at the expense of increasing exposure levels for shelf break and pelagic species. The analysis showed that overall there is a greater risk of potential impacts to marine animals with an increase of the coastal standoff from 22 km (12 nmi) to 46 km (25 nmi); and does not meet the standard of effecting the least practicable adverse impact on the species or stock under the MMPA. Details of this analysis are presented in Subchapter 4.8.6 of the 2007 FSEIS and are incorporated herein by reference.

4.8.2 Alternatives Considered in This SEIS/SOEIS

In previous SURTASS LFA sonar NEPA documents, numerous potential alternatives were analyzed including: acoustic and non-acoustic detection methods such as radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, biological technologies, passive sonar and high- or mid-frequency active sonar; unrestricted SURTASS LFA sonar operations; monitoring and mitigation for fish; the use of small boats and aircraft for pre-operational surveys; and an extended coastal standoff range of 46 km (25 nmi) vice 22 km (12 nmi). Non-acoustic alternative ASW detection technologies that were originally presented in Subchapter 1.2.1 of the 2001 FOEIS/EIS (Don, 2001) were reviewed and updated in Subchapter 1.1.4 of this SEIS/SOEIS reaching the same conclusions. It was concluded in the FOEIS/EIS (DoN, 2001) and the FSEIS (DoN, 2007a) that none of these potential alternatives was capable of accomplishing the Navy's purpose and need nor was considered practical and/or feasible for technical and economic reasons.

The following alternatives were proposed and considered in this SEIS/SOEIS (Table 4-29):

- No Action Alternative;
- Alternative 1—Same as the 2007 FSEIS Preferred Alternative; and
- Alternative 2—Alternative 1 with updated OBIA list.

The analyses of these alternatives take into account the analyses contained in this SEIS/SOEIS on the issues of OBIAs (Subchapter 4.5) and larger coastal standoff distances (Subchapter 4.5.6). Alternatives 1 and 2 also include the same mitigation and monitoring measures utilized in the 2007 FSEIS Subchapters 2.4, 5.1, 5.2, and 5.3, which are incorporated herein by reference.

Table 4-29. Alternatives considered in this document for SURTASS LFA sonar operation.

PROPOSED RESTRICTIONS/MONITORING	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2
Dive Sites	NA[39]	RL not exceed 145 dB SPL	RL not exceed 145 dB SPL
Coastline Restrictions	NA	RL <180 dB SPL within 12 nmi of coast	RL <180 dB SPL within 12 nmi of coast
2007 NMFS Final Rule (NOAA, 2007c) OBIAs (total 10)[40]	NA	Yes	No
Updated OBIAs (total 21)	NA	No	Yes
Visual Monitoring	NA	Yes	Yes
Passive Acoustic Monitoring	NA	Yes	Yes
Active Acoustic Monitoring	NA	Yes	Yes
Reporting	NA	Yes	Yes

4.8.2.1 No Action Alternative

Under the No Action Alternative, the SURTASS LFA sonar systems would not be deployed. While the No Action Alternative would avoid all environmental effects of employment of SURTASS LFA sonar, the Navy's stated priority ASW need for long-range underwater threat detection would not be realized. The implementation of this alternative would allow potentially hostile submarines to clandestinely threaten U.S. Fleet assets and land-based targets. Without the SURTASS LFA sonar long-range surveillance capability, the reaction times to enemy submarine threats would be greatly reduced and the effectiveness of close-in, tactical systems to neutralize threats would be seriously, if not fatally, compromised.

Because the Navy would not conduct SURTASS LFA sonar operations, marine mammals present in the Atlantic, Pacific, and Indian Ocean, and the Mediterranean Sea would not be incidentally harassed by the SURTASS LFA sonar. This alternative would eliminate any potential risk to the environment from the proposed activities. The Navy would not need nor receive an exemption from the MMPA and ESA prohibitions against incidental take that would allow them to conduct the SURTASS LFA operations in compliance with these statutes.

39 NA = Not applicable

40 In the 2007 FSEIS (DoN, 2007a), the Navy's alternatives analyses included 9 OBIAs. During the rulemaking process, NMFS added The Gully as the 10th OBIA,

4.8.2.2 Alternative 1

Alternative 1 is the same as Alternative 2 presented in Subchapter 2.6.3 of the FSEIS (DoN, 2007a), which is incorporated herein by reference. This alternative proposes the employment of SURTASS LFA sonar technology with geographical restrictions to include maintaining SURTASS LFA sonar received levels below 180 dB re 1 µPa (rms) within 22 km (12 nmi) of any coastline and within the designated OBIAs (see Table 2-4 of the FSEIS [DoN, 2007a] and the Final Rule [NOAA, 2007c]) that are outside of 22 km (12 nmi). Restrictions for OBIAs are year-round or seasonal, as dictated by marine animal abundances. SURTASS LFA sonar sound fields will not exceed received levels of 145 dB re 1 µPa (rms) within known recreational and commercial dive sites. Monitoring mitigation includes visual, passive acoustic, and active acoustic (HF/M3 sonar) to prevent injury to marine animals when employing SURTASS LFA sonar by providing methods to detect these animals within the LFA mitigation zone and delay/suspend transmissions accordingly.

Under Alternative 1, as was concluded in the FOEIS/EIS, the potential effects on any stock of marine mammals from injury are considered to be negligible, and the effect on the stock of any marine mammal from significant change in a biologically important behavior is considered to be minimal. Any momentary behavioral responses and possible indirect effects on marine mammals due to potential effects on prey species are considered not to be biologically significant effects. Any auditory masking in mysticetes, odontocetes, or pinnipeds is expected to be temporary and not severe. Further, the potential effects on any stock of fish or sea turtles from injury are also considered to be negligible, and the effect on the stock of any fish or sea turtles from significant change in a biologically important behavior is considered to be negligible to minimal. Any auditory masking in fish or sea turtles is expected to be temporary in duration and of minimal significance. Under this alternative, NMFS would incorporate mitigation and monitoring measures and reporting requirements into the MMPA rulemaking and Letters of Authorization.

4.8.2.3 Alternative 2 (The Preferred Alternative)

Alternative 2 is the Navy's preferred alternative. This alternative is the same as Alternative 1 but includes a comprehensive update of the OBIAs, as analyzed in Subchapter 4.5. Under this alternative, 21 OBIAs are proposed (Table 4-26).

Under Alternative 2, the Navy would implement additional geographic restrictions on SURTASS LFA sonar operations through the inclusion of more LFA MM OBIAs. The conclusions relative to Alternative 1 regarding the potential for injury to a marine animal or significant change in a biologically important behavior of a marine animal from the operation of SURTASS LFA sonar would also apply to this alternative. Potential effects to marine animals from SURTASS LFA sonar operations under this alternative would be expected to be less when compared to Alternative 1 conclusions due to the more restricted geographic area available for operations of SURTASS LFA sonar systems.

Under this alternative, NMFS would incorporate mitigation and monitoring measures and reporting requirements into the MMPA rulemaking and Letters of Authorization. Accordingly, this NEPA Alternative would satisfy the purpose and need of the NMFS' MMPA action—(the issuance of regulations and subsequent LOAs along with required mitigation measures and monitoring), and would enable the Navy to comply with the statutory and regulatory requirements of the MMPA and ESA.

4.8.2.4 Summary of Alternatives

Three alternatives were considered and assessed in this SEIS/SOEIS for their capability to meet the Navy's and NMFS' purpose and need for this action as well as effecting the least practicable adverse impact on marine mammal species or stocks under the MMPA. The No Action Alternative does not meet the Navy's ASW need for long-range underwater threat detection nor does it provide the Navy with needed training opportunities. While both Alternatives 1 and 2 meet the Navy's ASW and training needs, it is Alternative 2 that provides the most effective least practicable adverse impacts to marine mammals with the increased number of proposed OBIAs. Alternative 2 would, however, be expected to decrease to some extent the littoral areas where SURTASS LFA sonar operations could occur outside of 22 km (12 nmi). Thus, the long-range detection of threats in the littorals and Fleet training in the littorals would remain high but may be slightly degraded compared to Alternative 1.

4.9 CONCLUSION OF ANALYSES OF POTENTIAL IMPACTS AND EFFECTS OF SURTASS LFA SONAR ON MARINE SPECIES

This SEIS/SOEIS is the third NEPA analysis of the potential impacts of the employment of SURTASS LFA sonar. Since the late 1990's, these public documents (DoN, 2001 and 2007a) determined that the potential impact on any stock of marine mammal from injury was considered to be negligible, and the effect on the stock of any marine mammal from significant change in a biologically important behavior was considered to be minimal. Any momentary behavioral responses and possible indirect impacts to marine mammals due to potential impacts on prey species were not considered as biologically significant effects. Any auditory masking in mysticetes, odontocetes, or pinnipeds was not expected to be severe and would be temporary. Further, the potential impact on any stock of fish or sea turtles from injury was also considered to be negligible, and the effect on the stock of any fish or sea turtles from significant change in a biologically important behavior was considered to be negligible to minimal. Any auditory masking in fish or sea turtles was expected to be of minimal significance and, if occurring, would be temporary.

During the first two analyses, the U.S. Navy sponsored independent scientific research on the potential effects of SURTASS LFA sonar on human divers, marine mammals, and fish. The Naval Submarine Medical Research Laboratory conducted a series of in-water tests and laboratory experiments that determined the damage risk threshold for Navy divers was a received level of 160 dB re 1 µPa (rms) and a safe exposure limit for recreational and commercial divers of 145 dB re 1 µPa (rms) (DoN, 2001). The Low Frequency Sound Scientific Research Program (LFS SRP) field research in 1997-98 provided important results on and insights into the types of responses of whales to SURTASS LFA sonar signals. The results of the LFS SRP confirmed that some portion of the whales exposed to the SURTASS LFA sonar responded behaviorally by changing their vocal activity, moving away from the source vessel, or both, but the responses were short-lived (Clark et al., 2001; Croll et al., 2001b). Recent scientific results from fish controlled exposure experiments (CEE) with LFA signals indicate that the opportunity for a fish or a school of fish to be exposed to sound pressure levels from SURTASS LFA sonar transmissions that could cause injury is negligible (Popper et al., 2007; Kane et al., 2010).

This chapter reviewed and updated the potential for impacts on fish, sea turtles, and marine mammals. The potential impacts to fish stocks are minimal to negligible and potential impacts to sea turtles are considered negligible. The potential effects from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) are considered negligible, and the potential effects on the stock of any marine mammal from temporary loss of hearing or behavioral change (significant change in a biologically important behavior) are considered minimal. Any auditory masking in marine mammals due to SURTASS LFA sonar signal transmissions is not expected to be severe and would be temporary. The likelihood of SURTASS LFA sonar transmissions causing marine mammals to strand is negligible.

This chapter also provides supplemental risk assessment analyses of 19 additional operating areas (see Table 4-4) where SURTASS LFA sonar could potentially test, train or operate during the 5-year period of the next MMPA rule. It also includes an extensive review of areas of the world to identify OBIAs for LF sensitive species, recommending 21 areas where marine mammals will be protected from 180 dB re 1 µPa (rms) (RL) from SURTASS LFA sonar. Cumulative effects for SURTASS LFA sonar operations were analyzed, including an extensive analysis of the potential for cumulative effects from concurrent LFA and standard MFA sonar operations. It was concluded that the overall cumulative effects for the operation of up to four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine mammals. Alternatives were analyzed and Alternative 2 was the Navy's preferred alternative. This is the same as the preferred alternative from the SURTASS LFA Sonar FSEIS (DoN, 2007a) with updated OBIAs.

Based on the results of the analyses in this document and the two previous NEPA EISs, operation of SURTASS LFA sonars, when employed in accordance with the mitigation measures (geographic restrictions and monitoring/reporting) detailed in Chapter 5.0, support a negative impact determination. These include:

- Potential effects on most if not all individual marine mammals are expected to be limited to Level B harassment. The Navy does not expect those effects to impact rates of recruitment or survival on the associated marine mammal species and stocks.
- Navy's impact analysis does not anticipate any mortality nor any injury of marine mammals (Level A harassment) to occur as a result of LFA sonar operations, and the potential to cause strandings of marine mammals is negligible. Thus, effects on recruitment or survival are expected to be negligible.
- Potential for injury to sea turtles and fish species and stocks are negligible.
- Potential for non-injurious effects (TTS, masking, modification of biological important behavior) is minimal to negligible.
- Cumulative effects are not a reasonably foreseeable adverse impact.

Since the initial LOA was issued for the operation of SURTASS LFA sonar systems in 2002, the percent of Level B incidental takes of marine mammals has consistently been below the amounts authorized in the LOAs. There have been no reported strandings and no Level A takes incidental to LFA operations.

Therefore, this document supports the Navy application under the MMPA for take authorizations incidental to the operation of SURTASS LFA sonar by providing the means of effecting the least practicable adverse impact on the species or stock and its habitat and on the availability of the species or stock for "subsistence" uses. These results will also support the interagency consultations, or Section 7 consultations, under the ESA to ensure the operations of SURTASS LFA sonar do nor jeopardize the continued existence of a species or destroy or adversely modify critical habitat.

5.0 MITIGATION MEASURES

Mitigation, as defined by the Council on Environmental Quality (CEQ), includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. In this document, three alternatives for the operation of SURTASS LFA sonar are presented, two of which will meet, to varying degrees, the Navy's purpose and need and reduce potential impacts through the mitigation measures discussed in this chapter. The mitigation and monitoring measures presented for the SURTASS LFA sonar are similar to those in the FSEIS (DoN, 2007a).

The objective of these mitigation measures is to effect the least practicable adverse impact on marine mammal species or stocks and to avoid risk of injury to marine mammals, sea turtles, and human divers. These objectives are met by:

- Ensuring that coastal waters within 22 km (12 nmi) of shore (including islands) are not exposed to SURTASS LFA sonar signal received levels (RL) ≥180 dB re 1 µPa (rms) (sound pressure level [SPL]);
- Ensuring that no offshore biologically important areas (OBIA) are exposed to SURTASS LFA sonar signal RLs ≥180 dB re 1 µPa (rms) (SPL) during biologically important seasons;
- Minimizing exposure of marine mammals and sea turtles to SURTASS LFA sonar signal RLs below 180 dB re 1 µPa (rms) (SPL) by monitoring for their presence and delaying/suspending transmissions when one of these animals enters the LFA mitigation zone; and
- Ensuring that no known recreational or commercial dive sites are subjected to SURTASS LFA sonar signal RLs >145 dB re 1 µPa (rms) (SPL).

In the 2007-2012 Final Rule, NMFS required a 1-km (0.54-nmi) buffer zone operational restriction as discussed in Subchapter 2.5.2. In the Proposed Rule for the period 2012 to 2017, NMFS also proposes that the SURTASS LFA sonar sound field does not exceed 180 dB re 1 µPa received level at a distance of 1 km (0.54 nmi) beyond the LFA mitigation zone and 1 km (0.54 nmi) seaward of the outer boundary of any OBIA (NOAA, 2012). The mitigation measures presented in this chapter include this 1-km buffer zone requirement. Strict adherence to these measures will minimize impacts on marine mammal stocks and species, as well as on sea turtle stocks, and recreational or commercial divers.

5.1 GEOGRAPHIC RESTRICTIONS

The following geographic restrictions (Table 5-1) apply to the employment of SURTASS LFA sonar:

- SURTASS LFA sonar-generated sound field is below RLs of 180 dB re 1 µPa (rms) (SPL) within 22 km (12 nmi) of any coastlines (including islands);
- SURTASS LFA sonar-generated sound field is below RLs of 180 dB re 1 µPa (rms) (SPL) 1 km (0.54 nmi) seaward of the outer boundary of offshore areas outside of 22 km (12 nmi) of the coastline that have been determined by NMFS and the Navy to be biologically important (i.e., OBIAs);
- When in the vicinity of known recreational or commercial dive sites, SURTASS LFA sonar is operated such that the sound fields at those sites would not exceed RLs of 145 dB re 1 µPa (rms) (SPL); and
- SURTASS LFA sonar operators estimate LFA sound field RLs (SPL) prior to and during operations to provide the information necessary to modify operations, including the delay or suspension of transmissions, in order not to exceed RLs of 180 dB re 1 µPa (rms) and 145 dB re 1 µPa (rms) sound field criteria cited above.

Table 5-1. Summary of mitigation measures for the operation of SURTASS LFA sonar.

MITIGATION MEASURE	CRITERIA	ACTIONS
Geographic Restrictions		
22 km (12 nmi) from coastline/island	Sound field below 180 dB re 1 µPa (rms) RL, based on SPL modeling	Delay/suspend SURTASS LFA sonar operations if sound field criterion is exceeded
Offshore biologically important areas (OBIA) during biologically important seasons	Sound field below 180 dB re 1 µPa (rms) RL, based on SPL modeling, at 1 km (0.54 nmi) seaward of outer boundaries of OBIAs	Delay/suspend SURTASS LFA sonar operations if sound field criterion is exceeded
Recreational and commercial dive sites[1]	Sound field not to exceed 145 dB re 1 µPa (rms) RL, based on SPL modeling	Delay/suspend SURTASS LFA sonar operations if sound field criterion is exceeded
Monitoring to Prevent Injury to Marine Mammals and Sea Turtles		
Visual Monitoring	Potentially affected species near the vessel but outside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Notify Military Detachment (MILDET) Officer in Charge (OIC)
	Potentially affected species sighted inside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Delay/suspend SURTASS LFA sonar operations
Passive Acoustic Monitoring	Potentially affected species detected	Notify MILDET OIC
Active Acoustic Monitoring	Contact detected and determined to have a track that would pass within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Notify MILDET OIC
	Potentially affected species detected inside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone	Delay/suspend SURTASS LFA sonar operations

1 Recreational dive sites generally are located in coastal areas ranging from the shoreline out to the 40-m (130-ft) depth contour.

5.1.1 OFFSHORE BIOLOGICALLY IMPORTANT AREAS

There are certain areas of the world's oceans that are biologically important to marine animals of concern (those animals listed under the ESA and/or marine mammals). Because the majority of these areas exist within the coastal zone, SURTASS LFA sonar operations would be conducted such that the sound field is below RLs of 180 dB re 1 µPa (rms) within 22 km (12 nmi) of any coastline (including islands). Since certain areas of biological importance lie outside these coastal areas, the Navy and NMFS developed the concept of OBIAs as described in Chapter 4. OBIAs are part of a comprehensive suite of mitigation measures used in previous authorizations to minimize impacts and adverse effects to marine mammals. LFA sonar operations would be conducted such that the LFA sound field is below RLs of 180 dB re 1 µPa (rms) at 1 km (0.54 nmi) seaward of the outer boundary of designated OBIAs during the biologically important season for that particular area, as presented in Chapter 4 and as modified in the MMPA Rule/LOAs, as issued. The SURTASS LFA sonar sound field is estimated in accordance with the guidelines listed below.

5.1.2 RECREATIONAL AND COMMERCIAL DIVE SITES

SURTASS LFA sonar operations are constrained in the vicinity of known recreational and commercial dive sites to ensure that the sound field at such sites does not exceed RLs of 145 dB re 1 µPa (rms). Recreational dive sites are generally defined as coastal/island areas from the shoreline out to the 40-m (130-ft) depth contour, which are frequented by recreational divers; but it is recognized that there are other sites that may be outside this boundary. The SURTASS LFA sonar sound field is estimated in accordance with the guidelines that follow.

5.1.3 SOUND FIELD MODELING

SURTASS LFA sonar operators estimate LFA sound field RLs (SPL) prior to and during operations to provide the information necessary to modify operations, including the delay or suspension of transmissions, so that the sound field criteria cited in this chapter are not exceeded. Sound field limits are estimated using near-real-time environmental data and underwater acoustic performance prediction models. These models are an integral part of the SURTASS LFA sonar processing system. The acoustic models help determine the sound field by predicting the SPLs, or RLs, at various distances from the SURTASS LFA sonar source location. Acoustic model updates are nominally made every 12 hr, or more frequently when meteorological or oceanographic conditions change.

If the sound field criteria were exceeded, the sonar operator would notify the Military Detachment (MILDET) Officer in Charge (OIC), who would order the delay or suspension of transmissions. If it were predicted that the SPLs would exceed the criteria within the next 12 hr, the OIC would also be notified in order to take the necessary action to ensure that the sound field criteria would not be exceeded.

5.1.4 PREVIOUSLY CONSIDERED MITIGATION MEASURES

The following mitigation measures were considered in the previous SURTASS LFA sonar NEPA documents but not carried forward. Subchapter 5.4 of the SURTASS LFA Sonar FSEIS (DoN, 2007a) evaluated the use of small boats and aircraft for pre-operational surveys. It was concluded that these surveys were not feasible because they were not practicable, not effective, might increase the harassment of marine mammals, and were not safe to the human performers. Therefore, under the revisions to the MMPA by the National Defense Authorization Act of fiscal year 2004 (NDAA FY04), pre-operational surveys were not considered as a viable mitigation option. Subchapter 4.7.6 of the SURTASS LFA FSEIS (DoN, 2007a) also analyzed increasing the coastal standoff range to 46 km (25 nmi); this analysis showed that, overall, there is a greater risk of potential impacts to marine animals with the increase of the coastal standoff range from 22 km (12 nmi) to 46 km (25 nmi). This is due to an increase in the affected area with less of the ensonified annuluses overlapping land for the 46 km (25 nmi) standoff range than for the 22 km (12 nmi) standoff range. Other discussions of mitigation measures recommended in comments are provided in the response to comments Subchapter 10.3 of the SURTASS LFA FSEIS (DoN, 2007a) and Subchapter 7.3 of this document.

5.2 MONITORING TO PREVENT INJURY TO MARINE ANIMALS

The following monitoring to prevent injury to marine animals (Table 5-1) is required when employing SURTASS LFA sonar:

- **Visual monitoring** for marine mammals and sea turtles from the SURTASS LFA sonar vessels during daylight hours by personnel trained to detect and identify marine mammals and sea turtles;
- **Passive acoustic monitoring** using the passive (low frequency) SURTASS towed array to listen for sounds generated by marine mammals as an indicator of their presence; and
- **Active acoustic monitoring** using the High Frequency Marine Mammal Monitoring (HF/M3) sonar, which is a Navy-developed, enhanced HF commercial sonar, to detect, locate, and track marine mammals and, to some extent, sea turtles, that may pass close enough to the SURTASS LFA sonar's transmit array to enter the LFA mitigation zone plus the 1-km (0.54-nmi) buffer zone.

All sightings are recorded in the log and provided as part of the Long Term Monitoring (LTM) Program (as discussed in Subchapter 2.4.2 of the SURTASS LFA sonar FOEIS/EIS [DoN, 2001]) to monitor for potential long-term environmental effects, which is incorporated herein by reference

5.2.1 VISUAL MONITORING

Visual monitoring includes daytime observations for marine mammals and sea turtles from the vessel. Daytime is defined as 30 minutes before sunrise until 30 minutes after sunset. Visual monitoring begins 30 minutes before sunrise or 30 minutes before the SURTASS LFA sonar is deployed. Monitoring continues until 30 minutes after sunset or until the SURTASS LFA sonar is recovered. Observations are made by personnel trained in detecting and identifying marine mammals and sea turtles. Marine mammal biologists qualified in conducting at-sea marine mammal visual monitoring from surface vessels train and qualify designated ship personnel to conduct at-sea visual monitoring. The objective of these observations is to maintain a track of marine mammals and/or sea turtles observed and to ensure that none approach the source close enough to enter the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone as defined in Chapter 2 of this document.

These trained personnel maintain a topside watch and marine mammal/sea turtle observation log during operations that employ SURTASS LFA sonar in the active mode. The numbers and identification of marine mammals/sea turtles sighted, as well as any unusual behavior, is entered into the log. A designated ship's officer monitors the conduct of the visual watches and periodically reviews the log entries. There are two potential visual monitoring scenarios.

First, if a potentially affected marine mammal or sea turtle is sighted outside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone, the observer notifies the MILDET OIC. The MILDET OIC then notifies the HF/M3 sonar operator to determine the range and projected track of the animal. If it is determined that the animal will pass within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone, the MILDET OIC orders the delay or suspension of SURTASS LFA sonar transmissions when the animal enters the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone. The observer continues visual monitoring/recording until the animal is no longer seen.

Second, if the potentially affected animal is sighted anywhere within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone, the observer notifies the MILDET OIC who orders the immediate delay or suspension of SURTASS LFA sonar transmissions. All sightings are recorded in the log and provided as part of the LTM Program.

5.2.2 Passive Acoustic Monitoring

Passive acoustic monitoring is conducted when SURTASS is deployed, using the SURTASS towed horizontal line array (HLA) to listen for vocalizing marine mammals as an indicator of their presence. If the sound is estimated to be from a marine mammal that may be potentially affected by SURTASS LFA sonar, the technician notifies the MILDET OIC who alerts the HF/M3 sonar operator and visual observers (during daylight). If prior to or during transmissions, the MILDET OIC orders the delay or suspension of SURTASS LFA sonar transmissions when the HF/M3 sonar and/or visual observation indicates the animal is within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone. All contacts are recorded in the log and provided as part of the LTM Program.

5.2.3 Active Acoustic Monitoring

HF active acoustic monitoring uses the HF/M3 sonar to detect, locate, and track marine mammals (and possibly sea turtles) that could pass close enough to the SURTASS LFA sonar array to enter the LFA mitigation zone. HF acoustic monitoring begins 30 minutes before the first SURTASS LFA sonar transmission of a given mission is scheduled to commence and continues until transmissions are terminated. Prior to full-power operations, the HF/M3 sonar power level is ramped up over a period of 5 minutes from the source level of 180 dB re 1 µPa @ 1 m (rms) (SPL) in 10-dB increments until full power (if required) is attained to ensure that there are no inadvertent exposures of local animals to RLs ≥180 dB re 1 µPa (rms) from the HF/M3 sonar. There are two potential scenarios for mitigation via active acoustic monitoring.

First, if a contact is detected outside the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone, the HF/M3 sonar operator determines the range and projected track of the animal. If it is determined that the animal will pass within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone, the sonar operator notifies the MILDET OIC. The MILDET OIC then orders the delay or suspension of transmissions when the animal is predicted to enter the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone. Second, if a contact is detected by the HF/M3 sonar within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone, the operator notifies the MILDET OIC who orders the immediate delay or suspension of transmissions. All contacts are recorded in the log and provided as part of the LTM Program.

5.2.4 Resumption of SURTASS LFA Sonar Transmissions

SURTASS LFA sonar transmissions can commence/resume 15 minutes after there is no further detection by the HF/M3 sonar and there is no further visual observation of the animal within the LFA mitigation zone plus 1-km (0.54-nmi) buffer zone.

THIS PAGE IS INTENTIONALLY LEFT BLANK

6.0 OTHER CONSIDERATIONS

6.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

Unavoidable adverse impacts associated with the proposed action include potential effects on marine mammals, sea turtles, and fish stocks. Nearly all potential effects on marine mammals and sea turtles can be avoided due to the mitigation and monitoring methods implemented to prevent injury or harm to marine mammals and sea turtles. Additionally, the geographic restrictions on SURTASS LFA sonar use would result in negligible impacts to fish stocks on an annual basis and no impacts to commercial or recreational non-pelagic fisheries.

6.2 RELATIONSHIP OF THE PROPOSED ACTION TO FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

Operation of the SURTASS LFA sonar system does not conflict with the objectives or requirements of applicable Federal, state, regional, as well as local laws, policies, and regulations (Table 6-1). SURTASS LFA sonar is currently operating under a Final Rule pursuant to the MMPA (NOAA, 2007c) and a Biological Opinion under the statutes of the ESA. All permits, approvals, and authorizations required for the operation of SURTASS LFA sonar have been obtained and are current.

Table 6-1. Summary of this document's environmental compliance with applicable Federal, state, regional, and local laws, policies, and regulations.

PLANS, POLICIES, AND CONTROLS	RESPONSIBLE AGENCY	STATUS OF COMPLIANCE
National Environmental Policy Act (NEPA) (42 USC §§4321, et. seq.) Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR §§1500-1508) DoN Procedures for Implementing NEPA (32 CFR §775)	Navy with NMFS as a cooperating agency	This document has been prepared in accordance with NEPA, CEQ regulations, and the Navy's NEPA procedures. Public participation and review is being conducted in accordance with NEPA. The proposed action would not result in significant impacts.
Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions	Navy with NMFS as a cooperating agency	This document has been prepared in accordance with EO 12114, which requires environmental consideration for major Federal actions that may affect the environment outside of U.S. territorial waters. The proposed action would not result in significant impacts to the environment.

Table 6-1. Summary of this document's environmental compliance with applicable Federal, state, regional, and local laws, policies, and regulations.

PLANS, POLICIES, AND CONTROLS	RESPONSIBLE AGENCY	STATUS OF COMPLIANCE
Endangered Species Act (ESA) (16 USC §§1531, et seq.)	U.S. Fish and Wildlife Service (USFWS) NMFS	This SEIS/SOEIS analyzes potential effects to marine species listed under the ESA. The Navy has consulted under Section 7 with the NMFS on the potential of the proposed action to affect listed species.
The National Marine Sanctuaries Act (16 USC §§1431, et seq.)	NOAA	The proposed action would have no effect on sanctuary resources in the offshore environment of SURTASS LFA operating areas. Review of agency actions under Section 304 is not required.
Marine Mammal Protection Act (16 USC §§1431, et seq.)	USFWS NMFS	This SEIS/SOEIS analyzes the potential effects to marine mammals, some of which are also listed under the ESA. The Navy has been issued Letters of Authorization by the NMFS regarding effects on marine mammals.
EO 12962, Recreational Fisheries	Navy	EO 12962 requires the fulfillment of certain duties to promote the health and access of the public to recreational fishing areas. The proposed action complies with these duties.
Act to Prevent Pollution from Ships (APPS) (33 USC §§1901, et seq.)	Navy	The Navy and Marine Corps complies with the discharge regulations set forth under the requirements of the APPS.
EO 13158, Marine Protected Areas (MPAs)	Navy and NMFS	EO 13158 requires the avoidance of harm to the natural or cultural resources protected as MPAs and the identification of any actions that may affect those resources. The proposed action complies with these requirements.
EO 13175, Consultation and Coordination with Indian Tribal Governments	Navy	EO 13175 establishes the requirement for consultation and collaboration with tribal officials regarding development of Federal policy that has tribal implications. The Navy currently has no plans to operate SURTASS LFA sonar in the Gulf of Alaska or off the coast of Washington or Oregon. The

Table 6-1. Summary of this document's environmental compliance with applicable Federal, state, regional, and local laws, policies, and regulations.

PLANS, POLICIES, AND CONTROLS	RESPONSIBLE AGENCY	STATUS OF COMPLIANCE
		Navy will continue to keep native groups informed of the timeframes of any future SURTASS LFA sonar exercises planned for the Gulf of Alaska or off the coast of Washington and Oregon.
EO 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes	Navy	EO 13547 requires the development of coastal and marine spatial plans that build upon and improve existing Federal, State, tribal, local, and regional decision-making and planning processes. This and other mandates of EO 13547 have been met in this SEIS/SOEIS by using the best available data for all analyses, by conducting an analysis of potential and cumulative effects, and by defining OBIAs. Analyses of potential effects have been conducted in an integrated, systematic manner that incorporates cumulative effects from potential additional sound sources in the marine environment. In addition, OBIAs were defined within a marine spatial planning framework.

6.3 RELATIONSHIP BETWEEN SHORT-TERM USE OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The NEPA requires analysis of the relationship between a proposed action's short-term effects on the environment and any effects on the maintenance and enhancement of the long-term productivity of the affected environment. The Navy supports research that increases knowledge about marine mammals, sea turtles, and marine fishes and helps to develop methods to reduce or eliminate the potential for effects on these species that may be associated with the operation of SURTASS LFA sonar. While some short-term environmental effects may be associated with the use of SURTASS LFA sonar, no long-term environmental effects that would lead to decreased productivity, permanently reduce the range of beneficial environmental uses, or pose long-term risk to the health, safety, or general welfare of the public are reasonably expected.

6.4 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Section 102(c)(v) of NEPA requires that an EIS identify any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented. Although operating SURTASS LFA sonar immeasurably enhances national security by allowing the Navy to ascertain submarine threats at long-range, nonrenewable resources, such as petroleum-based fuel and steel, were used during the design, construction, and operation of SURTASS LFA sonar vessels and sonar systems. Because this is a supplemental environmental impact statement, and the four SURTASS LFA sonars and the vessels on which they are deployed are currently operated under previous NEPA documents, there are no nonrenewable resources that would be irretrievably and irreversibly committed through the implementation of the proposed action.

7.0 PUBLIC REVIEW PROCESS AND RESPONSE TO COMMENTS

Public involvement in the review of draft SEISs is stipulated in 40 CFR §1503.1 of the Council on Environmental Quality's (CEQ) regulations implementing the NEPA and in OPNAVINST 5090.1C. These regulations and guidance provide for active solicitation of public comment via public comment periods and public hearings. This chapter has been prepared to document the public involvement process in preparation of this SEIS/SOEIS and also presents the response to questions and comments raised by individual commenters during the public comment period on the Draft SEIS/SOEIS.

7.1 PUBLIC REVIEW PROCESS

On January 21, 2009, the Navy, with the NMFS as a cooperating agency, published a Notice of Intent (NOI) in the *Federal Register* to prepare a SEIS/SOEIS for the employment of SURTASS LFA sonar (DoN, 2009a). The NOI described the decision of the Deputy Assistant Secretary of the Navy (Environment) (DASN(E)) to further the purposes of NEPA, support the issuance of a new Final Rule under the MMPA for the taking of marine mammals incidental to operation of SURTASS LFA sonar systems, and to continue the Navy's commitment to environmental stewardship by preparing an additional supplemental analysis for operation of SURTASS LFA sonar. The DASN(E) called for the additional supplemental analysis to focus on potential OBIAs in regions of the world's oceans where the sonar systems might be used for routine training, testing, and military operations, as well as the potential for cumulative impacts associated with the use of other active sonar systems, and the potential for a larger coastal standoff distance, where operationally practicable. In the NOI, the Navy and NMFS solicited scoping comments on the above topics to include OBIAs, greater coastal standoff, and cumulative effects. At the end of the 45-day scoping period, no comments were received (DoN, 2009a).

7.1.1 FILING AND DISTRIBUTION OF THE DRAFT SEIS/SOEIS

Pursuant to Section 102(2) of the National Environmental Policy Act (NEPA) of 1969 as implemented by the Council on Environmental Quality regulations (40 CFR § 1500-1508) and EO 12114 (Environmental Effects Abroad of Major Federal Actions), the Navy prepared and filed with the U.S. Environmental Protection Agency (USEPA) a Draft Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (DSEIS/SOEIS) to provide supplemental analyses for the Navy's employment of SURTASS LFA sonar systems. USEPA published their notice of availability of the SURTASS LFA sonar draft supplement on 19 August 2011 (EIS No. 20110269).

Commencing with the filing of the Draft SEIS/SOEIS with the USEPA, copies of the SURTASS LFA Sonar DSEIS/SOEIS were distributed to agencies and officials of the Federal, state, and local governments, citizens groups and associations, and other interested parties.

7.1.2 PUBLIC REVIEW PERIOD AND PUBLIC HEARINGS

A 60-day public review and comment period on the DSEIS/SOEIS commenced when the Notice of Availability (NOA) was published in the *Federal Register* on 19 August 2012 and ended on 17 October 2011. Under the NEPA regulations, no public hearings or meetings were scheduled by the Navy. There were no timely requests by the public for meeting or hearing under the NEPA regulations. There were no requests for extensions of the comment period.

7.2 RECEIPT OF COMMENTS

Comments on the Draft SEIS/SOEIS were received by letter and email. Written comments were received from federal agencies, non-governmental organizations, and an individual (Table 7-1). Because of the small number of comments received, each set of comments has been addressed individually (Table 7-2). Responses to these comments/questions were drafted and reviewed for scientific and technical accuracy and completeness. The Navy's and NMFS' responses also identify cases in which a specific comment generated a revision to the DSEIS/SOEIS. When existing text of the SURTASS LFA Sonar FSEIS/SOEIS (DoN, 2007a) and/or FOEIS/EIS (DoN, 2001) was deemed an adequate response to a comment, the appropriate chapter, subchapter, and/or appendix is identified.

Table 7-1. SURTASS LFA sonar DSEIS/SOEIS commenters.

ORGANIZATION	COMMENTER IDENTIFICATION
U.S. Environmental Protection Agency	USEPA
U.S. Department of Interior Office of Environmental Policy and Compliance Pacific Southwest Region	DOI
Marine Mammal Commission	MMC
National Resources Defense Council on behalf of the Natural Resources Defense Council (NRDC), The Humane Society of the United States, Whale and Dolphin Conservation Society, Cetacean Society International, and Citizens Opposing Active Sonar Threats	NRDC
Lindy Weilgart, Ph.D.	Weilgart

7.3 DETAILED RESPONSES TO COMMENTS

This subchapter presents the detailed responses to the comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar (Table 7-2).

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	U.S. EPA	
USEPA-01	Based on our review of the draft supplemental EIS/OEIS, we have rated the proposed action as LO –"Lack of Objections".	No action required.
	Department of Interior	
DOI-01	**Anthropogenic Component of Ambient Noise**—The ability of marine life to flee from damaging noise sources may be very different if the noise source is constant (as in the case of ship motors) than if it is intermittent. Commenter suggests that the SEIS address this difference as it relates to the level of risk to marine life.	**Response:** While a marine mammal's ability to avoid an anthropogenic noise source may be different from a continuous versus intermediate transmissions, the capability to identify and respond to the energy source can be severely affected or reduced by a number of factors including: a) the acoustic propagation mode present in the area, b) the depth of the source and the animal, c) the frequency spectrum of the transmission or vessel noise, d) the frequency spectrum capable of being heard by the species present and its sensitivity to that frequency, e) the duration of individual signals, f) the spreading affects of the environment on the signal, g) the type of signal (i.e., pulsed or non-pulsed to use Southall et al (2007)'s categories), and h) the beam pattern, if any, with which the sound is projected and received by the animal. Because of the complexity discussed above, it is nearly impossible to draw any general conclusions relating how intermittent transmissions of the various anthropogenic sources listed in Subchapter 3.1.1.2 of the LFA FSEIS/SOEIS relates to the risk those sources pose to marine life.
DOI-02	**Ocean Acoustic Regimes**—Commenter suggests that the SEIS quantify the volume and present information on depth and distance from the source array with respect to the three zones described, in order to determine the significance relative to populations. (Page 2-9 provides only generalities.)	**Response:** As noted in the SEIS/SOEIS, Subchapter 3.1.3, the oceans are not homogeneous and do not have the same physical characteristics throughout (e.g., temperature, salinity, water depth, bottom type). Sound speed in water varies with water density, which is a function of depth, temperature, and salinity. Within approximately 1 km (0.54 nmi) of the array, these factors have less effect and therefore the distance can be estimated by simple spherical

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		spreading model. Outside of that distance, there are complex interrelationships between these variables, so the information requested by commenter cannot be provided in any generic format. The oceanic conditions in each area in which SURTASS LFA sonar will potentially operate also vary by location and season. The acoustic propagation from the LFA array is modeled with the Ocean and Atmospheric Master Library (OAML[1])-approved Parabolic Equation (PE[2]) model (Zingareli et al., 1999) for the LFA ship and/or the ray-based BELLHOP[3] model (Porter, 1992) for the MFA source (because BELLHOP is better suited to the acoustic parameters of MF sources than PE). The received level (RL) by distance and depth from the array can therefore be predicted. This is discussed in FSEIS/SOEIS, Appendix C, Section C-2.8.
DOI-03	In addressing the effects of sound on marine life, the document asserts that little is known, points out experimental flaws in studies that found effects, and identifies cases of missing or incomplete data or compromised studies in saltwater fish and other taxa. Given this limited data base it is important that the SEIS describe, in detail, the degree of certainty for selection of 180dB as a threshold for effects, and any evidence for effects at lower levels. The DEIS describes numerous studies, however, it is difficult to determine at what dB	**Response:** To clarify, the 180-dB criterion is not a basis for screening which animals will be affected and which will not. Rather, the 180-dB criterion was chosen as the threshold at or above which any animals that met the screening criteria would be treated for purposes of the analysis as though they had been injured. The screening criteria are the species must: (1) occur within the same ocean region and during the same time of year as the SURTASS LFA sonar operation, and (2) possess some sensory mechanism that

1 The CNO established the OAML in 1984. The OAML suite consists of Navy-standard core-models, algorithms and databases that support the DoN, DoD, research and development laboratories, as well as U.S. DoD Joint and NATO activities.

2 Parabolic Equation (PE) 5.0 is a robust and capable model that incorporates one of the fastest and most accurate acoustic models, the Range-dependent Acoustic Model (RAM). For the most part, both the ocean acoustics R&D community and the Navy operational community are using the same PE model.

3 BELLHOP computes underwater acoustic transmission paths via beam (ray) tracing. Ray tracing is a method for calculating the path of sonar beams through water with regions of varying propagation conditions, absorption characteristics, and reflecting surfaces. Under these circumstances, sonar beam may bend, change direction, or reflect off the water surface or seafloor, complicating analysis. Ray tracing solves the problem by repeatedly advancing idealized narrow beams called *rays* through the water by discrete amounts. Simple problems can be analyzed by propagating a few rays using simple mathematics. More detailed analyses can be performed by using a computer to propagate many rays.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	levels the effects were found. We suggest that the DEIS include documentation of studies that support the selection of 180 dB, the taxa that were tested, relevant classes of animals represented, the thresholds for effects and types of effects identified, and the effects of water volume on the threshold. Items that require additional explanation or references include the following Item Numbers DOI-04 thru DOI-08:	allows it to perceive the LF sounds, and/or (3) possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds (Subchapter 3.2.1). The Navy did a detailed review of the data available on the utilization of 180-dB re: 180 dB re 1 µPa (rms) (RL) criterion for this SEIS/SOEIS as it has done for the previous NEPA documents. These are detailed in Chapter 4.0, Subchapter 4.1.1.1, 4.1.1.5, 4.2.1, 4.3.1, and 4.3.1.3. Based on the injury criteria published by Southall et al. (2007) and other scientific articles by Nowacek et al. (2007), Popper et al. (2007), and Kane et al. (2010), the 180-dB RL utilized by SURTASS LFA sonar for mitigation is conservative. The LFA Mitigation Zone is defined in the text box in Subchapter 2.5.1.
DOI-04	André et al. (2011) exposed four cephalopod species (*Loligo vulgaris, Sepia officinalis, Octopus vulgaris,* and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 Hz at 157 ± 5 dB re 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound in a manner incompatible with life. However, scientists have expressed concern that this study contains flaws. The two most egregious errors include the experimental design and lack of controls.	**Response:** The sound pressure levels in the study (157 ± 5 dB re 1 µPa) were received sound pressure levels (rms) at the animals. This will be clarified in the final document. The sounds were produced and amplified through an in-air loudspeaker but measured under water in the two tanks used in the study: a 2,000-L fiberglass reinforced plastic tank and a 200-L glass-walled tank. However, the results of this study are questionable for several reasons, which are described in Subchapter 3.2.1.1. Moreover, because the available data suggest that some of the major cephalopods and decapods may not hear well, SURTASS LFA sonar operations could only have a lasting impact on these animals if they are within a few tens of meters from the source. Therefore, the fraction of the cephalopod and decapod stocks that could possibly be found in the water column near a SURTASS LFA sonar vessel would be negligible. Cephalopods and decapods, therefore, were eliminated from further consideration because the potential for effects on invertebrates is vanishingly small.
DOI-05	Although there are no direct data on auditory thresholds for any	**Response:** Information has been added to Subchapter 3.2.1.2 that

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	mysticete species anatomical evidence strongly suggests that their inner ears are well adapted for LF hearing.	summarizes the following research. Parks et al. (2007) analyzed 18 inner ears from 13 stranded North Atlantic right whales (*Eubalaena glacialis*) to develop a preliminary model of the frequency range of hearing. The thickness/width measurements of the basilar membrane from slides resulted in an estimated hearing range of 10 Hz–22 kHz based on established marine mammal models. Original work by Ketten (1998) was summarized in the SURTASS LFA FOEIS/EIS in Figure 1-4 and pages 1-21 through 1-23 (DoN, 2001). The resonant properties of the basilar membrane suggest the functional hearing range for mysticetes is 15 Hz to 20 kHz, with good sensitivity from 20 Hz to 2 kHz (Ketten, 1998).
DOI-06	Items that require additional explanation or references include: One caveat with all data collected with sharks is that the earlier work was all based on studies of single animals, which means the data do not reflect inter-animal variability in sensitivity and bandwidth within a single species, something widely known to occur in all animal groups. While more recent studies (e.g., Casper et al. 2003; Casper and Mann 2006, 2007) used multiple animals, there is still the issue that hearing ability changes with age, health, and many other variables. While the thresholds reported for sharks give an indication of the sounds they can detect, it would be of great value to replicate these analyses using modern methods and several animals.	**Response:** Revised Subchapter 3.2.2.2 text rewritten for DOI -06 through DOI-08 as follows. Sharks are also of interest because of their low frequency sound detection ability, a capability that is particularly important for detecting sounds produced by potential prey (Nelson and Gruber, 1963; Myrberg et al., 1976; Nelson and Johnson, 1976; Myrberg, 1978). Hearing data have been obtained on very few shark species, and it is not yet clear whether sharks and rays respond to sound pressure or to particle velocity (or displacement), or to both. The function of the lateral line system of sharks is likely, as in other fish, to detect and respond to low frequency hydrodynamic stimuli (Au and Hastings, 2008). In general, sharks appear to only detect frequencies that are in a range similar to that of fish classified as hearing generalists, and hearing sensitivity (the lowest sound levels detectable) is probably poorer than hearing generalist fishes (Banner, 1967; Nelson, 1967; Kelly and Nelson, 1975; Casper et al., 2003). Olla (1962) observed that hammerhead sharks detect sounds below 750 Hz, with best sensitivity from 250 to 275 Hz, and Kritzler and Wood (1961) reported that the bull shark responded to signals at

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
DOI-06 (Continued)		frequencies between 100 and 1,400 Hz, with best hearing from 400 to 600 Hz. Lemon sharks responded to sounds from 10 to 640 Hz, with the greatest sensitivity at 40 Hz, but the lowest frequency may not accurately represent the lower limit of lemon shark hearing due to limitations in the test tank (tank acoustics) used in the experiments (Nelson, 1967). Moreover, lemon sharks may have responded at higher frequencies, but sounds of sufficiently high intensity could not be produced to elicit attraction responses (Nelson, 1967). Banner (1972) reported that the lemon sharks he studied responded to sounds varying from 10 to 1,000 Hz. In a conditioning experiment with horn sharks, Kelly and Nelson (1975) discovered the sharks responded to frequencies of 20 to 160 Hz and that the lowest particle motion threshold was at 60 Hz. One caveat regarding the data collected on shark hearing is that the majority of the earlier work (1960s to 1970s) was based on studies of single animals, which means the data do not reflect inter-animal variability in sensitivity and bandwidth within a single species, something widely known to occur in all vertebrate groups due to age, health, and other differences (Hill, 2005; Houser and Finneran, 2006). While the thresholds reported for sharks give an indication of the sounds they can detect, it would be of great value to replicate these analyses using modern methods and monitoring hearing in multiple animals of the same species. A second issue with earlier shark hearing research (but much less so with the recent studies) is that hearing was measured in terms of sound pressure levels. However, we now know that elasmobranchs very likely detect particle motion rather than sound pressure (Casper and Mann, 2007), and so interpretation of thresholds and even bandwidth from earlier studies must be assessed in terms of this knowledge. Sharks do not have the hearing specialization of a swim bladder linked to the inner ear; swim bladders' response to sound

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		pressure may enhance hearing sensitivity (Au and Hastings, 2008). Regardless of whether elasmobranchs detect sound pressure or particle motion, it is certainly clear that elasmobranchs do not detect sounds much above 1,000 Hz, and it is possible that the usable upper limit of their hearing is not much higher than 500 Hz.
DOI-07	Items that require additional explanation or references include: Data on shark hearing are very limited and in need of replication and expansion to include more species and more specimens.	**Response:** See DOI-06 for revised Subchapter 3.2.2.2 text.
DOI-08	Items that require additional explanation or references include: A second issue with earlier shark work (but much less so with the recent studies) is that hearing was measured in terms of sound pressure levels. However, we now know that elasmobranches are very likely detectors of particle motion rather than pressure (e.g., Casper and Mann, 2007), and so interpretation of thresholds and even bandwidth from earlier studies need to be taken with some caution.	**Response:** See DOI-06 for revised Subchapter 3.2.2.2 text.
DOI-09	The document states that, "Loggerheads are highly migratory, capable of traveling hundreds to thousands of kilometers between feeding and nesting grounds." Commenter suggests adding information on sea turtle migration from the USGS reference: Dodd, C.K., Jr.; Byles., R. 2003. Post-nesting movements and behavior of loggerhead sea turtles (*Caretta caretta*) departing from east-central Florida nesting beaches. Chelonian Conservation and Biology. Vol. 4 p. 530-536.	**Response:** The commenter correctly identified that movement information in the ocean region where this species occurs most prolifically was missing from the DSEIS/SOEIS. Information per the reference listed has been included in revised Subchapter 3.2.3.2 text to provide information on this species' movements in the NW Atlantic Ocean. Additionally, the latest information from NMFS' 2009 loggerhead status review (Conant et al., 2009) and other related references have also been included in the revised text to provide additional insight into the movement/migrational patterns of this species' in other ocean basins. Revised text for Subchapter section 3.2.3.2 is provided as follows. Loggerhead turtles are found in coastal and pelagic habitats in temperate, tropical, and subtropical waters of the Atlantic, Pacific,

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
DOI-09 (Continued)		and Indian Oceans, as well as the Mediterranean Sea (Dodd, 1988). Habitat usage varies with loggerhead lifestage. Loggerheads are highly migratory, capable of traveling hundreds to thousands of kilometers between feeding and nesting grounds. In the western North Atlantic Ocean, the largest loggerhead turtle nesting aggregations are found along the southeastern U.S. coast, particularly the coast of eastern Florida (Dodd and Byles, 2003). Another area of high loggerhead nesting occurs in the northwestern Indian Ocean on Masirah Island, Oman, where along with peninsular Florida, as many as 10,000 females nest per year (Conant et al., 2009). Many of the southeast U.S. nesting turtles travel to foraging habitats in waters of the northeastern U.S. and Canada but some remain to feed in the waters of the southeastern U.S., most of the southeast U.S. nesting turtles overwinter in the shallow waters of the Bahamas, Cuba, Hispaniola, and the southeastern U.S. (Dodd and Byles, 2003). Along the South American coast, nesting of loggerheads only occurs in significant numbers in Brazil (Conant et al., 2009). Very few loggerheads forage along the European or African coasts of the Atlantic Ocean and nesting only occurs in the Cape Verde Islands and along the coast of west Africa (Spotila, 2004; Conant et al., 2009). Although loggerheads are widely distributed in the Mediterranean Sea and forage there, 45% migrate between the Atlantic Ocean and Mediterranean Sea and nesting only occurs in the eastern Mediterranean (Margaritoulis et al., 2003). Indian Ocean loggerheads occupy foraging grounds along the coasts of southern Africa, Madagascar, Yemen, and Oman, and in the Arabian Gulf, as well as along Western Australia into Indonesian waters. Tagging data has shown that nesting turtles from the dense nesting aggregations along the Oman coast use the waters of the Arabian Peninsula for foraging and seasonal migrational movements (Conant et al., 2009). In the Pacific, loggerheads nest only in a limited number of sites in Japan and eastern Australia, New

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

Commenter ID / Comment Number	Comments	Response
		Caledonia, Vanuatu, and Tokelau, while foraging occurs in the Gulf of California and along Baja California and in waters of Peru and Chile (Kamazaki, 2003; Limpus and Limpus, 2003; Conant et al., 2009). Hatchlings from nests in Japan (including the Ryukyu Archipelago) make the 10,000 km (5,400 nmi) migration to Mexican developmental and foraging habitat, using the Kuroshio and North Pacific Currents as transport, until returning to the western Pacific as large juveniles (Bowen et al., 1995). Post-hatchling loggerheads from eastern Australia are thought to also make the extensive trans-Pacific migration to the waters of Chile and Peru to forage (Boyle et al., 2009).
Marine Mammal Commission		
MMC-01	To clarify the Navy's request for authorization and ensure consistency between the Navy's documents and the proposed rule, the Marine Mammal Commission recommends that the Navy amend its DSEIS and related application for letters of authorization to (1) request authority to take marine mammals by Level A harassment and (2) specify the numbers of marine mammals that could be taken by Level A and B harassment incidental to operating SURTASS LFA sonar, rather than providing only the probabilities of such takes.	**Response**: Amendments to the SURTASS LFA Sonar DSEIS/SOEIS and Application for Letters of Authorization are not required. The application specifically requests LOAs and rulemaking under the MMPA for taking of marine mammals by Level A and Level B (non-lethal) harassment incidental to the employment of up to four SURTASS LFA sonar systems within specified areas of the world's oceans for the five year period from August 2012 to August 2017 (See Application Sections 1.1 and 5). With respect to the MMC's second point, the percentages given in Tables 6 through 27 in the Navy's application and Tables 4-5 to 4-23 in this SEIS/SOEIS are not probabilities, but rather indicate the percent of the affected stock for a specific marine mammal species. For the Navy's Level A and Level B harassment take request, that percentage is then multiplied by the number of animals in the relevant species or stock to arrive at an estimated number of animals that may be harassed by SURTASS LFA sonar operations. The Navy's approach to estimating Level A harassment and Level B harassment takes is consistent with the approach used in previous

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

Commenter ID / Comment Number	Comments	Response
		rules for SURTASS LFA sonar. This proposed rule does not specify the number of marine mammals that may be taken in the proposed locations because these are determined annually through various inputs such as LFA sonar mission location, mission duration, and season of operation. As with the 2002 and 2007 Rules, the Navy will limit operation of LFA sonar to ensure no marine mammal stock will be subject to more than 12 percent of takes by Level B harassment annually, over the course of the five-year regulations. This annual per-stock cap applies regardless of the number of LFA vessels operating. The Navy will use the 12 percent cap to guide its mission planning and annual LOA applications. For the annual applications for LOAs, the Navy proposes to present both the estimated percentage of stock incidentally harassed as well as the estimated number of animals that may be potentially harassed by SURTASS LFA sonar.
MMC-02	Work with the National Marine Fisheries Service to (1) describe fully the process used to select offshore biologically important areas (OBIAs) and provide an explanation for all deviations from it, (2) ensure that the outside expert group used to identify possible OBIAs is consulted on all the areas proposed for designation, (3) evaluate the potential for geographic bias in the OBIA selection process and develop a plan for addressing the sources of that bias, (4) provide a well-reasoned explanation for any area rejected for designation as an OBIA, and (5) provide support for the Service's claim that marine mammals other than mysticetes are not sensitive to LFA sonar and, therefore, need not be protected within OBIAs.	**Response:** In support of the Navy's preparation of the SEIS/SOEIS, NMFS (a cooperating agency) developed a more systematic process for selecting, assessing, and designating OBIAs for SURTASS LFA sonar. See SEIS/SOEIS Subchapter 4.5 and Appendix D. In summary, NMFS first developed screening criteria to help initially select potential areas and then determine an area's eligibility for consideration as an OBIA nominee. These OBIA screening criteria included: 1. Areas with: a. high densities of one or more species of marine mammals; or b. known/defined breeding/calving grounds, foraging grounds, migration routes; or

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
MMC-02 (Continued)		c. small, distinct populations of marine mammals with limited distributions; and 2. Areas that are outside of the coastal standoff distance and within potential operational areas for SURTASS LFA (i.e., greater than 22 km (12 nmi) from any shoreline and not in polar regions). NMFS used the screening criteria to review 403 existing and potential marine protected areas based on the World Database on Protected Areas (WDPA) (WDPA, 2009), Hoyt (2005), and prior SURTASS LFA sonar OBIAs. To eliminate the potential for geographic bias in the OBIA selection process, NMFS' initial scoping of potential OBIA candidates encompassed a review of 16 marine regions as designated by the World Commission on Protected Areas (IUCN World Commission on Protected Areas—WCPA): Region 3—Mediterranean; Region 4—Northwest Atlantic; Region 5—Northeast Atlantic; Region 6—Baltic; Region 7—Wider Caribbean; Region 8—West Africa; Region 9—South Atlantic; Region 10—Central Indian Ocean; Region 11—Arabian Sea; Region 12—East Africa; Region 13—East Asian Sea; Region 14—South Pacific; Region 15—Northeast Pacific; Region 16—Northwest Pacific; Region 17—Southeast Pacific; and Region 18—Australia/New Zealand. The Navy will not operate SURTASS LFA sonar in polar regions (i.e., Regions 1 and 2), so those areas were not included in the scoping process. Within the first pass over 80% of the potential candidate areas did not meet the criterion of an OBIA because they were within 12 nmi (22 km; 13.6 mi) of any coastline. NMFS screened the remaining areas under the biological criteria and produced a preliminary list of 27 OBIA nominees to send to the expert review panel discussed below (See SEIS/SOEIS Appendix D). NMFS next convened an expert review panel of biologists knowledgeable about potentially affected marine mammal biologically

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
MMC-02 (Continued)		important areas. This panel consisted of eight subject matter experts (SME), each with expertise in geographic regions including the Atlantic Ocean, Pacific Ocean, Mediterranean Sea, Indian Ocean/Southeast Asia, and East Africa. The SMEs provided their individual analyses of NMFS' preliminary list of OBIA nominees and provided additional recommendations for other OBIAs. This resulted in a total number of 73 potential OBIAs submitted by the SMEs. To ensure that the 73 nominated areas were ranked consistently, NMFS further screened the nominations for sufficient scientific support, assigning a rank of zero (lowest) to four (highest) depending upon the robustness of the supporting documentation for each criterion for which the area was nominated. Areas receiving a score of two or higher were considered eligible for consideration, resulting in 45 potential OBIAs (see SEIS/SOEIS Appendix D). In addition, consideration of marine mammal hearing frequency sensitivity led NMFS to screen out additional areas that qualified *solely* on the basis of their importance for mid- or high-frequency hearing specialists, resulting in a list of 22 final OBIA nominees for the Navy's consideration. The 22 areas were discussed in Subchapter 4.5.2 and Appendix D. Contrary to the commenter's understanding of the selection process, NMFS did not claim that marine mammals other than mysticetes are not sensitive to LFA sound. However, NMFS and the Navy did conclude that odontocete (mid-frequency [MF] and high frequency [HF] hearing specialists) have reduced sensitivity to the LFA source. Therefore, limiting ensonification in OBIAs for those animals would not afford protection beyond that which is already provided by implementing a shutdown when any marine mammal enters the LFA mitigation and buffer zones. The Navy agreed that these areas met NMFS' criteria and based on its practicability assessment pursuant to the MMPA, the Navy

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		proposed 21 of the 22 sites in its application for rulemaking and LOAs (DoN, 2011). An area within the Southern California Bight, specifically an area including Tanner and Cortes Banks (see SEIS/SOEIS Subchapter 4.5.2.3 for boundary information) from June through November, met the criteria as a concentrated area for blue whales based on predictive modeling (Barlow et al., 2009) or as a foraging area based on a 2000-2004 study of blue whale calls (Oleson, et al., 2007). However, the Navy concluded that the underlying data cover a short time period and the dynamic nature of blue whale distribution and the variability of prey abundance make it difficult to assign any permanence to this area as one of blue whale concentration. The Navy also determined that avoiding this area was operationally impracticable as much of the OBIA is within the existing Southern California (SOCAL) Range Complex which plays a vital part in ensuring military readiness. The year-round training that occurs in the SOCAL Range Complex includes antisubmarine warfare (ASW) training and the SOCAL Range Complex provides the uneven, mountainous underwater topography that is essential to such training, because it is similar to the kind of underwater topography that submarines use to hide or mask their presence.
MMC-03	Work with the National Marine Fisheries Service to devise a plan for gathering the information needed to conduct a reliable review of candidate OBIAs rejected because of insufficient information.	**Response:** The process described in response to comment MMC-02 resulted in a reliable review of candidate OBIAs. The Navy recognizes, however, that the available data regarding certain areas is likely to evolve over the five-year course of the proposed action. Accordingly, the Navy and NMFS propose to include an adaptive management component within the framework of the scientific underpinning of its 2011 FSEIS/SOEIS and within the rulemaking under the MMPA. See FSEIS/SOEIS Subchapter 1.4.5 and response to comment MMC-04 below. This allows the Navy, in concert with NMFS, to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, and

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		government/non-government organizations to determine (with input regarding practicability) whether SURTASS LFA sonar mitigation measures (which includes OBIAs) should be modified (including additions or deletions) if new scientific data indicate that such modifications would be appropriate. In addition, NMFS and the Navy have again reviewed the areas for which there was insufficient information using the same screening criteria described in the SEIS/SOEIS Subchapter 4.5 and Appendix D. Based upon the best available scientific information, NMFS and the Navy have concluded that there are no additional areas that qualify at this time.
MMC-04	1. Work with the National Marine Fisheries Service to (1) review the strengths and weaknesses of the current geographic mitigation measures involving the stand-off range and OBIAs and (2) develop a plan for collecting the information needed to refine or revise these mitigation measures to ensure that they are, in fact, providing the necessary level of protection for marine mammals. 2. The 2011 DSEIS states in several places that it considers the idea of extending the coastal stand-off range beyond 22 km (12 nm), but the Commission could not find that analysis. The DSEIS does refer to a comparison in the 2007 DSEIS between areas within 22 km from shore and areas out to 46 km from shore. The 2011 DSEIS also states that the 2007 analysis "was effectively combined with the OBIA analysis ... because as part of the OBIA analysis the Service and the Navy considered the biological importance of coastal areas outside the current 22 km (12 nm) coastal standoff range." However, if this were the case, then it is not clear from the 2011 DSEIS how these analyses were combined and whether or how the subject matter experts were involved in such review.	**Response:** 1. As noted in the response to comment MMC-03, NMFS and the Navy propose to include an adaptive management component within the framework of the scientific underpinning of this SEIS/SOEIS and within the rulemaking under the MMPA, which includes modification to mitigation measures based on new scientific data and continuous review of pertinent updates to these data. 2 Both DSEIS/SOEIS Subchapters 4.5.6 and 4.8.1.3 were titled "Coastal Standoff Range" which may have caused confusion as to their contents. Subchapter 4.5.6 has been revised to discuss the dual criteria for coastal exclusion and has been renamed "Dual Criteria for Coastal Exclusion Zones." Subchapter 4.8.1.3 (Coastal Standoff Range), as part of Subchapter 4.8.1 (Alternatives Previously Considered), provides a summary of the results of the detailed analysis of the differences in potential impacts if the coastal standoff were increased from 22 km (12 nmi) to 46 km (25 nmi), which was provided in Subchapter 4.8.6 of the 2007 FSEIS. Both DSEIS/SOEIS Subchapters 4.5.6 and 4.8.1.3 have been

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
MMC-4 (Continued)	3. The value of extending the stand-off range will be determined by the distribution and abundance of marine mammals in the affected areas. Unfortunately, much of the information needed to assess the density of marine mammals in those areas does not exist. This same lack of information is a problem with the development of OBIAs. The Navy and the Service seem to have two main choices. The first would be to extend the stand-off range based on the assumption that the density of marine mammals between 22 and 46 km is sufficient to warrant such a measure. The second would be to continue to focus on the identification of OBIAs. In either case, if the Navy and the Service seek to ensure adequate protection of marine mammals, then they must increase the investment in surveys to assess the distribution and abundance of marine mammals in affected areas.	revised in the FSEIS/SOEIS. As previously discussed, the SMEs were involved in the process of identifying possible OBIAs based on their biological significance, including in coastal areas outside the 22 km (12 nmi) coastal standoff range. 3. As noted above, the Navy's analysis of the coastal standoff range demonstrated that overall there is a greater risk of impact to marine animals with an increase of the range from 22 km (12 nmi) to 46 km (25 nmi). This analysis accounted for the density differences of marine mammals based on shelf species, shelf break species, and pelagic species. Therefore, increasing the standoff distance to 46 km (25 nmi) is not warranted and would be arbitrary. The Navy and NMFS recognize that there is incomplete and unavailable information regarding abundances and densities for marine mammal species in many areas of the world's oceans. The understanding of the potential effects of SURTASS LFA sonar on marine mammals is continually evolving. Reflecting this, the Navy has included an adaptive management component within the framework of the scientific underpinning of this SEIS/OEIS. The following adaptive management section has been added as Subchapter 1.4.5 in the SEIS/SOEIS: **Adaptive Management** The Navy, in concert with NMFS, will consider, on a case-by-case basis, new/revised, peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, and government/non-government organizations to determine (with input regarding practicability) whether SURTASS LFA sonar mitigation, monitoring, or reporting measures should be modified (including additions or deletions); if new scientific data indicate that such modifications would be appropriate. This allows for

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		updates to marine mammal stock estimates to be included in annual LOA applications which, in turn, provides for the use of the best available scientific data for predictive models, including AIM. Unanticipated changes in the geo-political climate may also necessitate consideration of modifications to SURTASS LFA sonar mitigation, monitoring, or reporting measures. Modification of mitigation could include the addition (or deletion) of OBIAs based on emergent scientific data. Adaptive management is included in NMFS' Proposed Rule (NOAA, 2012a). As to providing additional research, the commenter is referred to this SEIS/SOEIS Subchapter 2.7.2, which provides a detailed discussion of significant research and monitoring projects to study the potential effects of U.S. Naval activities on marine mammals. The Navy provided $31M in FY 2009 and $32M in FY 2010 and continues to provide a large share of marine mammal research funding, which includes surveys to assess the distribution and abundance of marine mammals in affected areas.
MMC-05	The DSEIS states that the Navy would monitor the area near the vessel for at least 30 minutes prior to deployment of the LFA sonar source. The DSEIS also states that when the sonar transmissions have been delayed or suspended because a marine mammal has been detected within the proposed LFA mitigation zone, active LFA sonar transmissions would resume 15 minutes after the last detection of the animal in the mitigation zone by either visual observation or high-frequency active sonar. However, for other sonar exercises and sound-generating activities the Marine Mammal Commission has recommended a delay of 60 minutes because a number of species that may be affected routinely dive for at least that long. In addition, some marine mammals are difficult to detect at the surface, even in good sea surface conditions, and if they are present in the mitigation	**Response:** The Navy recognizes that several species of deep-diving cetaceans are capable of remaining underwater for more than 15 minutes; however, for the following reasons NMFS believes that 15 minutes is an adequate length of the monitoring period prior to resuming SURTASS LFA sonar transmissions: 1. The Navy will continue monitoring for marine mammals and marine turtles using its three part monitoring system (visual, passive acoustic, and active acoustic) before resuming SURTASS LFA sonar transmissions. If there are any contacts within the 15-minute period, the Navy will not resume SURTASS LFA transmissions. 2. If a deep diving marine mammal remains submerged within the

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	zone but not resighted or detected by active sonar, then they are likely to be exposed to high levels of low-frequency sound. Use a 60-minute clearance time before resuming SURTASS LFA sonar transmissions after a delay or suspension related to the sighting of a marine mammal in the mitigation zone.	LFA mitigation zone during the 15-minute period, the Navy would be able to track the animal's movement with a high level of certainty (~99%) using the HF/M3 sonar and would not resume SURTASS LFA transmissions. The HF/M3 sonar is located at the top of the LFA vertical line array (VLA) at approximately 80 m (262 ft) depth facilitating its ability to detect deep diving marine mammals at the depth of the LFA mitigation zone. Also, if a deep-diving animal was outside of the mitigation zone before shutdown but entered it after shutdown, there is a very high level of certainty that it would be detected by the HF/M3 sonar when it entered the zone, before transmissions restarted. The Navy, therefore, does not rely solely on visual monitoring to determine if the LFA mitigation zone is clear prior to resuming LFA transmissions. Because of the effectiveness of the three part monitoring mitigation employed during all SURTASS LFA sonar missions, extending the period for SURTASS LFA sonar after a shutdown to 60 minutes vice 15 minutes would not meaningfully increase the effectiveness of observing marine mammals approaching or entering the 180-dB LFA mitigation zone and would not further minimize the potential for Level A or Level B harassment.
MMC-06	Additional OBIAs comments: 1. The selection of OBIAs should not rely so heavily on information requirements that infrequently are met outside of U.S. waters. 2. Further, the absence of selected experts with primary experience in the Austro-Asian region and responsibility for identifying candidates in that region creates a significant gap in the geographic coverage, creating another factor that could have contributed to bias in selecting OBIAs.	**Response:** 1. It is true that information and data on marine mammal habitat are sparsely available for many parts of the world and not available in the same forms as exist in the U.S. (e.g., peer-reviewed publications or conference proceedings). This is why NMFS and the subject matter experts (SMEs) convened during the OBIA process. NMFS and the Navy also used information from personal communications with regional/local researchers, cruise or survey reports, unpublished reports, and NGO reports to gather as much

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
MMC-06 (Continued)	3. Given that the subject matter experts were volunteers, the Service should provide a description of how it ensured that a bias was not introduced into the OBIA selection process simply as a result of differences in the effort the various experts contributed to the process. 4. The Commission does not find the Service's analysis of hearing sensitivities of other marine mammal taxa a sufficient basis for excluding other species from the analyses. Available research suggests the frequency range for hearing sensitivities of mid-frequency odontocetes and pinnipeds (Southall et al. 2007) overlaps to some extent with the operational frequency range of LFA sonar. 5. If mysticetes are, in fact, the only species of concern, then greater emphasis should have been placed on recruiting and selecting experts whose primary experience and expertise is with mysticetes. 6. A number of areas that appear to have been designated primarily to protect marine mammals appear to have been rejected for designation as OBIAs (e.g., portions of the Pelagos Sanctuary for Marine Mammals, Falkland Islands Marine Mammal Sanctuary, and the Tristan da Cunha Cetacean Sanctuary) without sufficient explanation in the DSEIS. It seems that even a moderately precautionary approach would include those sites based on the fact that they were designed specifically to protect marine mammals. 7. A number of areas previously suggested for consideration as OBIAs do not appear to have been included on the list of possible sites to be considered during this selection process (e.g., the Emperor Seamount Chain, the southern portion of the Oyashio/Kuroshio area, Davidson Seamount, and	information as possible on marine mammal habitat around the world. In addition to the regional or local expertise the SMEs themselves possessed on marine mammal habitat, all available information was then considered in the OBIA process. 2. There were experts for the Austro-Asian regions as presented in this SEIS/SOEIS page D-102. As noted there were no volunteers for Australia, however, NMFS reviewed the waters around Australia (Region 18—Australia/New Zealand) and suggested two OBIAs independent of the SMEs: OBIA # 18 – Great Barrier Reef 16° S to 21° S and OBIA # 19 – Bonney Upwelling/ Southwestern Australia. 3. While the evaluation and input of the SMEs was a crucial component of the LFA OBIA selection process, the SMEs were not solely responsible for the selection of LFA OBIAs. Since the SME input and all available data/information on each recommended OBIA were independently assessed and evaluated by the NMFS and Navy, bias on the part of the SMEs was not a factor in the selection process. 4. See response to comments MMC-02 and NRDC-09. 5. SMEs were recruited for their expertise related to specific geographic habitats of marine mammals worldwide, as the identification of habitat areas biologically important to all marine mammals (in areas where SURTASS LFA sonar might be operated) was the key goal of the OBIA process. To obtain the broadest input from the experts, they were instructed to provide OBIA candidates based on Criteria 1 and 2 as presented in SEIS/SOEIS Subchapter 4.5.2.1 for all marine mammals, not just mysticetes. Also, members of the SME panel do possess baleen whale

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
MMC-06 (Continued)	Papahanaumokuakea Marine National Monument) without sufficient explanation in the DSEIS for excluding these sites from consideration. 8. A number of sites that the experts judged to be important for marine mammals (e.g., Challenger Bank off Bermuda, Ombai Strait in the Savu Sea) were rejected and the DSEIS did not provide an explanation for excluding these sites from the list of accepted sites. 9. It is not clear whether the expert group was asked to evaluate all the sites that were rejected; if the expert group was not asked, then the sites that were not evaluated should be listed with a description of why they were rejected without expert review. 10. The interpretation of the scoring system used by the experts in their evaluation of the final list of potential sites appears to have been inconsistent and the deviations should be identified and explained.	expertise. Several of the SME panel, for instance, are authors or contributors to the annual NMFS stock assessment reports (Drs. J. Barlow and R. Brownell), which include every mysticete whale species occurring in U.S. waters. 6. These areas were thoroughly evaluated; and, as a result of the more rigorous OBIA process, they did not meet the designation criteria. See Appendices D and F. 7. See response to comments NRDC-15 and NRDC-23. As presented in SEIS/SOEIS Subchapter 4.5, Davidson Seamount Management Zone is part of the Central California NMSs and as such is part of the OBIA #10. 8. Commenter is referred to the SEIS/SOEIS Subchapter 4.5.2.3 for explanations for these exclusions. 9. See response to comment MMC-02 for an explanation of the evaluation process conducted by NMFS, the Navy, and the SMEs. Briefly, Appendix D-3 of the SEIS/SOEIS contains the initial screening matrix of 403 potential areas that NMFS presented to the SMEs for review. For each site, the matrix describes an area's eligibility or ineligibility for consideration as an OBIA nominee. The next phase of the review process resulted in a total of 73 potential OBIAs (vetted by NMFS, the Navy, and the SMEs). NMFS' classification methodology (See Appendix D) for OBIA recommendations further screened the 73 areas for sufficient scientific support, assigning a rank of zero (lowest) to four (highest) based on the robustness of the supporting documentation for each criteria for which the area was nominated. For areas where NMFS, the Navy, and the SME could not provide clear justification (qualitative or quantitative) for the corresponding OBIA criteria; or could not provide sufficient detail for criteria evaluation, NMFS scored these areas as a zero or a one. This

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
MMC-06 (Continued)		screening resulted in a list of 45 potential OBIAs receiving a score of 2 or higher for at least one eligibility criteria. Additional screening based on a marine mammal's hearing specialization resulted in a list of 22 potential OBIAs. See response to comment MMC-02 above. Thus, NMFS did not reject the 51 areas (73 minus 22) but did not consider them further as OBIA candidates for the Navy's analysis at that time. For each annual LOA application under the MMPA rulemaking, the Navy will complete modeling for its planned mission areas which includes factoring in the most current marine mammal density/abundance data. The Navy's adaptive management component within the framework of the MMPA rulemaking will consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, and government/non-government organizations to determine modifications to the OBIA list, if new scientific data indicate that such modifications would be appropriate. NMFS and the Navy have again reviewed the data poor candidates using the same screening criteria described in the SEIS/SOEIS. Based upon the best available scientific information, NMFS and the Navy have concluded that there are no additional areas that qualify as an OBIA for SURTASS LFA sonar operations at this time. 10. Without specific examples, neither the Navy nor NMFS can respond to the comment about asserted inconsistencies in the evaluation process. Table 4-24 of the SEIS/SOEIS and Appendix D explain NMFS' classification methodology for the SURTASS LFA sonar OBIA recommendations for marine mammals. To clarify, NMFS did not ask the SMEs to evaluate the final list of potential sites based on NMFS' classification methodology. The SMEs provided their individual analyses of NMFS' preliminary

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		candidates as potential marine mammal OBIAs in waters where the Navy potentially could use the SURTASS LFA sonar systems and provided additional recommendations for other OBIAs. As stated in the Process Summary for Expert Input (See Appendix D-3), Stage 1 (c) specifically states that NMFS will incorporate expert input, as appropriate, to produce the final OBIA Nominees, which were included for consideration in the Navy's 2011 draft supplemental environmental impact statement (DSEIS/SOEIS) for SURTASS LFA sonar. See response to comment MMC-02 and Appendix D of the SEIS/SOEIS for an explanation of the evaluation process conducted by NMFS, the Navy, and the SMEs. Subchapter 4.5.2.3 of the SEIS/SOEIS includes reasons for excluding some of the recommended OBIAs from further consideration.
NRDC et al.		
NRDC-01	We are particularly concerned about the Navy's proposed geographic mitigation, which lies at the heart of the new DSEIS. Perhaps most importantly, the OBIA designation process failed to include any form of habitat suitability or density modeling for marine mammals, relying instead on a few volunteer regional experts who, qualified as they are, represent in their expertise only a very small fraction of the Navy's intended operating area. For the limited number of biologically important areas that were proposed, the process established an unreasonably high bar for further consideration, meaning that most of these recommended areas were not even advanced to the Navy for discussion—regardless of the practicability of actually protecting them. And for at least one major area that remained, the agencies failed to consider more limited forms of mitigation when a complete exclusion was deemed impracticable, a failure that led to a complete lack of additional protection for the Southern California Bight.	**Response**: To meet the least practicable adverse impacts to marine mammals under the MMPA, NMFS and the Navy developed a suite of mitigation measures including visual, passive acoustic, and active acoustic monitoring for marine mammals with shutdown protocols, as well as geographic restrictions to reduce the potential for adverse impacts. Given the unique operational characteristics of SURTASS LFA sonar, Navy and NMFS were able to develop as part of the geographic restrictions a systematic methodology to identify offshore biologically important areas (OBIAs) for marine mammals throughout all areas where LFA sonar may operate. See response to comments MMC-02 and MMC-06 above and Subchapter 4.5 and Appendix D of this SEIS/SOEIS. In order for NMFS to make a preliminary determination that an area is biologically important for marine mammals, it needs detailed information on the proposed area.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		To conduct the OBIA analyses, NMFS and the Navy relied on all of the evidence available. This evidence generally consisted of reports prepared by natural resource agencies in other countries; reports from non-governmental organizations involved in marine conservation issues; information from subject matter experts; and the general scientific literature. During this process, NMFS and the Navy researched the general scientific literature using search engines, including Aquatic Sciences and Fisheries Abstracts, Conference Papers Index, BioOne, Science Direct, JSTOR, Web of Science-Science Citation Index, and Google Scholar. NMFS also supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports whether an area qualified as having: 1. high densities of one or more species of marine mammals; or 2. known/defined breeding/calving grounds, foraging grounds, migration routes; or 3. small, distinct populations of marine mammals with limited distributions. The OBIA designation process did include habitat suitability and/or density modeling for marine mammals where appropriate based on available input data. Subchapter 4.5.2.1 clearly demonstrated that habitat suitability models were an integral part of the OBIA designation criteria. Appendix D clearly shows that the SMEs were instructed to use habitat modeling, where appropriate, as part of their review process. For example, in Subchapter 4.5.2.3 biological criteria for the proposed SOCAL OBIA utilized data based on predictive modeling to describe it as a concentrated area for blue whales. NMFS used the screening criteria as detailed in response to

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		comment MMC-02, Subchapter 4.5, and Appendix D. See also response to comment NRDC-16 and FSEIS/SOEIS Subchapter 4.5.2.3 for discussion of the Southern California Bight. The biological criteria established for this process were less restrictive than was the case for the previous OBIA designation processes used for the 2001 FOEIS/EIS, 2007 FSEIS, 2002 Rule, and 2007 Rule, making it more likely that a potential OBIA would be considered/designated. As discussed in Subchapter 4.5.2.1, Appendix D, and response to comment MMC-02 above, NMFS developed screening criteria to determine an area's eligibility to be considered as a nominee for an OBIA for marine mammals. These OBIA criteria differ from the criteria in the 2001 FOEIS/EIS (as continued in the 2007 FSEIS) and the 2007 MMPA Final Rule in two respects. First, under the 2001 FOEIS/EIS, 2007 SEIS, and the 2007 Final Rule, an area could be designated as an OBIA only if it met a conjunctive test of being an area where: (a) marine mammals congregate in high densities, and (b) for a biologically important purpose. Under the new NMFS criteria, high density alone can be sufficient. Second, the new criteria include an additional criterion that, standing alone, could be a basis for designation; i.e., "Small, distinct populations with limited distributions."
NRDC-02	The result of all this is to establish only 21 offshore biologically important areas—21 areas within an MMPA application that encompasses 70-75% of the world's oceans, including almost the entirety of the Atlantic, Pacific, and Indian Oceans and the Mediterranean Sea. In its 2002, 2003, and 2008 opinions on SURTASS LFA, the District Court repeatedly emphasized the importance of geographic mitigation to reduce impacts from the LFA system, the need to ensure meaningful inclusion of OBIAs throughout the LFA operating area, and the agencies' obligation to affirmatively identify and protect marine mammal habitat. The	**Response:** Assumptions were made throughout these analyses that erred to the benefit of the marine animals. As discussed in Subchapter 4.3, recent scientific data and information that was published after the FSEIS (DoN, 2007a) (e.g., Nowacek et al., 2007; Southall et al., 2007) have demonstrated that the potential effects from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) are considered negligible, and the potential effects on the stock of any marine mammal from temporary loss of hearing or behavioral change (significant change in a biologically important behavior) are

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-02 (Continued)	agencies' draft approach to designating OBIAs — which leaves most of the Navy's operating area unrepresented and shifts much of the burden for justifying individual areas to experts—does not satisfy the requirements of NEPA and MMPA or the Court's concerns. What is more, the SDEIS fails to consider even a single dual-criteria alternative for coastal protection, despite the Court's repeated recognition of the importance of the continental shelf.	considered minimal. The likelihood of LFA sonar transmissions causing marine mammals to strand is negligible. Despite the fact that potential injurious impacts from SURTASS LFA sonar transmissions are negligible, the Navy and NMFS understand the importance of providing additional protection for areas that have been identified as biologically significant for species that may be sensitive to SURTASS LFA sonar signals. The Navy and NMFS, however, disagree with the commenter in that the analysis was incomplete because only 21 OBIAs were designated. For additional information see responses to comments MMC-02 and NRDC-01. The Navy considered coastal areas, including coastal shelf areas beyond 22 km (12 nmi), as a part of the OBIA analysis (see SEIS/SOEIS Subchapter 4.5.6) and, as such, was part for the alternative analyses. See also response to comment MMC-04. Of the 21 OBIAs, 17 included important areas for coastal protection, such as continental shelf/slope areas and similar coastal areas. It should also be noted that the east coast continental shelf area previously designated as an OBIA was considered by the SMEs and NMFS. It was determined that the entire eastern seaboard out to the 200-m isobath did not meet the criteria, but that certain more defined areas did, which included: • Georges Bank (LFA OBIA #1); • Roseway Basin Right Whale Conservation Area (LFA OBIA #2); • Southeastern U.S. Right Whale Seasonal Habitat (North Atlantic right whale [NARW] Critical Habitat) (LFA OBIA #4); and • Great South Channel (LFA OBIA #3) including NARW Critical Habitat, Stellwagen Bank NMS, and areas within the Gulf of Maine.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-03	Nearly one year remains before the Navy's Record of Decision and NMFS' final rule governing the next 5 years of SURTASS LFA activity are slated to issue. We trust, during that time, that the geographic mitigation proposed in the DSEIS can be improved. Our interest is in mitigation that conservatively identifies and protects important habitat, that reflects the nearly global scope of the Navy's take application, and that meaningfully addresses the Court's concerns. The mitigation proposed in the Draft SEIS does not achieve these goals. **We propose that the parties to the *LFA II* litigation meet and confer** in an effort to resolve the issues raised in this letter.	**Response:** The "meet-and-confer" provision that the commenter appears to be referring to is contained in the 12 August 2008 Stipulated Settlement Agreement Order (Civ. Action No. 07-4771-EDL) and relates to altering the agreed-upon operating areas contained in that agreement for the 5-year period of the 2007 Rule. That agreement expires on the termination of the 2007 Final Rule or upon being superseded by the issuance of a new rule.
NRDC-04	A. Need for predictive modeling—The fundamental purpose of an EIS is to compel decision-makers to take a "hard look" at a particular action–both at the environmental impacts it will have and at the alternatives and mitigation measures available to reduce those impacts – *before* a decision to proceed is made. 40 C.F.R. §§ 1500.1(b), 1502.1; *Baltimore Gas & Electric v. NRDC*, 462 U.S. 87, 97 (1983). To that end, NEPA requires agencies to make every attempt to obtain and disclose data necessary to analyze environmental effects and make a reasoned choice among alternatives. *See* 40 C.F.R. § 1502.22(a). The simple assertion that "no information exists" does not suffice; unless the costs of securing the information are exorbitant or the means to obtain it are not known, NEPA requires that it be obtained. *Id.*; *see, e.g.*, *Cabinet Resource Group v. U.S. Fish and Wildlife Service*, 465 F.Supp.2d 1067, 1100 (D. Mont. 2006).	**Response:** In Subchapter 1.4.4, the Navy and NMFS acknowledge that there is incomplete and unavailable information, but also states that this is not expected to change the evaluation of the potential effects of SURTASS LFA sonar in relation to reasonably foreseeable significant impacts, because of: 1) the extensive literature reviews of current scientific data performed for this analysis to provide the best available data and information for the analyses, 2) the identification and evaluation of incomplete and unavailable information, 3) the determination of potential methods to fill the data gaps in a manner timely for the analyses, 4) the determination and evaluation of use of surrogate data when appropriate, and 5) the potential effects of not obtaining this data on the overall analyses. Further, the Navy sponsored three independent scientific research projects to help fill data gaps regarding the potential effects of SURTASS LFA sonar on humans and marine species: • Low Frequency Sound Scientific Research Program (LFS SRP) 1997-98. Three phases: 1) blue and fin whales feeding in Southern California Bight; 2) gray whales migrating along California coast; and 3) humpback whales breeding off Hawaii.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-04 (Continued)		Program successfully documented behavioral responses and assessed the potential behavioral effects of LF sound on three species of free-ranging mysticetes. • <u>Diver Risk Analyses</u> . Two phases: 1) 1993-95: tests with Navy divers conducted by Applied Research Laboratory, University of Texas under direction of the Navy Submarine Medical Research Laboratory (NSMRL); 2) 1997-98: tests to develop guidance for safe exposure limits for recreational and commercial divers who might be exposed to LF underwater sound. Research conducted by scientists from the Office of Naval Research (ONR) and NSMRL, in conjunction with scientists from a number of universities. Project results allowed NSMRL to set the received level criterion for recreational and commercial divers at 145 dB. • <u>Fish Controlled Exposure Experiments</u> (CEE) at the Naval Underwater Warfare Center (NUWC) sonar test facility on Seneca Lake, NY. The CEEs examined the effect of LFA on hearing, the structure of the ear, and select non-auditory systems in the rainbow trout, channel catfish and hybrid sunfish. Peer-reviewed research papers on the data collected have been published in 2005, 2006, 2007 and 2010. The conclusion was that LFA exposure to 193 dB had no real adverse effects on the fish tested; thus the potential for fish stocks to be impacted by LFA is negligible. In addition the Navy has and is sponsoring research to fill many other data gaps. It provided $31M in FY 2009 and $32M in FY 2010. The Navy is continuing to provide a large share of marine mammal research funding, which includes surveys to assess the distribution and abundance of marine mammals in affected areas. In sum, the available data, including recent studies funded by the Navy, have allowed the Navy and NMFS to take the requisite hard look at the

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		potential environmental impacts of a reasonable range of alternatives. In addition, the adaptive management component of the proposed action (see Subchapter 1.4.5 and response to comment MMC-04) will allow the Navy, in concert with NMFS, to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, and government/non-government organizations to determine (with input regarding practicability) whether SURTASS LFA sonar mitigation measures (which includes OBIAs) should be modified (including additions or deletions) if new scientific data indicate that such modifications would be appropriate.
NRDC-05	A. <u>Need for predictive modeling</u>—Offshore biologically important areas (OBIAs) lie at the core of the Navy's current alternatives analysis, representing the sole difference between the new preferred alternative and the one selected by the agencies during the 2007 SEIS and rulemaking processes, and ultimately rejected by the Court. DSEIS at 2-11 to 2-13. Obtaining sufficient data on potential OBIAs throughout the Navy's entire proposed operating area is therefore critical. *NRDC v. Gutierrez*, Case No. 07-4771-EDL, 2008 WL 360852 at *7 (N.D. Cal. 2008) ("…having chosen not to confine operations to relatively sterile areas of the ocean and seasons of the year and to reduce the coastal exclusion zone, the Secretary must make a serious effort to investigate plausible candidates for OBIAs").	**Response:** NMFS and the Navy performed a detailed, worldwide evaluation for potential sensitive areas, including coastal exclusion zones. A serious effort to investigate plausible candidates for OBIAs was made. (See response to comment NRDC-01).
NRDC-06	A. <u>Need for predictive modeling</u>—Yet NMFS' approach to habitat identification leaves most of the Navy's vast operating area unanalyzed. The agency's efforts appear to consist of reviewing the first edition of Hoyt's *Marine Protected Areas for Whales, Dolphins, and Porpoises* and then asking a small number of regional experts for additional recommendations. Some regions had no experts assigned to them (*e.g.*, Australia); some had only	**Response:** The analysis presented in Appendix D is indeed global, contrary to the assertion of the commenter. As described in response to comment MMC-02 above, NMFS' initial scoping of potential OBIA candidates encompassed a review of 16 marine regions as designated by the IUCN World Commission on Protected Areas, which initially included over 400 potential OBIA candidates located across the globe in all oceans and seas where SURTASS LFA sonar

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-06 (Continued)	one (*e.g.*, offshore Africa and South America) (DSEIS at D-102); and based on personal communications, we believe that at least some of NMFS' experts nominated only those areas they had particular knowledge of rather than attempt a systematic review of an entire oceanic basin or region — which is not surprising given that NMFS did not contract with anyone to perform that type of analysis. The result is a candidate list that includes, for example, only three OBIAs for the whole of South America (and none on the Pacific side), two for Australia, and three for the entire northern, central, and southern Indian Ocean. This incomplete approach to habitat identification does not meet the agencies' burden in mitigating a project with near-global sweep, and does not satisfy the Court's concerns. *NRDC v. Gutierrez*, 2008 WL 360852 at *7 ("Nor is there any evidence on the record that North America has a near monopoly on the oceanic zones important for marine mammal life as compared to the rest of the world").	could be operated. The assertion that certain areas were insufficiently considered because NMFS and the Navy propose only 21 OBIAs is incorrect. For the Caribbean/Central/South America there were 98 initial candidates; for West/East Africa there were 78 initial candidates; for the Indian Ocean there were 13 initial candidates; and for Australia/New Zealand there were 28 initial candidates. Finally the comment implies that there are more OBIAs proposed for North America than elsewhere around the globe. Again this is not supported by the analysis presented in Subchapter 4.5 and Appendix D. Two thirds of the proposed OBIAs (14 of 21) are ***not*** located in areas offshore of North America. See response to comments MMC-02 and NRDC-01 for a more detailed description and discussion of the OBIA process. Moreover, it is incorrect to state that the Navy's "vast" operating areas are not analyzed. To clarify, for each annual LOA application, the Navy must project where it intends to operate during the period of the annual LOAs and provide NMFS with reasonable and realistic risk estimates of the marine mammal stocks in the proposed areas of operations. The Navy also considers marine mammal habitats, seasonal activities, and behavioral activities during the process of determining potential mission areas and avoids planning and conducting LFA sonar operations in areas of known high marine animal densities or ''hot spots". The Navy performs a risk assessment for each planned mission site for each vessel. This process utilizes the best available data and is detailed in the 2007 FSEIS including a case study (FSEIS Subchapter 4.4, pp. 4-37 to 4-51) and in the FSEIS/SOEIS Subchapters 4.4.3 and 4.4.4. During the initial steps of the risk analysis process, if the take estimates exceed those required under the regulations (including the annual 12 percent per-stock cap), then the Navy changes or refines the location of the mission areas and

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		reruns the analysis. Again, the primary reason for establishing OBIAs for SURTASS LFA sonar is to minimize impacts and adverse effects to marine mammals and marine turtles in key areas outside of the 22 km (12 nmi) coastal restriction. This process utilizes the best available data. Thus, in selecting areas where the Navy will and will not operate SURTASS LFA sonar, both agencies must rely on what is known about marine mammal concentrations and attempt to avoid them, continue to fill knowledge gaps through additional research, and recognize that, by necessity, NMFS is regulating in a dynamic area of science. The Navy understands several groups are developing comprehensive habitat-based density maps and tools for marine regions around the world. These maps and tools identifying cetacean density and distribution would support the NMFS and the Navy's future efforts for habitat identification under the Adaptive Management requirements of the requested MMPA regulations under section 101(a)(5)(A).
NRDC-07	A. <u>Need for predictive modeling</u>—NMFS' instructions to its experts recognizes that, "for locations/ regions and species and stocks for which density information is limited or not available," high-density areas should be identified "using some combination of the following: available data, regional expertise, and/or habitat suitability models utilizing static and/or predictable dynamic oceanographic features and other factors that have been shown to be associated with high marine mammal densities." SDEIS at D-4. Such models are available on a regional scale for many species off the continental United States, and indeed have already been developed and applied by the Navy. For other parts of the world, there exists *at least one* mature global habitat suitability and/or density model, licensed by a group closely associated with St. Andrews University's Sea Mammal Research	**Response:** As part of the instruction to the subject matter experts (SMEs) when developing the list of potential OBIAs, they were specifically directed to review predictive habitat or density modeling (pg. D-4), Section 2a. High Densities, second sentence "In addition to survey data, predictive habitat or density modeling may be used to identify areas of high density." Several of the SMEs were part of the team that developed the SMRU predictive model that is referenced, and therefore had the very best insight into its applicability for identifying OBIAs. In summary, for identifying OBIAs for SURTASS LFA, SMEs were directed to use predictive habitat or density modeling in their review process. While predictive models can indicate regions with physical properties that might have relatively high probabilities of species

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	Unit (SMRU). That model has been used not only by the British Royal Navy for purposes of environmental impact assessment and mitigation, but also by the U.S. Navy itself.	occurrence, the actual abundance/density estimates for the region are often not known. Predictive models are only as good as the input data and the relationships between animal abundance/density and physical properties. Outside of U.S. EEZ waters, much of this information is not available with sufficient certainty for most applications.
NRDC-08	A. Need for predictive modeling—Predictive modeling is feasible (*i.e.*, non-exorbitant), and is necessary to provide coverage for most of the Navy's proposed LFA operating area. We urge the agencies to undertake this analysis.	**Response:** In 2011, NOAA initiated several efforts to improve methods to manage cumulative impacts of human activities on marine mammals, including convening a working group to develop tools to map cetacean density and distribution within U.S. waters. The specific objective of the Cetacean Density and Distribution Mapping Group (CetMap) is to create regional cetacean density and distribution maps that are time- and species-specific, using survey data and models that estimate density using predictive environmental factors. CetMap is producing and/or geospatially depicting one of the following (in order of preference) for all areas, periods, and cetacean species within the U.S. EEZ: 1) habitat-based density estimates; 2) stratified density estimates; 3) habitat affinity indicators; 4) presence-only information, or; 5) an indicator that no data are available. CetMap is also completing comprehensive habitat-based density modeling for the U.S. East Coast, the Gulf of Mexico, and the Alaskan Arctic. When developed, these maps and tools would support the Navy's future analyses of these areas under the Adaptive Management requirements of the requested MMPA regulations under section 101(a)(5)(A). The Navy, under license agreements with St. Andrews University's Sea Mammal Research Unit and Dr. Kristin Kaschner, has developed a preliminary database of density estimations for the Navy's areas of responsibility. These predictive density estimates were unfortunately not available for the SURTASS LFA NEPA process including both Draft SEIS/SOEIS and Final SEIS/SOEIS. However, these data will

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		be considered, as applicable, for future density estimation. The Navy, in concert with NMFS, has included in Subchapter 1.4.5, an adaptive management component to provide the means to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, government, and non-government organizations.
NRDC-09	B. Screening out non-baleen whales—The DSEIS rules out more than 20 recommended OBIAs that otherwise received habitat rankings of "two" or greater, on the grounds that they are not of high importance for baleen whales. Indeed, most of the areas proposed for the Northeast Atlantic and the Mediterranean Sea, including offshore MPAs and areas with small, localized populations, appear to have been eliminated on this basis. We believe this approach, which evidently was adopted late in the OBIA designation process, is non-precautionary and inappropriate for the vast majority of marine mammal species on which the LFA system has not been tested. Moreover, certain species other than baleen whales, such as sperm whales and pinnipeds, have greater acoustic sensitivity in the low frequencies than do odontocetes as a group; and a number of other species, such as beaked whales and harbor porpoises, have demonstrated sensitivity to a variety of sounds at relatively low acoustic thresholds.	**Response:** Subchapter 4.5.3.2 provides the scientific rationale for the determination by NMFS and the Navy that it was appropriate to consider marine mammal OBIAs only for those species whose best hearing sensitivity is in the LF range. NMFS and the Navy have acknowledged that there may be some possibility that a marine mammal MF and/or HF species could detect, either acoustically or vibrotactally, and possibly behaviorally respond to LFA sonar. However, the chances of injury and/or significant behavioral responses to SURTASS LFA sonar are very low to negligible and thus this approach is appropriate based on the scientific data. The recent "Sperm Whale *(Physeter macrocephalus)* 5-Year Review: Summary and Evaluation" by NMFS Office of Protected Resources, January 2009, stated that sperm whales may possess better LF hearing than some of the other odontocetes, although not as low as many baleen whales (Ketten, 1992). Møhl et al. (2003) found that the monopulse nature of on-axis clicks emitted by sperm whales was similar in shape and spectrum to dolphin echolocation signals, but with peaks between 15 to 25 kHz. These clicks had source levels up to 236 dB re 1µPa (rms) with center frequency of 15 kHz. Møhl et al. results were consistent with the auditory sensitivity from evoked potential responses on a young sperm whale to clicks, indicating the most sensitive to sounds between 5 and 20 kHz (Ridgway and Carder, 2001). Southall et al., (2007) stated that odontocetes' best hearing sensitivity occur at or near the frequency where echolocation

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		signals are the strongest. NMFS and the Navy did recognize the fact that certain species of pinnipeds do have good sensitivity to LF sound. OBIA Number 8, Patagonian Shelf Break, in the southern Atlantic ocean, was designated for the southern elephant seal. Beaked whales may well be more susceptible to certain types of LF noise than other MF and HF species, based on observations of marine mammal responses to other types of anthropogenic sounds, such as pile driving or seismic airguns. These types of activities produce impulsive, broadband sounds which include MF and HF bands as well as LF sounds. LFA sonar is not impulsive but consists of narrowband tonals that resemble some of the sounds produced by certain LF whales. Therefore, an LFA sonar sound presents a fundamentally different context compared to impulsive anthropogenic sound sources and is not the kind of sound that would be expected to, or that have been observed to, evoke behavioral responses in MF or HF animals including beaked whales.
NRDC-10	B. <u>Screening out non-baleen whales</u>—One effect of the agencies' approach is to reject candidate areas with small, demographically isolated populations such as the Gully — a designated OBIA from 2007 through the present, designed to protect a small population of northern bottlenose whales—without even considering the practicability of avoiding them. *See*, *e.g.*, *NRDC v. Gutierrez*, 2008 WL 360852 at *16. Originally, NMFS intended to treat frequency specialization as one factor among several in determining the relative importance of a would-be OBIA. Including such areas in practicability discussions with the Navy, and addressing them on a case-by-case basis, is a reasonable alternative that should be considered, and adopted, in the SEIS.	**Response:** See response to comments MMC-02 and NRDC-09.
NRDC-11a	C. <u>Improperly screening out candidate OBIAs for other reasons</u>	**Response:** Both the Navy and NMFS recognize that baseline data

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	1. Unreasonably high bars for further consideration a) The instructions NMFS sent to its regional experts rightly draw a distinction between areas for which comparative density information is available (*e.g.*, some species in some regions off the U.S. coast) and areas for which it is not, which would include most of the waterspace encompassed in the Navy's proposal. SDEIS at D-4. For the latter group of areas, NMFS calls for the use of alternative sources (including expert opinion) to justify their inclusion—sources that presumably need not supply the direct, comparative density measurements required in more data-rich locations. *Id.* Yet in ranking these areas, NMFS appears to have established an unreasonably high bar that does not take into account the limited density information available in most parts of the world.	on the distribution and behavior of marine animals are limited for certain areas of the world's oceans. For the SEIS/SOEIS, NMFS, the Navy, and the SMEs used the best available data to assess ocean areas greater than 22 km (12 nmi) from any shoreline with: (1) high densities of marine mammals; (2) known/defined breeding/calving grounds, foraging grounds, migration routes; or (3) small, distinct populations of marine mammals with limited distributions. NMFS further screened the areas for hearing sensitivity. For areas where NMFS, the Navy, or the SME could not provide clear justification (qualitative or quantitative) for the corresponding OBIA criteria (1, 2, or 3); or could not provide sufficient detail for criteria evaluation, NMFS scored these areas as a zero (Not Applicable) or a one (Insufficient Detail). Until such time that these data-poor areas are surveyed or more information becomes available, there is no valid scientific basis for designating these areas as OBIAs. Marine mammals that may be present in these areas would still be protected from potential injurious received sound levels by the Navy's three-part mitigation monitoring (visual, passive acoustic, and active acoustic), delay/ shutdown protocols for LFA transmissions, geographic restrictions, and mission planning for annual LOA applications. The Navy has included within its adaptive management component of the MMPA rulemaking, means to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, government, and non-government organizations to determine modifications to the OBIA list, if new scientific data indicate that such modifications would be appropriate. This would include, as appropriate, additional OBIAs. Finally, the Navy plans SURTASS LFA sonar operations for areas with reduced risk by avoiding areas of high marine life concentrations

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		to the greatest extent feasible considering national security requirements. Mission planning for the Navy's annual applications to NMFS for SURTASS LFA sonar LOA renewals use a sensitivity/risk assessment process to assess potential impacts to marine mammals (DoN, 2002; 2003b; 2004b; 2005b; 2006b). This process starts with mission areas proposed by the CNO and Fleet commanders and includes: 1) data collection and analyses for marine mammal abundances/densities; 2) spatial/ temporal analyses for potential geographic restrictions/migration corridors/habitat preferences; 3) mission area changes/refinements as required; 4) risk analysis/estimates; and 5) determination on viability of mission area based on potential marine mammal impacts.
NRDC-11b	b) For example, the DSEIS explicitly rejects Challenger Bank, an area that has repeatedly been shown to seasonally host humpback whales on their northward migration, on the grounds that "the available sighting data and information are insufficient to clearly demonstrate that the Challenger Bank individually is the most significant biologically important area in Bermudian waters for humpback whales." DSEIS at 4-81. Following this logic, locations in data-poor regions that should otherwise quality as OBIAs are excludable if comparative density and habitat usage information are not available for the wider region. Other recommended OBIAs with multiple lines of support are given low rankings with little or no explanation in the DSEIS. For example, the proposed Dogger Bank OBIA was shown in a survey of the German EEZ to contain "fairly high" densities of harbor porpoises, is associated with several oceanographic features relevant to marine mammal distribution (*e.g.*, a submerged sandbar), and has been proposed by the German government as an MPA, yet is unaccountably accorded a "one" on NMFS' scale. DSEIS at D-286. NMFS	**<u>Response</u>:** As noted by the commenters, the SEIS Subchapter 4.5.2.3 on the proposed Challenger Bank (Bermuda) OBIA did not adequately describe the justifications for excluding this habitat area as an OBIA. This section has been revised to show that although humpback whales meet the OBIA criterion for the LF hearing sensitivity, the criteria for biological importance, namely that this area is a migration route and a feeding ground, are unsubstantiated and in the later case, based on a researcher's unproven hypothesis regarding humpback whale foraging. The commenter stated that NMFS should review the OBIA ranking for Dogger Bank. NMFS has reanalyzed the ranking for the Dogger Bank area, an area that NMFS independently nominated as a potential OBIA. To clarify, Germany's Federal Agency for Nature Conservation conducted aerial surveys within the German exclusive economic zone and 12 nmi zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. They reported that the north-east survey area, off the North Friesian islands of Sylt and Amrum, showed the highest mean summer densities (2.75 individuals per square kilometer [indiv./km^2]

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	should review its low ranking of areas such as Dogger Bank.	in 2002 and 3.7 indiv./km^2) of harbor porpoises (Gilles et al., 2008). These survey areas fall under the geographic restriction that requires the Navy to restrict operation of SURTASS LFA sonar such that the sound field does not exceed 180 dB re: 1 µPa within 22 km (12 nmi) of any coastline. Conversely, Giles et al. (2008) reported that the area offshore from Dogger Bank area showed a summer density of 1 indiv./km^2 in 2002 and 1.5 indiv./km^2 in 2003 with a 95% confidence limit on their estimates. In 2010, the Joint Nature Conservation Committee (JNCC) re-evaluated Dogger Bank according to the Habitats Directive selection criteria and guiding principles in response to scientific questions on site justification for harbor porpoises. They concluded that the data indicated that there is no difference in occurrence of harbor porpoise within the Dogger Bank Special Area of Consideration (SAC) (identified for its sandbank habitat) compared to outside the SAC (JNCC, 2010). They concluded that there is not "good population density (in relation to neighboring areas and that the Dogger Bank SAC cannot be considered a "clearly identifiable area essential to the life and reproduction" of harbor porpoise, and that therefore the species should not be a qualifying feature for the site (JNCC, 2010). Based on these, the best available data/information, NMFS concluded that Dogger Bank is not eligible at this time under the high density OBIA criterion for SURTASS LFA sonar.
NRDC-11c	c) Despite its heavy reliance on experts to supply information (see below), NMFS appears to give comparatively little weight to expert opinion. For example, NMFS assigns rankings of "two" to most of the OBIAs recommended for the Mediterranean Sea, even though the consulted expert, Dr. Giuseppe Notarbartolo di Sciara, is almost without question the world's leading authority on marine mammal distribution	**Response:** See response to comments MMC-02 and NRDC-01 for information on NMFS' Process Summary for Expert Input (Also see Appendix D-3). Although habitat is a contributing factor to supporting NMFS' biological criteria for OBIAs, NMFS did not base its recommendations on areas that solely feature baleen whale habitat. For the SEIS/SOEIS, NMFS, the Navy, and the SMEs used the best available data to assess ocean areas greater than 12 nmi (22 km;

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	and abundance in that region. Many of his recommendations are based not only on his expert opinion, but also on the expert opinion of the ACCOBAMS Scientific Committee, which he chaired, and which has worked over the last decade to develop and propose marine protected areas for the region's cetaceans; as well as on additional papers and reports, some of which he cited. Yet under NMFS' weighting system, areas with rankings of "two" are not necessarily considered for OBIA protection even if they feature baleen whale habitat and might practicably be avoided.	13.6 mi) from any shoreline with: (1) high densities of marine mammals; (2) known/defined breeding/calving grounds, foraging grounds, migration routes; or (3) small, distinct populations of marine mammals with limited distributions. For areas where NMFS, the Navy, or the SME recommended the area based on habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature, NMFS ranked these areas as a two (Eligible: Requires More Justification). Contrary to the commenter's assertion, under NMFS' classification methodology, NMFS considered areas with a rank of two or higher as eligible for consideration as an OBIA for SURTASS LFA sonar operations. Thus, Dr. Notarbartolo di Sciara's submitted areas were included within the initial screening for OBIA candidates and NMFS conducted additional screenings for sufficient scientific support and for hearing sensitivity. Many of Dr. Notarbartolo di Sciara's recommended areas did not meet the screening criterion for low frequency hearing specialization. The Ligurian-Corsican-Provencal Basin, which did meet the screening criterion for fin whales, was proposed as OBIA #15. Until such time that these data-poor areas are surveyed or more information becomes available, marine mammals that may be present in areas not selected as an OBIA would be more than adequately protected by the Navy's three-part mitigation monitoring (visual, passive acoustic, and active acoustic) and delay/shutdown protocols for LFA transmissions. Based on the results of nine years of SURTASS LFA sonar operations, the Navy's three-part mitigation monitoring program has a high probability of detecting marine mammals within of an area of approximately 2-km (1.1 nmi) radius from the array. No Level A harassment of marine mammals by SURTASS LFA sonar transmissions has been reported during that

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		period of time. In addition, the Navy plans SURTASS LFA sonar operations for areas with reduced risk by avoiding areas of high marine life concentrations to the greatest extent feasible considering national security tasking. The Navy's annual applications to NMFS for SURTASS LFA sonar LOA renewals use a sensitivity/risk assessment process to assess potential impacts to marine mammals (DoN, 2002; 2003b; 2004b; 2005b; 2006b). This process starts with mission areas proposed by the CNO and Fleet commanders and includes: 1) data collection and analyses for marine mammal abundances/densities; 2) spatial/temporal analyses for potential geographic restrictions/migration corridors/habitat preferences; 3) mission area changes/refinements as required; 4) risk analysis/estimates; and 5) determination on viability of mission area based on potential marine mammal impacts. Identifying OBIAs for SURTASS LFA sonar operations is not final. The Navy has included within its adaptive management component of the MMPA rulemaking, means to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, government, and non-government organizations to determine modifications to the OBIA list, if new scientific data indicate that such modifications would be appropriate. This would include, as appropriate, additional OBIAs. To reiterate, NMFS incorporated expert input, as appropriate, to produce the final OBIA Nominees. The commenter's statement about "heavy reliance" disregards the extensive analysis that NMFS and the Navy conducted during the initial phase of the identification process as well as the continual efforts to update information on potential OBIAs for the adaptive management component of the

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		MMPA rulemaking.
NRDC-11d	d) Given the extent of the area available for LFA operations, the lack of comparative density data in most parts of the world, and NMFS' express reliance on experts, it is reasonable for the agencies to consider the practicability of recommended OBIAs that score a "one" or above on NMFS' scale.	**Response:** As is detailed in the SEIS/SOEIS Subchapter 4.5.2 and Appendix D, the list of proposed OBIAs from which the final 21 were selected included OBIA sites with rankings of 2, 3, and 4. So OBIA sites with other than the highest rankings were indeed considered in the final assessment phase as potential LFA OBIAs. The rationale for rankings of 0 and 1 being considered as "Not Eligible" is discussed in the SEIS/SOEIS Subchapter 4.5.2 and pages D-103 and D-231.
NRDC-12	C. Improperly screening out candidate OBIAs for other reasons 2. Overreliance on expert responses to data requests Both *LFA I* and *LFA II* recognize that the burden to identify OBIAs rests squarely with the agencies. As the Court has noted, "it is improper for NMFS, the government agency tasked by the MMPA with requiring measures to ensure the least practicable impact on marine mammals when authorizing takes, to shift the burden to members of the public to prove that additional exclusion areas are warranted." *NRDC v. Gutierrez*, 2008 WL 360852 at *8. And it is equally improper for the agencies to shift that same burden to other agencies or experts. *Id.* (observing that NMFS had "improperly shifted the burden to its own parent agency to provide detailed information regarding the marine life there"). Yet NMFS, in the current process, has effectively shifted the burden of identifying OBIA to its volunteer experts, appearing to have screened out areas where its experts did not supply "sufficient" information even though additional information might be available. For example, for the Gulf of Mexico, where NMFS' expert recommended the inclusion of slope waters between the 200m and 1000m depth contours, the agency merely listed the	**Response:** NMFS did not shift the burden of identifying OBIAs to other agencies or to the subject matter experts (SME). To reiterate, NMFS implemented a comprehensive process to identify OBIAs for SURTASS LFA sonar operations in the world's oceans. In the Process Summary for Expert Input (See Appendix D-3), Stage 1 (c) specifically states that "NMFS will incorporate expert input, as appropriate, to produce the final OBIA nominees, which will be included for consideration in the Navy's 2009 draft supplemental environmental impact statement (DSEIS) for SURTASS LFA sonar." NMFS did not place the entire burden of selecting OBIAs upon the SMEs. Rather, NMFS incorporated expert input, as appropriate, and produced a list of OBIA nominees for the MMPA rulemaking (See Subchapter 4.5.2.3 Further Analysis by NMFS and the Navy). To conduct the OBIA analyses, NMFS and the Navy relied on all of the evidence available. This evidence generally consist of reports prepared by natural resource agencies in other countries; reports from non-governmental organizations involved in marine conservation issues; information from subject matter experts; and the general scientific literature. During all phases of the identification process, NMFS and the Navy conducted electronic searches of the general scientific literature using search engines, including Aquatic Sciences and Fisheries Abstracts, Conference Papers Index,

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-12 (Continued)	"background" information that the expert provided, and without explanation gave the area two disqualifying "ones" for "high density" and "foraging" and "zeroes" in every other habitat category. SDEIS at D-290. Even supposing *arguendo* that these rankings were reasonable, the agency apparently did not compile other information that might support the recommendation, even though such information was readily available, nor did it consider on its own any alternative areas in the Gulf, including parts of the recommended OBIA, that might have additional support. *Cf.*, *e.g.*, Appendix B to this letter. Instead, NMFS appears to have relied entirely on its expert to define the OBIA boundary and justify it. That form of burden-shifting is not acceptable.	BioOne, Science Direct, JSTOR, Web of Science-Science Citation Index, and Google Scholar. NMFS also supplemented these searches with electronic searches of doctoral dissertations and master's theses. See Subchapter 4.5.2.3 *Further Analysis by NMFS and the Navy*. Both NMFS and the Navy conducted extensive analysis during the initial phase of the identification process and continued to conduct literature reviews in support of the areas for which there was insufficient information throughout the entire OBIA process. For the SEIS/SOEIS, NMFS, the Navy, and the SMEs used the best available data to assess ocean areas greater than 22 km (12 nmi) from any shoreline with: (1) high densities of marine mammals; (2) known/defined breeding/calving grounds, foraging grounds, migration routes; or (3) small, distinct populations of marine mammals with limited distributions. Under the classification methodology for OBIAs, we believe that assigning a rank of one (Not Eligible: Insufficient Information) for an OBIA recommendation located greater than 22 km (12 nmi) from any shoreline in the Gulf of Mexico was reasonable and based on the best available science. NMFS and the Navy have again reviewed the latest and best available scientific information and could not locate adequate information to support designation of an OBIA for SURTASS LFA sonar between the 200 and 1,000 m depth contours in the Gulf of Mexico. In fact, several papers noted that most marine mammal species had a wide spatial distribution along the slope as well as a wide temporal distribution (Mullin et al., 1991; Davis et al., 1998; Baumgartner et al., 2001). Until such time that more information becomes available that supports the biological criteria (i.e., marine mammals present in high densities or an area on the slope with known/defined breeding/calving grounds, foraging grounds, migration routes, or an area with small, distinct populations of marine mammals

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		with limited distributions) on the continental slope of the northern Gulf of Mexico, NMFS and the Navy cannot recommend this area as an OBIA for SURTASS LFA sonar operations. If SURTASS LFA sonar operations were to occur on the continental slope of the northern Gulf of Mexico, marine mammals present in the operational area are more than adequately protected by the Navy's three-part mitigation monitoring (visual, passive acoustic, and active acoustic), delay/shutdown protocols for LFA transmissions, and geographic restrictions. The Navy has included within its adaptive management component of the MMPA rulemaking, means to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, government, and non-government organizations to determine modifications to the OBIA list, if new scientific data indicate that such modifications would be appropriate. This would include, as appropriate, additional OBIAs.
NRDC-13	C. <u>Improperly screening out candidate OBIAs for other reasons</u> 3. Exclusion of areas within 12nm of shore The agencies have improperly rejected numerous areas on the grounds that they occur entirely within the Navy's 12nm coastal exclusion zone. First, NMFS failed to consider the relevance of identifying important near-coastal habitat to establishing meaningful buffer zones for these areas (see *infra* I(F) below). Instead, it summarily ruled out the vast majority of established and proposed MPAs as ineligible for additional protection because they fall within the coastal zone (*see* DSEIS at D-39 to D-101), and instructed its experts to nominate only areas extending at least partly beyond the 12nm limit (DSEIS at D-4). (This problem is soluble by generally enlarging the coastal stand-off zone.) Additionally,	**Response:** Response to comment NRDC-17 discusses increasing the buffer zone out to the 150-dB (RL) isopleths and provides the rationale that, based on the best scientific data available, larger buffer zones are not warranted. Therefore, the screening criterion that a potential OBIA candidate must be outside of 12 nmi from the coast is proper. Identifying candidates within that zone is unnecessary because they will receive the same level of protection as all areas within the 12-nmi coastal zone. The Navy and NMFS concur that the Papahanaumokuakea (Northwestern Hawaiian Islands) Marine National Monument (MNM) boundaries do extend seaward of the 22-km (12-nmi) standoff. Under Presidential Proclamation 8031 of 15 June 2006, Establishment of the Northwestern Hawaiian Islands Marine National Monument, the

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	the agency incorrectly assumes that certain established or proposed MPAs and recommended OBIAs are located entirely within 12nm of shore. For example, the Papahanaumokuakea Marine National Monument was apparently excluded early in the OBIA process on the assumption that it does not extend seaward of that distance, which is incorrect	prohibitions required by this proclamation do not apply to Armed Forces activities and exercises, provided that these activities are carried out in a manner that avoids, to the extent practicable and consistent with operational requirements, adverse impacts on monument resources and qualities. Marine animals present in the operational MNM area are more than adequately protected by the Navy's three-part mitigation monitoring (visual, passive acoustic, and active acoustic), delay/shutdown protocols for LFA transmissions, and geographic restrictions. For additional discussion on this MNM see response to comment NRDC-15. The Northwestern Hawaiian Islands were considered in the additional analysis for OBIAs in Appendix F. Johnston et al. (2007) modeled the extent and spatial location of humpback whale wintering habitat across the Hawaiian Archipelago, using synoptic data from January–March for areas shallower than 200 m (656 ft) with sea surface temperatures warmer than 21.1°C (70.0°F) as potential wintering habitat. They conducted a March 2007 pilot survey across the NWHI and reported nine sightings of humpback whales (n = 19) during the 15-day cruise, including 3 groups with small calves or exhibiting breeding behaviors. All sightings occurred in warm, shallow water at or within their predicted habitat regions. They detected humpback whales on the shallow banks surrounding Nihoa Island, Necker Island, Gardner Pinnacles, Maro Reef, and Lisianski Island (Johnston et al., 2007). No humpback whale sightings occurred outside of 200-m isobath despite considerable survey efforts in deeper areas. It was concluded that the breeding activities occurred in waters mostly within 22 km (12 nmi) of the islands and atolls, There was not enough information to support designation outside of the 22 km (12 nmi) buffer around the islands and atolls. For additional details see Appendix F, page 28.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-14	C. Improperly screening out candidate OBIAs for other reasons 4. Exclusion of areas practicably avoided by the Navy Under the various settlement agreements and orders that have helped govern use of the LFA system since 2002, the Navy has practicably avoided several biologically important areas in the western Pacific, particularly off the coast of Asia and in the Philippine Sea. It is not entirely clear how NMFS considered these areas in the present process, since the DSEIS suggests that its regional experts proposed somewhat different (and generally more expansive) boundaries than the ones adopted in the course of negotiation in *LFA I* and *LFA II*; in any case, however, all but one of these candidate OBIAs were rejected, most receiving scores of "zero" (or at best "one") on the agency's scale. NMFS' evaluation of these areas is highly problematic. Even though they occur in a region where little comparative density information is available and thus require the use of alternative sources to assess; even though they are supported by expert recommendation; even though additional sources suggest the occurrence there of small, localized populations and endemism in some species; and even though avoidance of at least part of these areas appears practicable, at least on a seasonal basis — none of these potential avoidance areas was assessed for its practicability. *See*, *e.g.*, DSEIS at D-338 (scoring as "zero" a resident population of fin whales in the Yellow Sea and East China Sea that exhibits morphological differences from other fin whales. Nor, apparently, did NMFS attempt to obtain additional data on these areas beyond what its regional experts proposed. *See supra* at I(C)(2).	**Response:** These areas in the northwestern Pacific Ocean and Philippine Sea are not and have never met the biological criteria to be designated as OBIAs. This is confirmed by the lack of support for all of the areas from NMFS' marine biological subject matter experts during the comprehensive process for selecting, assessing, and designating OBIAs for SURTASS LFA sonar. See responses to comments MMC-02 and NRDC-01 for information on the OBIA designation process. There are no new data to clarify the population structure of the fin whale in the North Pacific Ocean. Mizroch et al. (2009) reviewed the distribution and movement data available for the region and cited the same literature from the late 1950s, early 1960s as the SME regarding the possibility of a non-migratory stock of fin whales in the East China Sea. Fujino (1960) suggested that whales caught in the East China Sea were part of a local population that did not migrate to northern waters. In addition to his immunogenetic findings, he analyzed unpublished data that indicated that fin whales from the East China Sea were different from other North Pacific fin whales in terms of growth rate, length at sexual maturity, external body proportions, shape of skull and shape and growth rate of baleen.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-15	D. Omitted areas Among other areas that NMFS apparently did not consider are: habitat off the Atlantic identified in the Navy's 2008 AFAST EIS as "Areas of Increased Awareness"; additional MPAs and proposed MPAs identified in the expanded second edition of Hoyt's *Marine Protected Areas for Whales, Dolphins, and Porpoises* (2011), as supplemented by Hoyt's online directory of cetacean protected areas; areas referenced in the previous *LFA I* and *LFA II* cases; important habitat in the Northwest Pacific Ocean, as summarized at Appendix A to this letter; important habitat in the Gulf of Mexico, as summarized at Appendix B to this letter; important habitat off the main Hawaiian Islands, as summarized at Appendix C to this letter; areas such as waters off southeast Alaska that the SPLASH project identified as seasonal habitat or migration corridors for humpback whales; and the North Atlantic right whale migration corridor, whose protection in prior years was lost when the east-coast 200m isobath OBIA was unaccountably dropped during the current process. These suggestions are not intended to be comprehensive, nor, again, should the burden fall on the public to identify OBIAs. *NRDC v. Gutierrez*, 2008 WL 360852 at *8. But we note again the limits of the process that NMFS has conceived.	**Response:** 1. It is worth noting that the number of LFA OBIAs designated in the SEIS/SOEIS (21) is more than double the number of LFA OBIAs designated previously (10). 2. While it is not the expectation of the Navy or NMFS that the public should be burdened with identifying LFA OBIAs, it is, however, possible that additional and pertinent information may be provided or additional areas of the world's oceans may be recommended by the public as part of the SEIS/SOEIS public review process. 3. In Alternative 3 of the AFAST EIS (DoN, 2008), the Navy identified "Areas of Increased Awareness" (AIA) off the U.S. Atlantic. This alternative was not the preferred alternative nor was it the alternative selected by the Navy for implementation of the proposed action. In fact, in the AFAST Record of Decision, the Navy specifically noted that, "the world today is a rapidly changing and extremely complex place. This is especially true in the arena of ASW and the scientific advances in submarine quieting technology. Not only is this technology rapidly improving, the availability of these quiet submarines has also significantly increased. Since these submarines typically operate in coastal regions, which are the most difficult acoustically to conduct ASW, the Navy needs to ensure it has the ability to train in areas that are environmentally similar to where these submarines currently operate, as well as areas that may arise in the future. Limiting where naval forces can train will eliminate this critical option of training flexibility to respond to future crises." It is also incorrect to suggest that these AIAs were not included in the OBIA selection process. Several of the AFAST AIAs are

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		indeed already included in OBIAs. These include the North Atlantic right whale NE and SE critical habitat areas, which are included as OBIAs (OBIAs 3 and 4) and areas of seasonal high marine mammal densities identified as AIAs such as the Gulf of Maine, Great South Channel, Georges Bank, and the Roseway Basin, which have been included as OBIAs (OBIAs 1, 2, and 3). Regarding National Marine Sanctuaries, of which the remaining U.S. Atlantic and Gulf of Mexico sanctuaries were included as AIAs in the AFAST EIS alternative, these NMSs (Flower Garden Bank, Florida Keys, Gray's Reef, and Monitor NMSs) are considered to be recreational dive sites. As such, the SURTASS LFA sonar sound field will not exceed 145 dB re 1 µPa (rms) (SPL) in these NMSs. See Table 3-24 and Appendix A. 4. The Navy and NMFS could not have been reasonably expected to have considered and incorporated the information in Hoyt's 2011 book on marine mammal MPAs between the time it was published in May 2011 and the publication date of the DSEIS/SOEIS in August 2011. The Navy and NMFS were aware of Hoyt's 2011 book, but it was unfortunately not available in sufficient time prior to the publication of the DSEIS/SOEIS to allow incorporation of potential new information or assessment of any MPAs not already assessed by NMFS or its subject matter experts in the lengthy and thorough assessment of more than 403 potential OBIAs that began in November 2009. To continue their assessment of potential OBIAs for SURTASS LFA sonar, NMFS has completed their review of the Hoyt (2011) *Marine Protected Areas for Whales, Dolphins, and Porpoises*. The results of NMFS' analyses for those areas that meet the geographic and biological selection criteria are presented in Appendix F.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		5. Contrary to what the commenters imply, the marine areas noted in the U.S. District Court Opinions were not omitted from the DSEIS/SOEIS OBIA selection process. In its 6 February 2008 Opinion and Order, the U.S. District Court for the Northern District of California noted concerns that certain marine habitats were not protected under the NMFS MMPA Final Rule (NOAA, 2007). The Opinion provided examples of marine areas that had not been protected, which follows. Also provided below are the OBIA status of each of the court's noted areas as specified in the SEIS/SOEIS: ➢ *The Great Barrier Reef*—The portion of the reef between 16°S and 21°S has been designated as a potential LFA MM OBIA (OBIA #18). ➢ *The Pelagos*—The Ligurian-Corsican-Provincial Basin and Western Pelagos Sanctuary has been selected as a potential LFA MM OBIA (OBIA #15) ➢ *Davidson Seamount*—The Central California National Marine Sanctuaries (NMS) created a single stratum boundary from the Cordell Bank, Gulf of the Farallones, and Monterey Bay NMSs' legal boundaries, which included the Davidson Seamount Management Zone (15 CFR 922 Subpart M, Appendix F). The Central California NMSs have been recommended as one of the potential LFA MM OBIAs (OBIA #10). ➢ *Galapagos Islands*—The Galapagos Marine Resources Reserve (MRR) was analyzed with emphasis on the areas around Bartolome and Espanola Islands. Even though blue whales are reported to be present, there is no scientific evidence that these whales occur in these waters in densities higher than any other similar location. Therefore, this area

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		was not recommended as an LFA MM OBIA. ➢ *Emperor Seamount Chain*—Even though there is evidence of baleen whale activity in waters surrounding the seamounts, there is no scientific evidence that these whales occur in these waters in densities higher than any other similar location. On this basis, the Emperor Seamount Chain area was not recommended as an LFA MM OBIA. ➢ *Oyashio/Kuroshio Currents*—Even though there is evidence of baleen whale activity in these areas, there is no scientific evidence that the baleen whale densities are higher in these waters than any other similar location. Therefore, this area was not recommended as an LFA MM OBIA. ➢ *Papahanaumokuakea Marine National Monument (formally Northwestern Hawaiian Islands Marine National Monument)*—The monument consists of emergent and submerged lands and waters and is the habitat for the endangered Hawaiian monk seal, which is not an LF-hearing specialist. For this reason, the area did not qualify as an LFA MM OBIA. ➢ *Xiamen Marine National Park and Conservation Area*—This area does not qualify to be designated as an LFA MM OBIA because it does not meet the screening Criteria 1 (see section 4.5.2.1 of the SEIS/SOEIS). The area lies wholly within 22 km (12 nmi) of the coastline. ➢ *Far Eastern Marine Nature Reserve*—This area does not qualify to be designated as an LFA MM OBIA because it does not Criteria 1. The area lies wholly within 22 km (12 nmi) of the coastline. 6. Areas mentioned in the commenter's appendices are addressed

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		separately (see NRDC-23 through 25). 7. It is not accurate to imply that the waters of southeast Alaska were omitted from the LFA OBIA selection process. For example, Fairweather Grounds, although not specifically mentioned in the SPLASH report (Calambokidis et al., 2008), was an area considered but ultimately not selected as a potential OBIA seasonally for humpback whales in southeastern Alaska waters. Additionally, the Glacier Bay National Park and Preserve, southeastern Alaska, was also considered but not selected as an LFA MM OBIA. Also, the commenters have mischaracterized what the SPLASH report states regarding migration corridors for humpback whales in the North Pacific Ocean. The SPLASH report does not discuss, delineate, nor depict migration corridors, but instead describes and depicts migrational movements of individually tagged whales between the winter and summer grounds (Calambokidis et al., 2008). The SPLASH report details the complexity of humpback whale migratory movements in the North Pacific, which encompass much of the North Pacific Ocean between the Hawaiian and Japanese Islands and the Gulf of Alaska and waters of northeastern Russia. No migrational corridors have been defined for the humpback whale in this region thus far. This vast area of the North Pacific Ocean could not reasonably be set aside as an area where SURTASS LFA sonar would be seasonally restricted. 8. The commenter notes the existence of "the North Atlantic right whale migration corridor" in waters <200 meters in depth off the U.S. Atlantic coast. The available sighting data, collected over several decades, are insufficient to represent a specific migrational corridor for the North Atlantic right whale off the U.S.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		Atlantic coast or elsewhere in the North Atlantic Ocean (Kenney, 2012). The winter locations and movements of much of the North Atlantic right whale population are currently unknown (Waring et al., 2010).
NRDC-16	E. <u>Practicability analysis</u> According to the DSEIS, the Navy eliminated the Southern California Bight from the list of "eligible" OBIAs because it determined that "avoiding this area is impracticable." DSEIS at 4-80. The Navy does not provide any specific information on LFA training in the SOCAL Range Complex, making a full assessment difficult; but even assuming that its determination is well-founded, more analysis is required. As it stands, the DSEIS appears to consider the practicability only of a complete, year-round LFA exclusion. It does not consider any procedural requirements (*e.g.*, requiring Fleet-level approval for use), substantive standards (*e.g.*, allowing use only when certain criteria are met), or targeted restrictions (*e.g.*, limiting the number of activities per annum or avoiding biologically important periods such as the blue whale foraging season), or any other mitigation methods that would protect this vital habitat while allowing the Navy use for training purposes. The Southern California Bight is an area of high importance to multiple marine mammal species, including several species of endangered baleen whales, and maintains, despite some apparent shifts in habitat, what is certainly one of the largest concentrations of blue whales on the planet. Reconsideration of this area is essential. The DSEIS does not indicate which other candidates, if any, beyond the Southern California Bight were deemed impracticable and denied OBIA status on that basis. The Navy should provide this information and, for each rejected area, a detailed summary	**Response:** The commenter states that "The Navy does not provide any specific information on LFA training in the SOCAL Range Complex…" The SEIS/SOEIS Subchapter 4.5.2.3 provides specific and sufficient information to support the Navy's determination that avoiding this area is operationally impracticable. See response to comment MMC-02 for additional information. The commenter objects to the lack of consideration of procedural requirements, substantive standards, targeted restrictions, or any other mitigation methods that would protect this habitat, while allowing the Navy use for training purposes. First and, most important, is the fact that for this area and all SURTASS LFA sonar operating areas, there are three layers of mitigation methods, entailing visual mitigation monitoring, passive acoustic mitigation monitoring, active acoustic mitigation monitoring, and shutdown protocols for LFA transmissions to protect marine mammals. Second, there has never been any evidence of MMPA Level A harassment of any marine mammals in any ocean area where SURTASS LFA sonar operations have occurred over the last ten years. Indeed, during the 1997-98 Low Frequency Sound Scientific Research Program(Phase I) in the SOCAL Bight, under Scientific Research Permit (875-1401) that allowed LFA exposure to marine mammals up to received levels of 160 dB re 1 µPa, the scientists were never able to expose marine mammals to received levels above 155 dB re 1 µPa. The commenter further states that the SOCAL Range Complex is "…certainly one of the highest concentrations of blue whales on the planet." The Navy concluded that the underlying data cover a short

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	of its practicability analysis.	time period and the dynamic nature of blue whale distribution and the variability of prey abundance make it difficult to assign any permanence to this area as one of blue whale concentration. This conclusion was based on scientific examination of all pertinent available data, which did not support the premise that when blue whales were foraging in this geographic region, high concentrations of the whales were always present in the SOCAL Range Complex. Because of the vital training that occurs on this range throughout the year, the SOCAL Range Complex was the only OBIA of the 22 candidates that qualified under the criteria established by NMFS that the Navy considered to be operationally impracticable.
NRDC-17	F. <u>Buffer zone:</u> NMFS has established a list of objectives for habitat avoidance and other mitigation measures, including reduction in the total number of marine mammal takes and the reduction in the severity, intensity, or number of exposures, particularly (but not exclusively) for vulnerable species. *See*, *e.g.*, 74 Fed. Reg. 3886 (Jan. 21, 2009). On this basis, the agencies should consider and adopt wider buffer zones around their OBIAs. According to the Navy's behavioral risk function, the 175-180 dB (RMS) annulus has an average "take" risk of 91.5%, the 170-175 dB (RMS) annulus a take risk of 80.5%, the 165-170 dB (RMS) annulus a risk of 61.5%, the 160-165 dB annulus a risk of 38.5% (RMS), the 155-160 dB annulus a risk of 18%, and the 150-155 dB annulus a risk on the order of 8-9%. *See* 2007 SEIS at 4-74. Given the greater area subsumed within the lower-decibel annuluses, the number of takes occurring within even the 150 dB annulus can be high, despite the lower relative risk. Indeed, the amount of take occurring within these areas is suggested by the Navy's nominal coastal exclusion analysis from 2007, for which the vast majority	**Response:** Commenter is suggesting that increasing the buffer zone for OBIAs out to the 150 dB isopleth is necessary because "the number of takes occurring within even the 150 dB annulus can be high, despite the lower relative risk." This was based on the Navy's risk function (DSEIS/SOEIS, Table C-13b) and the "Generic Analytical Methodology for Coastal Standoff Range Comparison" (2007 FSEIS, Subchapter 4.7.6). The commenter incorrectly interprets and misapplies the risk function, which does not represent the actual risk to a marine mammal stock but is part of a multi-step process to determine take estimates for SURTASS LFA sonar transmissions. First, using the Navy's standard parabolic equation (PE) model, the LFA acoustic sound field is determined from the source array to approximately 120 dB received level (RL). Next, the acoustic integration model (AIM) is used to predict the animal movement and convolves the results with the LFA sound field to determine exposure history (accumulated energy) for each simulated marine mammal out to approximately 120 dB RL, which is calculated to determine risk of Level B harassment. During post-processing, these results are scaled from model

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	of take in each of the two scenarios the Navy examined is attributable to the 155-160 dB annulus (the 150-155 dB annulus being unassessed). *See id.* at 4-74 and 4-77 (comparing the "corrected risk areas" of the various annuluses). Buffer zones that are designed to eliminate exposures out to at least the 150 dB (RMS) are likely to be practicable for most, if not all, areas. The Navy avoids dive sites out to 145 dB (RMS), nominally requiring a significantly greater stand-off distance than a 150 dB (RMS) stand-off would entail. Many of the OBIAs are small to begin with, and discretely drawn. *See* DSEIS at D-377 to 387. In any case, as the Court has stated, "in assessing Defendants' argument that it is impractical to place large areas of the ocean off limits for training, it is important to keep in mind the context. While we think of the continents we live on as huge, in fact most of the world's surface is covered by its vast oceans. So it is practicable to safeguard marine mammals by carving out some additional areas even if they measure thousands of square miles when placed in the context of the 70-75% of the world's oceans which the Final Rule would open to LFA sonar, while still meeting the Navy's need for access to the enormous majority of the world's marine waters." *NRDC v. Gutierrez*, 2008 WL 360852 at *10. The agencies should adopt at least a 150 dB (RMS) buffer zone around its OBIAs, except where geographically specific, clearly stated operational needs in the vicinity of a particular area make such a stand-off distance impracticable, in which case they should adopt the largest practicable buffer. (*See supra* the practicability discussion at I(E).)	densities to real-world density and abundance estimates to determine the overall percentage of potential risk to each marine mammal species stock. In the 2001 and 2007 Rules and LOAs, NMFS has limited the incidental take of any marine mammal stock to 12 percent annually combined for all vessels issued LOAs. As presented in Subchapter 4.4.4, Supplemental Risk Assessment and Tables 4-5 through 4-23, the estimated percent of marine mammal stocks potentially harassed are below the conditions delineated by NMFS in the LOAs issued under the 2001 and 2007 Rules. In order for NMFS to grant authorization under the MMPA, NMFS must find that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). In over 9 years of operations, SURTASS LFA sonar operations have remained under, and in most cases well under, this limit. Also there have been no incidences of SURTASS LFA sonar being involved in any marine mammal strandings or mortalities during the nine-year period. Therefore, SURTASS LFA sonar operations under the current mitigation meet the requirements of the MMPA as determined by the regulator, and no additional buffer zones are warranted. Also, the propagation model used for the "nominal coastal study" (2007 FSEIS, Subchapter 4.7.6) is sufficient for the relative comparison of the similar scenarios as presented in that study (which is effectively a sensitivity study), but its extrapolation for use in deriving absolute received level results (as per the commenter's statement) should not be expected to produce meaningful results. In other words, the commenter's use of this study to support his comment is invalid.
NRDC-18	G. <u>Defining the operations area as an alternative for Hawaii</u>	**Response:** The commenter states that "…the Navy may be able to

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	Finally, the Navy may be able to affirmatively define its operating area, in some regions, in a way that avoids high-value habitat and most if not all OBIAs. As the Court has observed, confining LFA operations to areas and seasons of lesser concern would be an effective means of mitigation. *See NRDC v. Gutierrez*, 2008 WL 360852 at *6. While the Navy has indicated that it cannot, as a general rule, practicably site its activities in low-value habitat for marine mammals, that option may be available in some regions. The Navy's current operating area off Hawaii, for example, which was established through the 2008 settlement agreement in *LFA II*, effectively avoids most if not all of the areas of greatest importance to small, localized populations of marine mammals around the main Hawaiian Islands, as well as the Papahanaumokuakea Marine National Monument. The agencies should consider using this reasonable alternative in specific places, like Hawaii, where it may be viable.	affirmatively define its operating areas in some regions in a way that avoids high-value habitat, and most if not all OBIAs." The goal of the Navy's annual LOA application process (Subchapter 2.4.2) is to identify marine areas for SURTASS LFA sonar routine testing, training and military operations that would contribute/support to the activity having the least practicable adverse impacts on marine mammals, while meeting National Security objectives. This entails, as part of the SURTASS LFA sonar sensitivity/risk assessment approach, the evaluation of operating areas with minimal marine mammal/animal activities, as portrayed in Figure 2-3 and discussed in Subchapter 4.4. As to the commenter's proposal for the Navy to adopt the 2008 settlement agreement's coastal standoff distance in specific places, like Hawaii, NMFS and the Navy refer to the comprehensive OBIA analysis process that is detailed in Appendices D and F. NMFS and the Navy are confident that this OBIA analysis process incorporated the prospect of the Navy avoiding areas of greatest importance to small, localized populations of marine mammals around the main Hawaiian Islands, and elsewhere.
NRDC-19	<u>Coastal Exclusion Zone</u> The DSEIS' treatment of coastal exclusion zones is inadequate. While the *LFA II* Court agreed that the Navy need not necessarily analyze the specific dual-criteria exclusion established in the previous years' injunction for the Philippine Sea, it also found that this did not excuse the Navy "from evaluating a dual criteria alternative that would meet the stated purpose and need, such as a dual criteria alternative used in some areas, but not others, with an exception for non-routine military tracking operations." *NRDC v. Gutierrez*, 2008 WL 360852 at *23. The Court based its conclusion particularly on "the importance of the location of the continental shelf to the environmental impact and the fact that the Navy has been	**Response:** This comment is addressed in part in response to comment MMC-04. In addition, the Navy questions the context of the commenter's objection, that "…the OBIA process…does not provide meaningful site-specific analysis for most of the world's coastal regions." First, all SURTASS LFA sonar operations must occur under the geographic restriction of a coastal standoff range of at least 22 km (12 nmi). Second, as part of the OBIA analysis, NMFS and the Navy considered the biological importance of coastal areas outside the current coastal standoff range, with many over the continental shelf. Hence, the Navy deems that the treatment of coastal exclusion zones (i.e., whether a greater coastal standoff range was practicable) has been reasonably examined to the

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	operating under a dual criteria for five years." *Id.* The Court's point is all the more salient to the present DSEIS, given that the Navy has been operating with dual criteria throughout the Western Pacific (*i.e.*, its entire effective operating area) for almost ten years now. The SDEIS suggests that the OBIA identification process obviates the need for any further consideration of coastal exclusions. According to the SDEIS, no further consideration is needed since 32 of the agencies' candidate OBIAs occur "completely or partially within shelf waters and outside of the [12nm] coastal standoff range." DSEIS at 4-95. But the OBIA process is not an effective substitute. As noted above, that process, as it has been conducted thus far, does not provide meaningful site-specific analysis for most of the world's coastal regions. Moreover, NMFS expressly limited its consideration of OBIAs to areas outside the Navy's preferred 12nm stand-off zone (SDEIS at D-4), meaning that it did not even attempt to identify an entire category of especially important shelf areas for which a wider coastal exclusion is needed to reduce take. *See also* DSEIS at D-39 to D-101 (ruling out most existing MPAs as occurring within 12nm of shore). Finally, the Navy's summary analysis, as the Court recognized, does not take into account the shelf's particular environmental importance and vulnerability. *NRDC v. Gutierrez*, 2008 WL 360852 at *23 ("the importance of the location of the continental shelf to the environmental impact"). The Court observed in *LFA II* that NMFS' failure to properly designate OBIAs "rendered more serious" its failure to consider dual-criteria alternatives for the continental shelf. SDEIS at *13. The Court did not say that an OBIA analysis could render a dual-criteria analysis completely unnecessary—but even if it could, the agencies' analysis in the DSEIS simply does not fill the need that the Court identified.	greatest extent feasible. The commenter stated that the analysis of dual coastal standoff in the DSEIS/SOEIS does not satisfy the Court's findings. The Court's concern was that the employment of SURTASS LFA sonar has the least practicable impact on marine mammals and important marine mammal habitats in coastal waters more than 22 km (12 nmi) from shore. To accomplish this, NMFS and the Navy developed the concept of marine mammal offshore biologically important areas (known as OBIAs) for SURTASS LFA sonar in the 2001 FOEIS/EIS (DoN, 2001). The criteria for candidate OBIAs, however, addressed the same issue—are there coastal areas outside the standoff range that are biologically important and merit additional protection?—that a separate dual coastal standoff distance analysis would have addressed. As noted in response to comment MMC-02, NMFS initially screened 403 marine areas, which encompassed a review of 16 worldwide marine regions (less the Arctic and Antarctic). Input from the SMEs resulted in 73 candidate OBIAs. As pointed out by the commenter, 32 of these were either completely or partially within shelf waters and outside of the coastal standoff range. As noted above, the Navy has operated SURTASS LFA sonar in the northwestern Pacific for over ten years, which has included fixed coastal standoff distances that were not necessarily based on the locations of the continental shelf. Most of these areas were analyzed and included the exclusions round Japan and the Ryukyu Islands, Sea of Japan, Yellow and East China Seas, South China Sea, and coast of Taiwan. Presently, based on the best information available, none of these areas qualify as OBIAs.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-20	Additional Issues—Abundance data for small population The Court, in 2008, observed that the Navy's impact analysis did not reflect the latest abundance data, particularly for "small localized" populations of marine mammals. *NRDC v. Gutierrez*, 2008 WL 360852 at *16-17. Unfortunately, in the present DSEIS, the Navy appears again to have used basin-wide or pelagic abundance estimates in determining the size of some more discrete marine mammal populations, as, for example, around Hawaii. DSEIS at 4-61 to 4-62. The Navy should use the latest, most precautionary data, to properly reflect new information on marine mammal population structuring.	**Response:** Pelagic data are used because the Navy is operating in offshore, pelagic waters. There is a geographic restriction that received levels are below 180 dB re 1 µPa (rms) (SPL) in Offshore Biologically Important Areas (OBIAs) and within 22 km (12 nmi) of any coastline. However, in instances where insular and/or coastal stocks may be affected, they have been modeled. Based on additional information, the false killer whale insular stock around Hawaii has been modeled in addition to the pelagic stock already modeled. In addition, coastal bottlenose dolphin stocks off U.S. east coast (southern migratory coastal stock, northern Florida coastal stock, and central Florida coastal stock) were modeled, in addition to the offshore stock already modeled. Tables 4-14, 4-14, 4-17, C-26, C-27, and C-29 have been updated in the FSEIS/SOEIS.
NRDC-21	Additional Issues—Reliance on the SRP The DSEIS, like the Navy's previous EIS and SEIS, relies heavily on the LFA Scientific Research Program (SRP) in establishing risk parameters for the LFA system. Indeed, the new DSEIS appears to put even more reliance on the SRP, applying it directly to non-focal species. DSEIS at 4-83. Yet marine mammal science has advanced considerably in the thirteen years since the SRP concluded, and behavioral response studies that have taken place in the intervening years indicate the limitations of the earlier Navy experiment, even with respect to baleen whales. For example, a tagging study of sperm whales in the Gulf of Mexico did not detect any significant avoidance of the noise source (an airgun array), but did find significant reductions in buzz rate, a proxy for prey capture. A tagging study of blue and fin whales off Southern California detected responses to a mid-frequency sound source (a playback of a mid-frequency sonar system) in some behavioral contexts but not others. It is unlikely that the SRP's focal follow technique, which was	**Response:** Very few active underwater systems/ sensors have the benefit of such a directed and extensive research effort as the 1997-98 Low Frequency Sound Scientific Research Program (LFS SRP). While it is true that technologies that produce finer resolution data have advanced since the LFS SRP, the results of the LFS SRP remain valid. Moreover, there has never been evidence of SURTASS LFA sonar causing MMPA Level A harassment, and all analysis and modeling results support the conclusion that no marine mammal species' stocks have ever been subjected to greater than 12 percent MMPA Level B harassment from SURTASS LFA sonar on an annual basis. In fact, Level B harassment has proven to be much lower for the majority of marine mammal stocks. On DSEIS/SOEIS page 4-83, there is no extrapolation to other species. In fact, there were numerous non-focal marine mammals (MF and HF hearing species) sighted in the vicinity of the sea tests, including short-finned pilot whales, pygmy and dwarf sperm whales, melon-headed whales, false killer whales, Cuvier's beaked whales,

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

Commenter ID / Comment Number	Comments	Response
	designed to pick up basic changes in vocalization and movement patterns, could detect these other types of responses, which may have significant implications for foraging and other biologically important activities. The DSEIS should therefore take a more conservative approach in extrapolating from the SRP.	common dolphins, bottlenose dolphins, spinner dolphins, Risso's dolphins, and California sea lions. There were no immediate responses observed from these odontocetes and pinnipeds and no immediately obvious changes in sighting rates for these species as a function of LFA source conditions during the LFS SRP. Consequently, it was concluded that none of these species had any obvious behavioral reaction to LFA signals at received levels similar to those that produced only minor, short-term behavioral responses from the baleen whales. There may be some possibility that a marine mammal MF and/or HF species could detect, either acoustically or vibrotactally, and then respond to LFA sonar. However, the chances of injury and/or significant behavioral responses to SURTASS LFA sonar are extremely low to negligible, given the following: • The MF/HF frequencies these animals are adapted to hear and produce (i.e., their natural acoustic ecologies); • Their observed lack of response to LFA sounds during the LFS SRP; and • The kinds of sounds to which they do or do not respond. It is also important to consider the acoustic characteristics of the stimuli for most of the behavioral response studies produced during the intervening years since the LFS SRP. The types of studies referenced generally use significantly different types of stimuli than LFA: airguns are impulsive, with a high pulse repetition rate. MFAS is much higher in frequency and pulse repetition rate. Marine mammal responses to these different types of stimuli provide little, if any, insight into possible responses to SURTASS LFA sonar.
NRDC-22	<u>Additional Issues—Monitoring Systems</u> The Navy's preferred alternative would allow LFA training to proceed within the Navy's existing U.S. ranges (among many other locations),	**Response:** First, Navy Range Complex mitigation and monitoring requirements are authorized for incidental take under separate regulations. When SURTASS LFA sonar operates on a Navy Range

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	particularly the Hawaii Range Complex and SOCAL Range Complex. Within these ranges, the Navy has greater opportunity to apply additional monitoring measures. While the 2007 SEIS evaluated and rejected a number of supplemental measures, it did not consider the use of passive gliders or other passive acoustic systems to monitor the potential on-range operating area in advance of LFA activity, whether to ensure that densities of target species are sufficiently low before exercises begin, to relocate or adjust the timing of an LFA exercise, or for another planning purpose. Nor of course could the earlier SEIS evaluate the various new marine mammal monitoring techniques developed by the Office of Naval Research and other bodies over the last four years. The Navy should consider additional monitoring measures when operating LFA close to shore or in established Navy ranges	Complex, it does so under its current NMFS Final Rule and letter of authorization (LOA). Second, under developing Navy Range Complex monitoring plans, there may be the inclusion of passive gliders and/or other passive acoustic systems that could be employed before and/or during an on-range exercise in which LFA would be a participant. If this scenario were to occur, any relocation or adjustment of the timing of the exercise because of data collected before or during the exercise would apply to SURTASS LFA sonar operations within the framework of the exercise. The commenter also notes "…the various new marine mammal monitoring techniques developed by the Office of Naval Research and other bodies over the last four years." The Navy's Deputy for Undersea Surveillance, under the Chief of Naval Operations, maintains a cooperative relationship with ONR's Marine Mammals Program and, as such, will be aware of any new marine mammal monitoring systems or techniques that could potentially be used with SURTASS LFA sonar, depending on its safety, efficacy, cost-effectiveness, and practicability. At this time no such monitoring systems or techniques have been proposed by ONR for possible use with SURTASS LFA sonar. With respect to the commenter's reference to "other bodies," more specificity is needed for the generation of a meaningful response. The commenter is also referred to NMFS' Proposed Rule, pp 880-881, wherein the Navy has included an adaptive management component within the framework of the scientific underpinning of the this FSEIS/SOEIS (Subchapter 1.4.5). This includes the consideration, on a case-by-case basis, of new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, and government/non-government organizations to determine (with input regarding practicability) whether SURTASS LFA sonar mitigation, monitoring, or reporting measures should be modified (including additions or deletions). See response to comment MMC-04 for

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		additional details.
NRDC-23	**NRDC et al. APPENDIX A** Some important habitat in the northwest pacific ocean not considered in the DSEIS: 1. The Oyashio/Kuroshio Currents 2. Ogasawara (Bonin) and Mariana Archipelagos 3. Humpback whale habitat around Babuyan Islands and northern Luzon, Philippines. 4. The Emperor Seamount Chain 5. Shatsky Rise 6. Transition Domain (40 to 44 degrees N)	**Response:** It is incorrect to state that these areas were not considered in the DSEIS/SOEIS. While perhaps the habitat area was called something different, these oceanic regions have been considered. The Kuroshio Current and Oyashio Current LMEs were considered as part of the Exclusion Around Japan and the Ryukyu Islands listed in Table 4-25 and discussed on pages D-332 to D-335. The Ogasawara and Mariana Archipelagos are located in the Philippine Sea and were considered as part of the Exclusion for the North Philippine Sea (p. D-347) and Exclusion for the West Philippine Sea (p. D-348). The Babuyan Islands and northern Luzon, Philippines were also considered as part of the Exclusion for the West Philippine Sea (p. D-348) and the Exclusion around Taiwan (p. D-340). While the Emperor Seamount Chain, Shatsky Rise, and Transition Domain were not considered in the DSEIS/SOEIS, these areas were previously presented by the commenter during the Court-ordered mediation leading to settlement agreements. These areas were not determined to meet the criteria at that point, and, as discussed further below, no new data have emerged to warrant them as OBIAs at this point either. 1. <u>Kuroshio Current and Oyashio Current Large Marine Ecosystems (LMEs)</u>—The commenters recommend a year-round exclusion of the two LMEs, or at least a seasonal restriction based on periods of highest likely productivity and species presence. They assert that the "area east of Japan provides feeding and calving grounds for numerous baleen whales." While baleen whales do meet the LFA MM OBIA criterion for LF sensitivity, the data supporting the claim that the region east of Japan represents a feeding or calving ground for baleen whales, another of the LFA MM OBIA criteria, do not exist. The manuscript cited regarding

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		North Pacific right whales (Rosenbaum et al., 2000) provides evidence for the existence of a distinct genetic lineage of right whales in the North Pacific, but it does not provide evidence for the location of feeding or breeding grounds. An OBIA has been designated for the known feeding North Pacific right whale ground off Sakhalin Island (OBIA #13). Other baleen species mentioned by the commenter include the humpback whale, which is known to winter in nearshore waters near the Philippines, Okinawa, and Ogasawara islands (Calambokidis et al., 2008). Less than 1,000 animals (of the 20,000 humpback whales estimated to exist in the North Pacific) are believed to winter off these islands, in nearshore waters. Because they winter near shore, they would be protected by the coastal exclusion already included. Minke, Bryde's, sei, blue, and fin whales do not have known concentrated feeding or breeding grounds within either of the LMEs. The commenter also suggests that small, localized populations of Dall's porpoise, harbor porpoise, sperm whale, and short-finned pilot whale are found off the coast of Japan. There is controversy around the distinction of separate subspecies of Dall's porpoise. Some scientists believe that they are color morphs of the same species, whereas others believe separate subspecies should be recognized. The commenter is incorrect in that the IUCN Red List does not recognize *truei*-type Dall's porpoise as a separate subspecies; the IUCN Red List classifies Dall's porpoise as a single species with a status of least concern. No evidence is available for small, localized populations of the other species. Furthermore, these species are not LF hearing specialists and, per the criteria applied for the MM OBIA delineation process for SURTASS LFA sonar, are not species for which an OBIA would be considered.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-23 (Continued)		Therefore, neither the Kuroshio Current nor the Oyashio Current Large Marine Ecosystem meets the selection criteria for a SURTASS LFA OBIA. 2. Ogasawara (Bonin) and Mariana Archipelagos—The areas around the Ogasawara and Mariana island chain has been recommended by the commenters as an important winter breeding ground for humpback whales, and year-round use by sperm whales and a small resident population of Indo-Pacific bottlenose dolphin. Of the species cited, only humpback whales may have best hearing sensitivity in the LF range. The humpback whale, which is known to winter near the Philippines, Okinawa, and Ogasawara islands (Calambokidis et al., 2008), is found in nearshore waters. In addition, less than 1,000 animals (of the 20,000 humpback whales estimated to exist in the North Pacific) are believed to winter off these islands. Because they winter near shore, the humpback whales in the region would be protected by the coastal exclusion and do not represent an offshore concentration. Similarly, Indo-Pacific bottlenose dolphins exhibit a nearshore distribution and are protected by the existing coastal exclusion. Furthermore, neither Indo-Pacific bottlenose dolphins nor sperm whales are believed to be LF hearing specialists. Therefore, the Ogasawara and Mariana archipelagos do not meet the selection criteria for SURTASS LFA OBIA status. 3. Philippines—The commenters assert that the humpback whales found around the Babuyan Island and northern Luzon, Philippines are a unique population, without citing specific literature but suggesting they use different songs. This assertion does not represent the most recent, best available information for humpback whales in this region. Acebes et al. (2007) identified

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-23 (Continued)		nine distinct themes between the Philippines and Hawaii, seven of which were common among the two locations. The order of the themes was also consistent between the Philippines and Hawaii. These authors suggest that, coupled with their sightings data, the humpback whales from this region are part of the larger western Pacific population. This conclusion is also supported by the SPLASH report (Calambokidis et al., 2008). Therefore, humpback whales around the Philippines do not represent a small, localized population and do not meet this selection criterion for SURTASS LFA OBIAs. Furthermore, the humpback whale, which is known to winter near the Philippines, Okinawa, and Ogasawara islands (Calambokidis et al., 2008), is found in nearshore waters. Because they winter near shore, the humpback whales in the region would be protected by the coastal exclusion and do not represent an offshore concentration. Thus, the region around the Babuyan Islands and northern Luzon Philippines does not meet the selection criteria for a SURTASS LFA OBIA. 4. The Emperor Seamount Chain—The commenters recommend an OBIA running 30 nm around the Chain for a variety of species, including tunas, squids, pomfrets, blue sharks, blue whales, fin whales, and minke whales. Tunas, pomfrets, and blue sharks are highly migratory fish species that move substantial distances during their life cycles. In addition, bony fishes, which include tunas and pomfrets, have been studied to determine their sensitivity to LFA transmissions, the results of which are summarized in Subchapter 4.1.1. With the caveat that only a few species have been examined in these studies, the investigations found little or no effect of high intensity sounds on a number of taxonomically and morphologically diverse species of species and

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-23 (Continued)		there was no mortality as a result of sound exposure, even when fish were maintained for days post-exposure. The blue shark is a cartilaginous fish and the potential for effects to these fishes was presented in Section 4.1.2. Since sharks are considered non-hearing specialists and there are limited direct data on cartilaginous fishes, they are assumed to have hearing sensitivities similar to bony non-specialist fishes. Squid are invertebrates and the potential for effects to invertebrates from LFA was discussed in the Subchapter 3.2.1.1. It was concluded that they might be impacted only if they were within a few tens of meters of the source. Therefore, the potential for impacts to tunas, squids, pomfrets, and blue sharks is considered negligible and there is no basis for establishing OBIAs for these species. Blue whales have been shown to call year round in the northwest Pacific Ocean, "Overall, blue whale calls were two to three times more numerous in the NW region (40°N to 55°N latitude, between 150°E and 180°W longitude) than in other regions of the North Pacific, with consistently high calling rates from August through November" (Moore et al., 2002). The authors state that the actual number of individuals producing the calls cannot be known. Furthermore, the calls occur across a broad ocean region, and no specific concentration of calling animals can be identified. Similarly, the broad distribution of fin whale calls does not represent a high density concentration of individuals in a specific region. Therefore, though LF hearing specialists occur in the region, they are not known to occur in high density concentrations or to conduct biologically important behaviors in this area. Thus, the region around the Emperor Seamount Chain does not meet the selection criteria for a SURTASS LFA OBIA. 5. Shatsky Rise—The commenters recommend that the region

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		encompassing the Shatsky Rise be considered as an OBIA. The Navy agrees with the commenters that the region is known to be a hotspot for juvenile loggerhead turtles (Polovina et al., 2006) and a nursery ground for Japanese anchovy and sardine (Komatsu et al., 2002). It is believed that sea turtles are most sensitive in the LF range of 100 and 900 Hz, but with poor hearing thresholds (See Subchapter 4.2 for discussion of potential impacts on sea turtles). Sea turtles would have to be well inside of the LFA mitigation zone (180-dB sound field) during a transmission to be affected. In addition, loggerhead turtles are found almost exclusively at depths shallower than 50 m (164 ft) (Polovina et al. 2006). Therefore, the potential impacts to loggerhead turtle stocks are considered negligible, and there is no basis for establishing an OBIA. Bony fishes, which include anchovy and sardine, have been studied to determine their sensitivity to LFA transmissions, the results of which are summarized in Subchapter 4.1.1. With the caveat that only a few species have been examined in these studies, the investigations found little or no effect of high intensity sounds on a number of taxonomically and morphologically diverse species of species and there was no mortality as a result of sound exposure, even when fish were maintained for days post-exposure. Therefore, the potential for impacts to anchovy and sardine is considered negligible and there is no basis for establishing OBIAs for these species. 6. <u>Transition Domain, 40-44°N/155-180°E, Apr to Dec</u>—The commenters recommend the Transition Domain (40-44°N/ 155-180°E) as an OBIA, claiming it represents important foraging habitat and migratory route for fishes, sharks, turtles, and marine mammals, and a nursery area for juvenile northern fur seals. Northern fur seals, Dall's porpoises, northern right whale dolphins,

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

Commenter ID / Comment Number	Comments	Response
		and Pacific white-sided dolphins were documented to occur as bycatch in squid driftnets in the region (Baba et al., 1993; Buckland et al., 1993; Yatsu et al., 1993). None of the species exhibited biologically important activities within the region nor were they found in high density concentrations. Furthermore, none of these species are believed to be LF hearing specialists. Therefore, data relevant to the SURTASS LFA OBIA selection criteria (high density, foraging, breeding/calving, migration, or small distinct population of LF marine mammal hearing specialists) are insufficient to consider the Transition Domain region as an OBIA.
NRDC-24	**NRDC et al. APPENDIX B** Some important habitat in the northern Gulf of Mexico not considered in the DSEIS: 1. Mississippi (MS) Canyon 2. DeSoto Canyon 3. Florida Keys/Dry Tortugas 4. Coastal Waters <20 m	**Response:** The commenters' assertion that four important habitat areas of the northern Gulf of Mexico (GOMEX) were not considered in the SEIS/SOEIS OBIA process is not correct (See Appendix D pages D-111, D-153, and D-290). Each of the four habitat areas is individually addressed in the following: 1. Mississippi (MS) Canyon—The commenters recommend that an area surrounding the MS Canyon be designated as an LFA marine mammal (MM) OBIA specifically for sperm whales. In the justification information presented by the commenters, they have made unsupported conclusions; because mother-calf pairs have been sighted frequently in the MS Canyon and Delta regions, the commenters conclude that this strongly suggests the region is a nursery ground. This is the commenters' conclusion or opinion and was not a conclusion made by the cited authors. Rather, in their preliminary findings, Weller et al. (2000) suggest that the area is ecologically important to sperm whales, and Jochens et al. (2006, 2008) in their summary and synthesis report on their three years of research in the area only concluded that female sperm whales have a high site fidelity to the MS Canyon/Delta region. The data on this region of the northern Gulf of Mexico are

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

NRDC-24 (Continued)

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-24 (Continued)		insufficient to conclude that they represent a nursery ground for sperm whales in the gulf. However, as stated in the SEIS/SOEIS, one of the final criteria for designation of MM OBIAs specifically for SURTASS LFA sonar is that OBIAs would be considered only for those marine mammal species whose best hearing sensitivity is in the low frequency (LF) range (<1,000 Hz). The only available measured data on sperm whale hearing indicates that best hearing sensitivity for sperm whales lies in the mid-frequency range, between 5 and 20 kHz with a better sensitivity at 40 kHz than at 2.5 kHz (Ridgway and Carder, 2001). Given that most animals hear in the same frequency range in which their vocalizations occur, Madsen and Mohl (2000) noted that the measured hearing frequency range matches "the spectral content (-10 dB)" of an adult male sperm whale's click. From the very limited available data, Madsen et al. (2002) suggested, based on the assumption that the hearing curve of sperm whales is the u-shaped curve characteristic of all mammals investigated thus far, that it is logical to assume that sperm whales have a lower best hearing range than most other odontocete species but not as low as baleen whales. Thus, per the criteria applied for the MM OBIA delineation process for SURTASS LFA sonar, sperm whales are not a marine mammal species for which an OBIA would be appropriate. 2. De Soto Canyon—The area surrounding and including De Soto Canyon has been recommended by the commenters as an important habitat for the Bryde's whale, sperm whale, and other species in the northern GOMEX. Of the potentially occurring species in the DeSoto Canyon area of the northern gulf, only the Bryde's whale may have best hearing sensitivity in the LF range. Like other baleen whales, no direct

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		measurements of the Bryde's whale hearing sensitivity have been made (Ketten, 2000). However, Southall et al. (2007) classify the Bryde's whale in the LF hearing group based on behavioral responses to noises in specific frequencies, vocalization frequency ranges, and ear morphology. Bryde's whales produce a variety of LF sounds ranging from 20 to 900 Hz (Cummings, 1985; Edds et al., 1993; Oleson et al., 2003). While the Bryde's whale meets the LFA MM OBIA selection criterion for LF hearing sensitivity, the data for the Bryde's whale in the northern GOMEX do not meet any of the other criteria for OBIA selection. The Bryde's whale is the most commonly occurring baleen whale in the GOMEX. However, to put this information in context, from 1990 through 2004, only 24 sightings of Bryde's whales have been recorded in the continental slope waters of the northeastern GOMEX, including the DeSoto Canyon region (DoN, 2007). These limited sightings do not represent a high density of the Bryde's whale; Mullin and Fulling (2004) calculated a density of 0.061 and abundance of 40 Bryde's whales in the northeastern GOMEX based on 4 sightings. The highest densities of Bryde's whales occur in the Pacific and Indian Oceans and off South Africa in the Atlantic (Kato and Perrin, 2009). LFA MM OBIA #14 in the western Indian Ocean and LFA MM OBIA #20 in the northern Indian Ocean include Bryde's whales. Although little is known about the Bryde's whale in the North Atlantic Ocean, Schmidly (1981) and others have speculated that the Bryde's whales that occur in the northeastern GOMEX may represent a small, dispersed resident population. Currently, however, data are not sufficient to allow differentiation of a stock of Bryde's whales in the northeastern GOMEX (Waring et al., 2010) or to determine if the Bryde's whales that occur there represent a small, distinct population with a limited distribution. No feeding or breeding grounds or migrational routes are known for the Bryde's whale in

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		the GOMEX. While the fact that the Bryde's whale likely hears best in the LF frequency range meets one of the LFA MM OBIA criteria, it does not meet the remainder of the criteria for selection as an OBIA for LFA. The Bryde's whale does not occur in a high density in the northeastern GOMEX nor can the Bryde's whale occurring there be categorized currently as a small, distinct population, as these terms are defined and used in the SEIS/SOEIS. The northeastern GOMEX does not represent a known feeding or breeding ground or migration pathway for this species. For these reasons, the DeSoto Canyon area of the northeastern GOMEX cannot be further considered as an LFA MM OBIA. 3. Florida Keys/Dry Tortugas—The commenters recommend that an area in the deep waters west of the Florida Keys and Dry Tortugas be designated as an LFA marine mammal (MM) OBIA due to its importance as a habitat for sperm whales. Please see response #1 above for a detailed explanation of why this area has not been proposed as an LFA MM OBIA for sperm whales. 4. Coastal Waters <20 m—The commenters note that waters of the northern GOMEX <20 m are important habitat for the manatee and bottlenose dolphin. SURTASS LFA sonar operations are geographically restricted to producing sound <180 dB re 1 µPa (rms) in waters within 22 kilometers (12 nautical miles) of the shore of northern GOMEX. This 22-km area along the shore of restricted sound transmission encompasses the majority of the waters of the N. GOMEX that are less than 20 m in depth. As previously mentioned, one of the selection criteria for designating MM OBIAs for SURTASS LFA sonar usage is that the best hearing sensitivity range of a marine mammal species must be in the low frequency (LF) range (<1,000 Hz). Neither the manatee nor the bottlenose dolphin possesses best hearing sensitivity in

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		the low frequency range. Rather, both species hear best in the mid-frequency range, at 6 to 20 kHz for manatees (Gerstein et al., 1999) and from 25 and 50 kHz for bottlenose dolphins (Nachtigall et al., 2000). Since neither the manatee nor the bottlenose dolphin possesses best hearing sensitivity in the LF range, neither species was eligible for consideration for LFA MM OBIAs.
NRDC-25	**NRDC et al. APPENDIX C** Some important habitat around the Main Hawaiian Islands not considered in the DSEIS: 1. Seamounts clustered southwest of Kona, Hawaii from Indianapolis to Cross Seamounts 2. Transition Zone Chlorophyll Front (TZCF) and Humpback Whale Migration Corridor 3. Important Habitat for Vulnerable Resident Odontocetes	**Response:** The three areas that the commenters identify as important habitat areas of the Main Hawaiian Islands have been considered in the SEIS/SOEIS. 1. Seamounts clustered southwest of Kona, Hawaii from Indianapolis to Cross Seamounts—The waters surrounding Cross Seamount were already considered but not selected during the LFA MM OBIA selection process due to the presence of only beaked whales, a non-LF hearing specialists. The available data for the biota in the waters surrounding the Navigator Seamount Chain southwest of Hawaii such as Indianapolis or Jagger Seamounts are very sparse. None of the seamounts other than Cross Seamount (350 to 450 m) rise to a water depth shallower than 760 meters; the water depths over Jagger and Annapolis Seamounts are even deeper (Itano, 1999). Other than the information Baird et al. (2008) notes in their survey report detailing sighting of three species in the waters of Jagger Seamount and one species at Annapolis Seamount, no other information on marine mammal occurrence or abundance exists for the seamounts in this area. In addition, fishermen report that prey aggregate routinely in commercial quantities only at Cross Seamount (Itano, 1999). Beaked whale vocalizations were detected at night over the seamount by Johnston, et al. (2008). The mere presence of several marine mammals and the presumption that the waters surrounding these seamounts may be suitable for foraging are insufficient justification for further

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-25 (Continued)		considering this area as an LFA MM OBIA. 2. Transition Zone Chlorophyll Front (TZCF) and Humpback Whale Migration Corridor— The TZCF is a geographically and seasonally dynamic ocean front that spans the width of the North Pacific Ocean (Polovina et al., 2001). An ocean front is the boundary or area between two water masses that have different properties; usually the differing properties keep the waters from mixing. At the TZCF, subarctic waters with a higher chlorophyll concentration meet subtropical waters that are lower in chlorophyll. In the ocean, chlorophyll concentration is important because it is indicative of how much primary (plant) production is occurring in those waters. The commenters recommend designating an indeterminant swath encompassing the boundary between waters with higher and lower chlorophyll concentrations, but presumably spanning the width of the entire North Pacific Ocean, at about 29° or 35° N, depending upon the season. The TZCF migrates about 1,000 km (540 nmi) between its most southerly and northerly positions over an annual cycle and exhibits great interannual variability in its geographic position (Polovina et al., 2001). Due to this positional variability, a designation of latitude such as the commenters suggest would not necessarily encompass the TZCF boundary in all years. For this reason alone, designation of this frontal boundary as an LFA MM OBIA at a static seasonal latitude would not effectively provide the protection for marine mammals the commenters seek. As noted in more detail in the response to comment NRDC-11, no specific migrational corridors for humpback whales in the North Pacific Ocean have yet been defined. Even if corridors were well defined, the north to south extent of a frontal boundary is a line of latitude in height and would provide only an insignificant amount of protection as humpbacks rapidly moved north or south during

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
NRDC-25 (Continued)		their seasonal migrations. The justification that designation of the TZCF would protect the humpback whale migrational corridors lacks sufficiency. 3. Important Habitat for Vulnerable Resident Odontocetes—The commenters reference the Navy's current LFA operating areas in the Hawaii Range Complex and note that it provides coverage to all habitats listed under this proposed additional OBIA. The agreed upon provisions (e.g., Hawaii operating areas) of the 12 August 2008 Stipulated Settlement Agreement Order (Civ. Action No. 07-4771-EDL) expire with the termination of the NMFS MMPA 2007 Final Rule or upon being superseded by the issuance of a new rule for SURTASS LFA sonar operations; new rulemaking is part of the MMPA compliance process associated with this SEIS. As noted previously, the Agreement is not intended to serve as precedent in any future rulemaking. SURTASS LFA sonar operations are already excluded from Hawaiian waters inside the coastal standoff range (22 km [12 nmi]). However, of the species mentioned in association with the Hawaiian habitat from the shoreline to the 3,500-m isobath recommended by the commenters, none meet the OBIA selection criterion of having best hearing sensitivity in the LF range. Beaked, melon-headed, and false killer whales all have best hearing sensitivity in the mid-frequency ranges that typically occur at or near the frequency where their echolocation signals are strongest (Southall et al., 2007). For this reason, the waters from the coastal standoff range to the 3,500-m isobath in Hawaiian waters are not appropriate as an LFA MM OBIA.
Dr. L. Weilgart		
Weilgart-01	Commenter is disturbed that the Draft SEIS bases its operational exclusion zones strictly on presumed mysticete hearing sensitivity,	**Response**: The large size and acoustic production characteristics of sperm whales do make it likely that they have better low-frequency

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

Commenter ID / Comment Number	Comments	Response
	ignoring evidence that odontocetes also react to low-frequency noise, sometimes apparently even more strongly than mysticetes (see below). Moreover, sperm whales cannot be lumped in with other odontocetes, as they are substantially larger than any other odontocete and their echolocation (bio-sonar) is very different. Their echolocation clicks are much lower in frequency, louder, longer in duration, are given at a slower and more regular repetition rate, and are heard over vastly larger (ca. 8 km) distances (Backus and Schevill 1966; Weilgart et al. 1996; Møhl et al. 2000). In fact, the echolocation clicks of sperm whales are so different from those of other odontocetes that some sperm whale experts did not believe they were used for echolocation at all, but rather represented “contact calls” (Watkins 1980).	hearing than the tested odontocete species. But the studies cited to support the responsiveness of odontocetes all had impulsive broadband sources of sound as the stimuli. Not only are these fundamentally different from LFA signals, the broadband signals, by definition, include higher frequencies.
Weilgart-02	There is good reason to believe that larger species using clicks of much lower frequency are also likely to hear lower frequencies. No good audiograms of sperm whales exist, though Carder and Ridgway (1991) tested a neonate, which indicated better low frequency hearing compared with other odontocetes. Moreover, recordings of two neonate sperm whales showed vocalizations with centroid frequencies of 300-1,000 Hz (clicks from Neonate #1), 500-1,700 Hz (clicks from Neonate #2), and 200-700 Hz (grunts from Neonate #1), indicating low-frequency sensitivity (Madsen et al. 2003). The -10 dB BW given in this paper, showed there is still considerable energy as low as 125 Hz in the clicks. The authors postulate that these vocalizations are important in maintaining mother-calf contact—a vital life function. Thus, assuming sperm whales are not sensitive to low frequency sound is thus just that—an assumption without solid evidence.	**Response**: The SEIS/SOEIS and the OBIA analysis did not assume that sperm whales are not sensitive to low frequency sound. NMFS and the Navy have acknowledged that marine mammal MF and/or HF species could detect, either acoustically or vibrotactally, and possibly respond to LFA sonar. However, the chances of injury and/or significant behavioral responses to SURTASS LFA sonar are very low to negligible. See response to comment NRDC-09 for further discussion. The recent “Sperm Whale *(Physeter macrocephalus)* 5-Year Review: Summary and Evaluation” by NMFS Office of Protected Resources, January 2009, stated that sperm whales may possess better LF hearing than some of the other odontocetes, although not as low as many baleen whales (Ketten, 1992). Møhl et al. (2003) found that the monopulse nature of on-axis clicks emitted by sperm whales were similar in shape and spectrum to dolphin echolocation signals, but with peaks between 15 to 25 kHz. These clicks had source levels up to 236 dB re 1µPa (rms) with centroid frequency of 15 kHz. Their results were consistent with the auditory sensitivity from evoked

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		potential responses on a young sperm whale to clicks indicating the most sensitive to sounds between 5 and 20 kHz (Ridgway and Carder, 2001). Southall et al., (2007) stated that odontocetes' best hearing sensitivity occur at or near the frequency where echolocation signals are the strongest.
Weilgart-03	Moreover, if the sound is loud enough, the sensitivity of an animal at particular frequencies (audiogram) becomes irrelevant to the amount of damage sustained. That is, the response or injury curve becomes very flat across all frequencies (frequency independent), at high amplitudes of sound. This basic fact seems have been ignored throughout the Draft SEIS where great emphasis in choosing OBIAs (Offshore Biologically Important Areas) is placed on the presumed frequency sensitivities (audiograms) of species. If species, even those not considered low-frequency specialists, occur in high densities, chances are some will be exposed to LFA sonar at high intensities.	**Response:** The SURTASS LFA three-part monitoring mitigation (visual, passive acoustic, and active acoustic) is used to detect all marine mammals within 1 km (0.54 nmi) (the approximate 180 dB isopleth). If any marine mammal closely approaches the source, it should be detected (most certainly one as large as a sperm whale) and the source is shut down. This procedure is implemented expressly to prevent such high-level exposures that could result in injury. As reported in the Final Comprehensive Reports required by NMFS under the regulations 50 CFR Subpart Q, there have been not Level A (injury) takes of marine mammals by SURTASS LFA sonar operations over the past 9 years (DoN, 2007c; 2011). Since the first analyses of potential impact to marine mammals in the 2001 FOEIS/EIS, the Navy has used, and continues to use, the criteria that any exposure to LFA signals ≥ 180 dB re I µPa at 1 m (rms) (RL) is considered to be injury, in other words a flat curve at and above 180 dB RL. Based on proposed injury criteria by Southall, et al. (2007), this value is considered to be very conservative. See the SEIS/SOEIS Subchapter 4.3.1.3 for additional discussion.
Weilgart-04	Commenter strongly disagrees with the characterization of TTS as not being an injury. If a whale suffers a gash to its side, that is an injury, even if the injury heals over several days. TTS can also last days to weeks, during which time an animal's welfare is severely compromised. Recent research also shows that long-term, progressive neural degeneration can occur after TTS (Kujawa and Liberman 2009). Even 24 hrs. after noise exposure, rapid, extensive	**Response:** Depending on the degree (elevation of threshold in dB), duration (i.e., recovery time), and frequency range of TTS, and the context in which it is experienced, TTS can have effects on marine mammals ranging from discountable to serious. However, Southall et al. (2007) indicate that TTS is not injury because the reduced hearing sensitivity following exposure to intense sound results primarily from cochlear hair cells (and supporting structures) exhibiting fatigue. TTS

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	loss of synapses between hair cells and nerve fibers can be found. Despite intact hair cells and the recovery of normal thresholds, the neural loss remained (Kujawa and Liberman 2009). Thus, TTS appears to be more harmful than previously thought	is not injury because the cochlear hair cells (and supporting structures) are not lost. Accordingly, NMFS classifies TTS (when resulting from exposure to either SURTASS LFA sonar or HF/M3 sonar) as Level B Harassment, not Level A Harassment (injury). Kujawa and Liberman's (2009) study which assayed cochlear functional and imaged the inner ear in the mouse (*Mus musculus*) after a 2 hour exposure to an octave band of noise (8 to 16 kHz) at 100 dB SPL, observed that acoustic overexposures resulted in irreversible loss of synapses within 24 hours post-exposure, and delayed and progressive loss of cochlear neurons over many months. Although the loss of peripheral terminals of the cochlear neurons was rapid, the death of the cell and the disappearance of the somata were extremely slow and the hair cells remained and recovered normal function (Kujawa and Liberman, 2009). The cage was suspended directly below the speaker. The proximity of subject and speaker suggests the possibility of nearfield effects that may have affected the results. Therefore, this experiment reflects the results of an extremely loud exposure for a prolonged period of time, at a level near that needed for PTS. These findings, not surprisingly, suggest that there may be a more continuous spectrum of hearing effects, and the categorical 'TTS' and 'PTS' may be points along a spectrum of possible effects. Nevertheless, the type of exposure used in this experiment is very different than that of an LFA system. The time between LFA transmissions can allow for partial or total recovery of any potential hearing effects. For cetaceans, published data on the onset of TTS are limited to the captive bottlenose dolphin, beluga, harbor porpoise, and Yangtze finless porpoise (Finneran et al., 2000, 2002, 2005, 2007, 2010, 2010a; Schlundt et al., 2000; Nachtigall et al., 2003, 2004; Mooney et al., 2009a, 2009b; Lucke et al., 2009; Finneran and Schlundt, 2010; Popov et al., 2011). For pinnipeds in water, data are limited to Kastak

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
		et al.'s (1999, 2005) measurement of TTS in one captive harbor seal, one captive elephant seal, and one captive California sea lion (Finneran et al., 2003 tried to induce TTS in two California sea lions but could not).
Weilgart-05	Even a cursory look at Table 4-25 (p. 4-75) reveals obvious flaws. For instance, by which definition of "high density" would the congregation of humpback whales on Silver and Navidad Banks rate a "0" out of "4"? This is one of the densest aggregations of biomass in the world, denser than wildebeest migrations on the Serengeti! Similarly, how could The Gully MPA get a "0" rank out of "4" for "small, distinct population"? The resident bottlenose whale population there is practically a poster child for this category! Moreover, The Gully is home to plenty mysticete species as well (Hooker et al. 1999), so there is no justification for eliminating it as an OBIA.	**Response:** NMFS and the Navy ranked Silver and Navidad Banks as a 4 for the biological criterion of breeding and calving. This rank of 4 assumes that the area was selected based on its high concentration (i.e., high densities) of marine mammals in the area for breeding and calving and does not refute the best available information of Silver and Navidad Banks having high densities of humpback whales. For clarity and to eliminate confusion, the Silver and Navidad Banks' rank for high densities will be updated to a rating of 4. Regarding the Gully MPA, the reader is referred to NMFS' Classification Scores for Supporting Documents for the Gully as the characterization of NMFS' ranking is not accurate. NMFS ranked the Gully MPA as a 4 for high density (northern bottlenose whales) and ranked the area as a 3 for foraging (bottlenose whales). Consideration of marine mammal hearing frequency sensitivity led NMFS to screen out areas that qualified solely on the basis of their importance for mid- or high-frequency hearing specialists. Thus, NMFS ranked the Gully MPA as "0" for qualifying as an OBIA for low-frequency hearing specialists. See response to comments MMC-02 and NRDC-09 for an explanation of the screening process. With regards to Hooker, Whitehead, & Gowans (1999), the authors reported no sightings of blue or humpback after 1,121 daylight hours. They reported sightings of minke whales, but at lower rates than sightings for northern bottlenose whales (Hooker et al., 1999).
Weilgart-06	The arguments made on p. 4-83, that short-term, observable responses are meaningful representations of population well-being, are not supported by a large body of literature (e.g. Gill et al. 2001;	**Response:** The responsiveness of animals to any potentially disturbing stimuli will indeed be affected by other factors (Ellison et al., 2012). The Bejder studies present an important look at an

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	Stillman and GossCustard 2002; Bejder 2005; Bejder et al. 2006). Disturbance studies can produce counterintuitive results. A weaker behavioral response to disturbance can mean that the impact on the population is more serious, not less. If individuals have low energy reserves or no alternative habitat, they cannot afford to flee, appearing as though they are unresponsive to disturbance, despite in fact being more vulnerable. Animals do not always react in an observable or obvious visible manner even if there is a population-level, long-term impact. Thus, the LFS SRP was unable to make any meaningful conclusions regarding long-term population impacts, i.e. those we care most about.	apparent absence of behavioral response that is associated with a longer scale response. However, in this case, the disturbance was persistent over weeks, months and years. Certainly the likelihood of a population level response is reduced when a potentially negative stimulus is transient, such as SURTASS LFA sonar, rather than persistent over much longer periods of time. Finally, the 1997 to 1998 LFS SRP was designed to examine for short-term behavioral responses. Those studies concluded that since such responses were short-lived, and the animals returned to baseline quickly, the probability of larger scale responses was minimal (but not impossible).
Weilgart-07	The Draft SEIS notes that "*observations of marine mammal responses to other types of anthropogenic sounds, such as pile driving or seismic airguns, provide little insight to the discussion here. These types of activities produce impulsive sounds which contain both a rapid onset and a broad band of frequencies, including some in the MF and HF bands, and which have been observed to elicit a behavioral response from marine mammal LF species. LFA sonar is not impulsive but consists of narrowband tonals that resemble some of the sounds produced by certain LF whales, such as humpback and right whales. Therefore, an LFA sonar sound presents a fundamentally different context compared to impulsive anthropogenic sound sources.*" (p. 4-82). The flaw in the above reasoning is that the Navy is arbitrarily choosing which characteristics matter to marine mammals. Yes, there are many differences between rapid onset, broadband, impulsive sounds and narrowband, tonal ones, such as LFA sonar, and yes, marine mammals can probably distinguish between these two types. However, I can also come up with categories that include both types of sounds, such as "unfamiliar" and "loud" and "moving (approaching)". Under certain contexts, it is likely marine mammals	**Response:** The context of sound exposure is undoubtedly an important component of an animal's response to any stimuli. But the differences in sound signals and the way in which animals respond to them depending upon whether those sounds are impulsive and non-impulsive, for example, is well-documented and is not arbitrary (e.g., Dunn et al., 1991, Hamernik et al., 1993). The subchapter referred to in the DSEIS/SOEIS states that airguns and pile-driving "have been observed to elicit a behavioral response from marine mammal LF species." This will be changed to read "have been observed to elicit a behavioral response from marine mammal species", so as to include other species.

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
	care more about these features of sounds. We humans find that police sirens, thunder, and fire alarms catch our attention and may even cause panic and anxiety, under the right circumstances, despite the difference in some of their acoustic characteristics. It is incorrect that pile-driving or seismic airguns have only produced a "*behavioral response from marine mammal LF species*". In fact, though these sound sources have most energy in the low frequencies, it is the high frequency marine mammal specialists that, surprisingly, sometimes show more of a reaction (Stone and Tasker 2006; Weir 2008; Tougaard et al. 2009). Some have postulated that this is because the small odontocetes, which are HF specialists, use a different avoidance strategy than the mysticetes, and are able to vacate the area as they are faster swimmers. This underlines the point made above, that visible responses alone are unreliable measures of a negative effect since they do not necessarily capture the full impact of a disturbance.	
Weilgart-08	Commenter urges the Navy to avoid important sperm whale habitat during the operation of LFA sonar. There is no good justification for including them in with other small odontocetes, nor assuming they do not respond to low frequencies. Areas of high biological primary productivity (as determined by, e.g., satellite color scanners) over about 1,000 m in depth remain fairly good predictors of sperm whale abundance (e.g. Whitehead 2003). Also, I understand that the predictive model of marine mammal abundance by Kristin Kaschner and others at St. Andrew's University's Sea Mammals Research Unit, U.K., is being used by the Royal Navy to avoid important marine mammal habitat. Has the U.S. Navy thoroughly examined this approach to supplement its proposed OBIAs? Given the obvious limitations of the OBIAs (as mentioned above), this would seem a necessary and logical course of action.	**Response:** The SEIS/SOEIS and the OBIA analysis did not assume that sperm whales are not sensitive to low frequency sound. NMFS and the Navy have acknowledged that marine mammal MF and/or HF species could detect, either acoustically or vibrotactally, and possibly respond to LFA sonar. However, the chances of injury and/or significant behavioral responses to SURTASS LFA sonar are very low to negligible. See response to comment NRDC-09 for further discussion. Yes, the Navy and NMFS have examined the use of predictive models of marine mammal abundance or density. In 2011, NOAA initiated several efforts to improve methods to manage cumulative impacts of human activities on marine mammals, including convening a working group to develop tools to map cetacean density and distribution within U.S. waters. The specific objective of the Cetacean Density and Distribution Mapping Group (CetMap) is to create

Table 7-2. Detailed responses by the Navy and the National Marine Fisheries Service (NMFS) to comments received on the Draft SEIS/SOEIS for SURTASS LFA sonar.

COMMENTER ID / COMMENT NUMBER	COMMENTS	RESPONSE
Weilgart-08 (Continued)		regional cetacean density and distribution maps that are time- and species-specific, using survey data and models that estimate density using predictive environmental factors. CetMap is producing and/or geospatially depicting one of the following (in order of preference) for all areas, periods, and cetacean species within the U.S. EEZ: 1) habitat-based density estimates; 2) stratified density estimates; 3) habitat affinity indicators; 4) presence-only information, or; 5) an indicator that no data are available. CetMap is also completing comprehensive habitat-based density modeling for the U.S. East Coast, the Gulf of Mexico, and the Alaskan Arctic. When developed, these maps and tools would support the Navy's future analyses of these areas under the Adaptive Management requirements of the requested MMPA regulations. The Navy, under license agreements with St. Andrews University's Sea Mammal Research Unit and Dr. Kristin Kaschner, has developed a preliminary database of density estimations for the Navy's areas of responsibility. These predictive density estimates were unfortunately not available for the SURTASS LFA NEPA process including both Draft SEIS/SOEIS and Final SEIS/SOEIS. However, these data will be considered, as applicable, for future density estimation. The Navy, in concert with NMFS, has included in Subchapter 1.4.5 an adaptive management component to provide means to consider, on a case-by-case basis, new/revised peer-reviewed and published scientific data and information from qualified and recognized sources within academia, industry, government, and non-government organizations.

8.0 DISTRIBUTION LIST

Federal Agencies

Horst Greczmiel
Associate Director of NEPA Oversight
Executive Office of the President
Council on Environmental Quality
722 Jackson Place, N.W.
Washington, DC 20503

U.S. Environmental Protection Agency (EPA)
Office of Federal Activities, EIS Filing Section
Mail Code 2252-A, Room 7220
Ariel Rios Building (South Oval Lobby)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

U.S. EPA New England HQ, Region 1
5 Post Office Square Suite 100
Boston, MA 02109-3912

U.S. EPA, Region 2
290 Broadway
New York, NY 10007-1866

U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

U.S. EPA, Region 4
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

U.S. EPA, Region 6
1445 Ross Avenue
Suite 1200
Dallas, TX 75202

U.S. EPA, Region 9
75 Hawthorne Street
San Francisco, CA 94105

U.S. EPA, Region 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101

Director, Office of Environmental Policy and Compliance
U.S. Department of the Interior
1849 C Street, NW, MS 2462
Washington, DC 20240

Regional Environmental Officer
Office of Environmental Policy and Compliance
U.S. Department of the Interior
Pacific Southwestern Region
333 Bush Street, Suite 515
San Francisco, CA 94104

U.S. Department of Justice
Environment and Natural Resources Division
Office of the Assistant Attorney General
950 Pennsylvania Avenue, NW
Washington, DC 20530-0001

U.S. Fish and Wildlife Service
Environmental Coordination Branch
Department of the Interior
1849 C Street, NW
Washington, DC 20240

Jolie Harrison
NOAA National Marine Fisheries Service
Office of Protected Resources F/PR1
Permits, Conservation, and Education Division
1315 East-West Highway
Silver Spring, MD 20910

Kristine Petersen
NOAA National Marine Fisheries Service
Office of Protected Resources F/PR5
Endangered Species Act Interagency Cooperation Division
1315 East-West Highway
Silver Spring, MD 20910

Jeannine Cody
NOAA National Marine Fisheries Service
Office of Protected Resources F/PR1
Permits, Conservation, and Education Division
1315 East-West Highway, SSMC3, 13707
Silver Spring, MD 20910

Daniel Basta
Director
NOAA National Marine Sanctuaries Program
1315 East-West Highway
Silver Spring, MD 20910

John Halas
Florida Keys National Marine Sanctuary
P.O. Box 1083
Key Largo, FL 33037

Kent Edwards
Lower Regional Office
Florida Keys National Marine Sanctuary
33 East Quay Road
Key West, FL 33040

Billy Causey
Regional Director
Florida Keys National Marine Sanctuary, HQ
33 East Quay Road
Key West, FL 33040

G. P. Schmahl
Superintendent
Flower Garden Banks National Marine Sanctuary
4700 Avenue U, Bldg 216
Galveston, TX 77551

Allen Tom
Hawaiian Islands Humpback Whale National Marine Sanctuary
726 South Kihei Road
Kihei, HI 96753
Robert Nishimoto
Program Manager
Hawaiian Islands Humpback Whale National Marine Sanctuary
Division of Aquatic Resources
Department of Land and Natural Resources
1151 Punchbowl St., #330
Honolulu, HI 96813

Maria Brown
Gulf of the Farallones/Cordell Bank National Marine Sanctuary
991 Marine Drive, The Presidio
San Francisco, CA 94129

Chris Mobley
Channel Islands National Marine Sanctuary
113 Harbor Way, Suite 150
Santa Barbara, CA 93109

Gene Brighouse
Fagatele Bay National Marine Sanctuary
P.O. Box 4318
Pago Pago, AS 96799

George Sedberry
Gray's Reef National Marine Sanctuary
10 Ocean Science Circle
Savannah, GA 31411

David Alberg
Monitor National Marine Sanctuary
c/o Mariners' Museum
100 Museum Drive
Newport News, VA 23606

Paul Michel
Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, CA 93940

Carol Bernthal
Olympic Coast National Marine Sanctuary
115 East Railroad Ave. Suite 301
Port Angeles, WA 98362

Craig MacDonald
Superintendent
Stellwagen Bank National Marine Sanctuary
175 Edward Foster Rd.
Scituate, MA 02066

Patricia Montanio
Director
Office of Habitat Conservation
National Marine Fisheries Service
1315 East West Highway SSMC3, 14th Floor F/HC
Silver Spring, MD 20910

Commanding Officer (MSC) Marine Safety and Environmental Protection Branch
U.S. Coast Guard
U.S. Department of Transportation
2100 2nd Street, SW Stop 7102
Washington, DC 20593-0001

Timothy Ragen
Executive Director
Marine Mammal Commission
4340 East West Highway, Suite 905
Bethesda, Maryland 20814

Dr. Jerome Montague
Native Affairs and Natural Resources Advisor
Building 10471
Suite 301A
Elmendorf Air Force Base, Alaska 99506-2100

State Officials and Agencies

Larry Simon
Federal Consistency Coordinator
California Coastal Commission
45 Fremont, Suite 2000
San Francisco, CA 94105-2219

William J. Aila, Jr.
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, HI 96809

Richard C. Lim
Director, Hawaii Office of Planning
Hawaii Department of Business, Economic Development, and Tourism
P.O. Box 2359
Honolulu, HI 96804

Tony VanDenBossche
Director, State of Maine
Executive Department
Maine State Planning Office
38 State House Station
Augusta, ME 04333-0038

Alaska Native Tribes near Gulf of Alaska

The Honorable Conrad Peterson
Village of Old Harbor
P.O. Box 62
Old Harbor, AK 99643

The Honorable Christopher Helms
Shoonaq Tribe of Kodiak
312 West Marine Way
Kodiak, AK 99615

The Honorable Sue Johnson
Native Village of Tatitlek
P.O. Box 171
Tatitlek, AK 99677

The Honorable Ivan Lukin
Native Village of Port Lions
P.O. Box 69
Port Lions, AK 99550

The Honorable Patrick Norman
Native Village of Port Graham
P.O. Box 5510
Port Graham, AK 99603

The Honorable Alex Ambrosia
Native Village of Ouzinkie
P.O. Box 130
Ouzinke, AK 99644

The Honorable Robert Henrichs
Native Village of Eyak
P.O. Box 1388
Cordova, AK 99574

The Honorable Pete Kompkoff
Native Village of Chenega
P.O. Box 8079
Chenega Bay, AK 99574

The Honorable Nancy Nelson
Native Village of Afognak
204 East Rezanof Drive
Suite 100
Kodiak, AK 99615

The Honorable Gordon Pullar
Lesnoi Village
P.O. Box 9009
Kodiak, AK 99615

The Honorable Phyllis Amado
Kaguyak Village
P.O. Box 5078
Akhiok, AK 99615

North West Native Tribes

The Honorable David Burnett
Confederated Tribes of the Chehalis Reservation
PO Box 536
Oakville, WA 98568

The Honorable William "Bill" Iyall
Cowlitz Indian Tribe
PO Box 2547
Longview, WA 98632-8594

The Honorable Maria Lopez
Hoh Indian Tribe of the Hoh Indian Reservation
PO Box 2196
Forks, WA 98331

The Honorable Micah McCarty
Makah Indian Tribe of the Makah Indian Reservation
PO Box 115
Neah Bay, WA 98357

The Honorable Tony Foster
Quileute Nation
PO Box 279
La Push, WA 98350

The Honorable Fawn Sharp
Quinault Nation
PO Box 189
Taholah, WA 98587

The Honorable Charlene Nelson
Shoalwater Bay Tribe of the Shoalwater Bay Indian Reservation
PO Box 130
Tokeland, WA 98590

The Honorable Cheryle A. Kennedy
Confederated Tribes of the Grand Ronde Community of Oregon
9615 Grand Ronde Road
Grand Ronde, OR 97347

The Honorable Warren Brainard
Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians of Oregon
1245 Fulton Avenue
Coos Bay, OR 97420

The Honorable Delores Pigsley
Confederated Tribes of Siletz Indians of Oregon
PO Box 549
Siletz, OR 97380

The Honorable Stanley Smith, Jr.
Confederated Tribes of the Warm Springs Reservation
PO Box 1299
Warm Springs, OR 97761

The Honorable Edward Metcalf
Coquille Tribe of Oregon
3050 Tremont
North Bend, OR 97459

The Honorable Dan Courtney
Cow Creek Band of Umpqua Indians of Oregon
2371 North East Stephens
Suite 100
Roseburg, OR 97470

The Honorable Gary Frost
Klamath Tribes
PO Box 436
Chiloquin, OR 97624

THIS PAGE IS INTENTIONALLY LEFT BLANK

9.0 LITERATURE CITED

32 CFR §775. 1990. Title 32: National defense, Department of the Navy, Section 775: Procedures for implementing the National Environmental Policy Act. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e70c7a2eac0ee6b50e00f265994039c1&rgn= div5&view=text&node=32:5.1.1.7.39&idno=32>.

40 CFR §1500 to 1508. 1978. Title 40: Protection of the environment, Sections 1500 to 1508: Council on Environmental Quality; Purpose, policy, and mandate. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e70c7a2eac0ee6b50e00f265994039c1&rgn =div5&view=text&node=40:33.0.3.3.1&idno=40>.

40 CFR §1502.22(b). 1978. Title 40: Protection of the environment, Section 1502.22(b): Council on Environmental Quality, Environmental impact statement, Incomplete or unavailable information. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=b5b5c3a24c6df89 d5f450afad559e036&rgn=div8&view=text&node=40:33.0.3.3.3.0.29.22&idno=40>.

40 CFR §1503.1. 1978. Title 40: Protection of the environment, Section 1503.1: Council on Environmental Quality; Environmental impact statement, Commenting: inviting comments. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=9d4c6b09e277b216b4a90b733f794696& rgn=div8&view=text&node=40:33.0.3.3.4.0.29.1&idno=40>.

40 CFR §1508.7. 1978. Title 40: Protection of the environment; Section 1508.7: Terminology and index, cumulative impact. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=0f60aa355e2417618cdfe4759e270b95;rgn=div5;view=text;node=40%3A32.0.3.3.9;idno=4 0;cc=ecfr>.

50 CFR §216.104. 1996. Title 50: Wildlife and fisheries; Section 216.104: Regulations governing the taking and importing of marine mammals, Submission of requests. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f48ff7d118904cd10b510fa67f20f036&rgn=div8& view=text&node=50:9.0.1.3.1.9.1.4&idno=50>.

50 CFR §216.184(f). 2007. Title 50: Wildlife and fisheries; Section 216.184: Mitigation, part f: OBIAs. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ec….gn=div8&view =text&node=50:7.0.1.3.1.16.1.5&idno=50>.

50 CFR §216.189. 2011. Title 50: Wildlife and fisheries; Section 216.187: Renewal of Letters of Authorization. Code of Federal Regulations (CFR). <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?type...189;rgn=div8;view=text;node=50%3A7.0.1.3.1.16.1.10>.

Abbott, R., and E. Bing-Sawyer. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Orthodon microlepidotus*). Draft report prepared for California Department of Transportation District 4.

Abbott, R., J. Reyff, and G. Marty. 2005. Final report: Monitoring the effects of conventional pile driving on three species of fish. Richmond, California: Manson Construction Company.

Aburto, A., D.J. Rountry, and J.L. Danzer. 1997. Behavioral response of blue whales to active signals. Technical Report. San Diego, California: Naval Command, Control and Ocean Surveillance Center.

Acebes, J.M.V., J.D. Darling, and M. Yamaguchi. 2007. Status and distribution of humpback whales (*Megaptera novaeangliae*) in northern Luzon, Philippines. Journal of Cetacean Research and Management 9(1):37-43.

ACT (Advanced Coherent Technologies, LLC). 2009. Advanced electro-optical imaging solution for naval operations. Virtual solutions brochure.

Agardy, T. 2001. Marine protected areas need to work for people and achieve conservation simultaneously. Keynote presentation presented at the Pacific Science Intercongress Meeting, 4 June 2001, Guam.

Agardy, T., P. Bridgewater, M.P. Crosby, J. Day, P.K. Dayton, R. Kenchington, D. Laffoley, P. Mcconney, P.A. Murray, J.E. Parks, and L. Peau. 2003. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation: Marine and Freshwater Ecosystems 13**:**353-367.

Aguilar, A. 2009. Fin whale (*Balaenoptera physalus*). Pages 433-437 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, Calfornia: Academic Press.

AIA (Automated Imaging Associates). 2009. FLIR systems receives US Navy order valued at $12.9 million. <http://www.machinevisiononline.org/vision-resources-details.cfm?content_id=827>.

Allen, B. M., and R.P. Angliss. 2010. Alaska marine mammal stock assessments, 2009. NOAA Technical Memorandum NMFS-AFSC-206. Seattle, Washington: Alaska Fisheries Science Center, National Marine Fisheries Service. 276 pages.

Alling, A.K., and R. Payne. 1990. Song of the Indian Ocean blue whale, *Balaenoptera musculus*. S. Leatherwood, ed. Special issue on the Indian Ocean Sanctuary. Cambridge, Massachusetts: International Whaling Commission.

André, M., M. Solé, M. Lenoir, M. Durfort, C. Quero, A. Mas, A. Lombarte, M. van der Schaar, M. López-Bejar, M. Morell, S. Zaugg, and L. Houégnigan. 2011. Low-frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment: Preprint. doi 10.1890/100124.

Andrew, R.K., B.M. Howe, J.A. Mercer, and M.A. Dzieciuch. 2002. Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast. Acoustics Research Letters Online 3(2):65-70.

Angliss, R.P., and B.M. Allen. 2009. Alaska marine mammal stock assessments, 2008. NOAA Technical Memorandum NMFS-AFSC-193. Seattle, Washington: Alaska Fisheries Science Center, National Marine Fisheries Service. 269 pages.

ANSI (American National Standard Institute). 2006. ANSI reference quantities for acoustical levels, ANSI-S1-8-1989, revised 2006. New York, New York: Acoustic Society of America.

Aragones, L.V., M.A.A. Roque, M.B. Flores, R.P. Encomienda, G.F. Laule, B.G. Espinos, F.E. Maniago, G.C. Diaz, E.B. Alesna, and R.C. Braun. 2010. The Philippine marine mammal strandings from 1998 to 2009: Animals in the Philippines in peril? Aquatic Mammals 36(3)**:** 219-233.

Archer, A. 2009. Striped dolphin (*Stenella coeruleoalba*). Pages 1127-1129 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Archer, F.I., and W.F. Perrin. 1999. *Stenella coeruleoalba*. Mammalian Species 603:1-9.

Aristotle. ~350 B.C. Historia animalium. Translation D.W. Thompson. 1910th edition. Oxford University Press.

Arnould, J.P. Y. 2009. Southern fur seals *Arctocephalus* spp. Pages 1079-1084 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Aroyan, J.L., M.A. McDonald, S.C. Webb, J.A. Hildebrand, D. Clark, J.T. Laitman, and J.S. Reidenberg. 2000. Acoustic Models of Sound Production and Propagation. Pages 409-469 in W.W.L. Au, A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Asselin, S., M.O. Hammill, and C. Barrette. 1993. Underwater vocalizations of ice breeding grey seals. Canadian Journal of Zoology 71(11):2211–2219.

Au, W.W.L. 1993. The sonar of dolphins. New York, New York: Springer-Verlag.

Au, W.W.L., and M.C. Hastings. 2008. Principles of marine bioacoustics. Modern acoustics and signal processing. New York, New York: Springer-Verlag.

Au, W.W.L., and D.L. Herzing. 2003. Echolocation signals of wild Atlantic spotted dolphin (*Stenella frontalis*). Journal of the Acoustical Society of America 113(1):598-604.

Au, W.W.L., and B. Würsig. 2004. Echolocation signals of dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand. Journal of the Acoustical Society of America 115(5):2307–2313.

Au, W.W.L., R.H. Penner, and C.W. Turl. 1987. Propagation of beluga echolocation signals. Journal of the Acoustical Society of America 82(3):807-813.

Au, W.W.L., P.E. Nachtigall, and J.L. Pawloski. 1997. Acoustic effects of the ATOC signal (75 Hz, 195 dB) on dolphins and whales. Journal of the Acoustical Society of America 101(5):2973-2977.

Au, W.W.L., D.L. Herzing, and R. Aubauer. 1998. Real-time measurement of the echolocation signals of wild dolphins using a 4-hydrophone array. In Proceedings of the World Marine Mammal Science Conference, 12th Biennial Conference, Monaco, 20-25 January 1998.

Au, W., A.N. Popper, and R.R. Fay. 2000. Hearing by whales and dolphins. Volume 12. Springer Handbook of auditory research. New York, New York: Springer-Verlag.

AUVAC (Autonomous Undersea Vehicle Applications Center). 2009. AUVAC: Strengthening the AUV community. Autonomous Undersea Vehicle Applications Center (AUVAC). Accessed April 28, 2009. <http://www.auvac.org/>.

Avallone, E.A., and T. Baumeister, III, eds. 1987. Dimensional analysis. Mark's standard handbook for mechanical engineers, 9th edition New York, New York: McGraw-Hill Book Company.

Avens, L., and K.J. Lohmann. 2004. Navigation and seasonal migratory orientation in juvenile sea turtles. Journal of Experimental Biology 207:1771-1778.

Awbrey, F.T., J.C. Norris, A.B. Hubbard, and W.E. Evans. 1979. The bioacoustics of the Dall porpoise-salmon drift net interaction. Hubbs/Sea World Research Institute Technical Report 79. San Diego, California: Hubbs/Sea World Research Institute. 120 pages.

Awbrey, F.T., J.A. Thomas, W.E. Evans, and S. Leatherwood. 1982. Ross Sea killer whale vocalizations: Preliminary description and comparison with those of some northern hemisphere killer whales. Report of the International Whaling Commission 32:667-670.

Awbrey, F.T., J.A. Thomas, and R.A. Kastelein. 1988. Low-frequency underwater hearing sensitivity in belugas, *Delphinapterus leucas*. Journal of the Acoustical Society of America 84(6):2273-2275.

Baba, N., M. Kiyota, H. Hatanaka, and A. Nitta. 1993. Biological information and mortality of northern fur seals (*Callorhinus ursinus*) by the high seas Japanese squid driftnet fishery. International North Pacific Fisheries Commission Bulletin 53:461-472.

Babushina, Y.S., G.L. Zaslavskii, and L.I. Yurkevich. 1991. Air and underwater hearing characteristics of the northern fur seal: Audiograms, frequency and differential thresholds. Biophysics 36(5):909-913.

Bain, D.E., B. Kriete, and M.E. Dahlheim. 1993. Hearing abilities of killer whales (*Orcinus orca*). Journal of the Acoustical Society of America 94(3):1829-1829.

Baird, R., D.L. Webster, G.S. Schorr, D.J. McSweeney, and J. Barlow. 2008. Diel variation in beaked whale diving behavior. Marine Mammal Science 24(3):630-642.

Baird, R.W. 2009a. False killer whales (*Pseudorca crassidens*). Pages 405-406 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Baird, R.W. 2009b. Risso's dolphin (*Grampus griseus*). Pages 975-976 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition, San Diego, California: Academic Press.

Baird, R.W., L.M. Dill, and M.B. Hanson. 1998. Diving behavior of killer whales. Abstract, Proceedings of The World Marine Mammal Science Conference, Monaco, 22-24 January 1998.

Baird, R.W., A.D. Ligon, S.K. Hooker, and A.M. Gorgone. 2001. Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawai'i. Canadian Journal of Zoology 79(6):988-996.

Baird, R. W, J. F Borsani, M. B Hanson, and P. L Tyack. 2002. Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. Marine Ecology Progress Series 237:301-305.

Baird, R.W., D.J. McSweeney, A.D. Ligon, and D.L. Webster. 2004. Tagging feasibility and diving of Cuvier's beaked whales (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawaii. Prepared for the National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California.

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, A.M. Gorgone, and S.J. Chivers. 2008. A survey to assess overlap of insular and offshore false killer whales (*Pseudorca crassidens*) off the island of Hawai'i. Report prepared under Order No. AB133F07SE4484 for the Protected Species Division, Pacific Islands Fisheries Science Center, Honolulu, Hawaii. 11 pages.

Baker, A.N. 1985. Pygmy right whale *Caperea marginata* (Gray, 1846). In S.H. Ridgway and R. Harrison, eds. Handbook of marine mammals, Volume 3: The sirenians and baleen whales. London, England: Academic Press.

Baldwin, R., G.R. Hughes, and R.I.T. Prince. 2003. Loggerhead turtles in the Indian Ocean. Pages 218-232 in A.B. Bolten., and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Ballance, L.T. 2009. Cetacean ecology. Pages 196-201 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Ballance, L.T., and R.L. Pitman. 1998. Cetaceans of the western tropical Indian Ocean: Distributoon, relative abundance, and comparisons with cetacean communiteis of two other tropical ecosystems. Marine Mammal Science 14(3):429-459.

Ballance, L.T., D.G. Ainley, and G.L. Hunt Jr. 2001. Seabird foraging ecology. Pages 2636-2644 in J.H. Steele, S.A. Thorpe, and K.K. Turekian, eds. Encyclopedia of ocean sciences, Volume 5. London, England: Academic Press.

Banner, A. 1967. Evidence of sensitivity to acoustic displacements in the lemon shark, *Negaprion brevirostris* (Poey). Pages 265-273 in P.H. Cahn, ed. Lateral line detectors. Bloomington, Indiana: Indiana University Press.

Banner, A. 1972. Use of sound in predation by young lemon sharks, *Negaprion brevirostris* (Poey). Bulletin of Marine Science 22(2):251-283.

Bannister, J.L. 2009. Baleen whales. Pages 80-89 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. 62-72. San Diego, California: Academic Press.

Baraff, L.S., P.J. Clapham, D.K. Mattila, and R.S. Bowman. 1991. Feeding behavior of a humpback whale in low-latitude waters. Marine Mammal Science 7(2):197-202.

Barco, S.G., W.A. McLellan, J.M. Allen, R.A. Asmutis-Silvia, R. Mallon-Day, E.M. Meacher, D.A. Pabst, J. Robbins, R. Seton, W.M. Swingle, M. Weinrich, and P. Clapham. 2002. Population identity of humpback whales (*Megaptera novaengliae*) in the waters of the US mid-Atlantic states. Journal of Cetacean Research and Management 4(2):135-142.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part 1: Ship surveys in summer and fall of 1991. Fishery Bulletin 93(1):1-14.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209-221 in G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. Mcdonald, and D.G. Robertson, eds. Marine mammal survey and assessment methods. Rotterdam, Netherlands: A.A. Balkema.

Barlow, J., M.C. Ferguson, E.A. Becker, J.V. Redfern, K.A. Forney, I.L. Vilchis, P.C. Fiedler, T. Gerrodette, and L.T. Ballance. 2009. Predictive modeling of cetacean densities in the eastern Pacific Ocean. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFSC-444. LaJolla, California: Southwest Fisheries Science Center, National Marine Fisheries Service. 229 pages.

Bartholomew, G.A., and N.E. Collias. 1962. The role of vocalization in the social behaviour of the northern elephant seal. Animal Behaviour 10(1):7-14.

Bartol, S.M. 2008. A review of auditory function of sea turtles. Bioacoustics 17(1):57-59.

Bartol, S.M., and J.A. Musick. 2003. Sensory biology of sea turtles. Pages 79-102 in P.L. Lutz, J. Wyneken, and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Bartol, S.M., J.A. Musick, and M.L. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 3: 836-840.

Bass, A.H., and F. Ladich. 2008. Vocal-acoustic communication: from neurons to brain. Pages 253-278 in J.F. Webb, R.R. Fay, and A.N. Popper, eds. Chapter 22. Fish bioacoustics. Springer Handbook of Auditory Research. New York, New York: Springer-Verlag.

Baumgartner, M.F., and B.R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. Marine Ecology Progress Series 264:123-135.

Baumgartner, M. F., K.D. Mullin, L.N. May, and T.D. Leming. 2001. Cetacean habitats in the northern Gulf of Mexico. Fishery Bulletin 99(2):219-239.

Baylis, A.M.M., B. Page, K. Peters, R. McIntosh, J. McKnzie, and S. Goldsworthy. 2005. The ontogeny of diving behaviour in New Zealand fur seal pups (*Arctocephalus forsteri*). Canadian Journal of Zoology 83(9):1149-1161.

Bazua-Duran, C., and W.W.L. Au. 2002. The whistles of Hawaiian spinner dolphins. Journal of the Acoustical Society of America 112(6):3064-3072.

Benedict, J.R. 2005. The unraveling and revitalization of U.S. Navy antisubmarine warfare. Naval War College Review 58(2):93-120.

Berkson, H. 1967. Physiological adjustments to deep diving in the Pacific green turtle (*Chelonia mydas agassizii*). Comparative Biochemistry and Physiology 21(3):507-524.

Berta, A. 2009. Pinnipedis, overview. Pages 878-884 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Best, P.B. 1960. Further information on Bryde's whale (*Balaenoptera edeni* Anderson) from Saldanha Bay, South Africa. Norsk Hvalfangst-Tidende 49:201-215.

Best, P.B. 1975. Status of Bryde's whale (*Balaenoptera edeni* or *B. brydei*). In Food and Agriculture Organization (FAO) of the United Nations, Advisory Comittee on Marine Resources Research, Marine Mammal Symposium, Research Paper MM/EC/12. Rome, Italy: FAO of the United Nations. 11 pages.

Best, P.B., R.A. Rademeyer, C. Burton, D. Ljungblad, K. Sekiguchi, H. Shimada, D. Thiele, D. Reeb, and D.S. Butterworth. 2003. The abundance of blue whales on the Madagascar Plateau, December 1996. Journal of Cetacean Research and Management 5:253-260.

Bigg, M. 1981. Harbour seal *Phoca vitulina* and *P. largha*. Pages 55-87 in S.H. Ridgway, and R.J. Harrison, editors. Handbook of marine mammals. San Diego, California, Academic Press.

Bjorge, A., and K.A. Tolley. 2009. Harbor porpoise *Phocoena phocoena*. Pages 530-533 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Bjorndal, K. 1997. Foraging ecology and nutrition of sea turtles. Pages 199-231 in P.L. Lutz, and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Black, N. 2009. Pacific white-sided dolphin *Lagenorhynchus obliquidens*. Pages 817-819 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Black, N.A. 1994. Behavior and ecology of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) in Monterey Bay, California. Master's thesis, San Francisco State University. 133 pages.

Bolten, A.B. 2003. Active swimmers—passive drifters: The oceanic juvenile stage of loggerheads in the Atlantic system. Pages 63-78 in B.E. Witherington and A.B. Bolten, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Books.

Bonner, W.N. 1990. The natural history of seals. New York, New York: Facts on File.

Bowen, B.W. and S.A. Karl. 2000. Meeting report: Taxonomic status of the east Pacific green turtle (*Chelonia agassizii*). Marine Turtle Newsletter 89:20-22.

Bowen, B.W., F.A. Abreu-Grobois, G.H. Balazs, N. Kamezaki, C.J. Limpus, and R.J. Ferl. 1995. Trans-Pacific migrations of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences of the United States of America 92(9):3731-3734.

Bowen, D.W., C.A. Beck, and D.A. Austin. 2009. Pinniped ecology. Pages 852-861 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Boyd, I. 2008a. Behavioral response study-2007 (BRS-07) cruise report. Department of the Navy. 107 pages.

Boyd, I. 2008b. Behavioral response study-2008 (BRS-08) cruise report. Department of the Navy. 203 pages.

Boyd, I.L. 2009. Pinniped life history. Pages 868-873 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Boyle, M.C., N.N. FitzSimmons, C.J. Limpus, S. Kelez, X. Velez-Zuazo, and M. Waycott. 2009. Evidence for transoceanic migrations by loggerhead sea turtles in the southern Pacific Ocean. Proceedings of the Royal Society B 276:1993-1999.

Bradley, D.L., and R. Stern. 2008. Underwater sound and the marine mammal acoustic environment: A guide to fundamental principles. Bethesda, Maryland: U.S. Marine Mammal Commission.

Braham, H.W. 1984. The bowhead whale, *Balaena mysticetus.* Marine Fisheries Review 46(4):45-53.

Branch, T.A. Branch, K.M. Stafford, D.M. Palacios, C. Allison, J.L. Bannister, C.L.K. Burton, E. Cabrera, C.A. Carlson, B. Galletti Vernazzani, P.C. Gill, R. Hucke-Gaete, K.C.S. Jenner, M-N.M. Jenner, K. Matsuoka, Y.A. Mikhalev, T. Miyashita, M.G. Morrice, S. Nishiwaki, V.J. Sturrock, D. Tormosov, R.C. Anderson, A.N. Baker, P.B. Best, P. Borsa, R.L. Brownell, Jr., S. Childerhouse, K.P. Findlay, T. Gerrodette, A.D. Ilangakoon, M. Joergensen, B. Kahn, D.K. Ljungblad, B. Maughan, R.D. McCauley, S. McKay, T.F. Norris, Oman Whale and Dolphin Research Group, S. Rankin, F. Samaran, D. Thiele, K. van Waerebeek, and R.M. Warneke. 2007. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. Mammalian Review 37(2):116-175.

Breese, D.B., and B.R. Tershy. 1993. Relative abundance of cetacea in the Canal de Ballenas, Gulf of California. Marine Mammal Science 9(3):319-324.

Brewer, P.G., and K.C. Hester. 2009. Ocean acidification and the increasing transparency of the ocean to low-frequency sound. Oceanography 22:86-93.

Brill, R.W., G.H. Balazs, K.N. Holland, R.K.C. Chang, S. Sullivan, and J. George. 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian islands. Journal of Experimental Marine Biology and Ecology 185:203-218.

Brodie, P.F. 1989. The white whale—*Delphinapterus leucas*. Pages 119-144 in S.H. Ridgeway and R.J. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. San Diego, California: Academic Press.

Brown, D.H., D.K. Caldwell, and M.C. Caldwell. 1966. Observations on the behavior of wild and captive false killer whales, with notes on associated behavior of other genera of captive delphinids. Los Angeles County Museum Contributions in Science 95:1-32.

Buckland, S.T., K.L. Cattanach, and R.C. Hobbs. 1993. Abundance estimates of Pacific white-sided dolphin, northern right whale dolphin, Dall‘s porpoise and northern fur seal in the North Pacific. International North Pacific Fisheries Commission Bulletin 53:387-407.

Budelmann, B.U., and R. Williamson. 1994. Directional sensitivity of hair cell afferents in the octopus statocyst. Journal of Experimental Biology 187(1):245-259.

Buerki, C.B., T.W. Cranford, K.M. Langan, and K.L. Marten. 1989. Acoustic recordings from two stranded beaked whales in captivity. Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals, Pacific Grove, California.

Buerkle, U. 1968. Relation of pure tone thresholds to background noise level in the Atlantic cod *(Gadus morhua)*. Journal of the Fisheries Board of Canada 25:1155-1160.

Buran, B.N., X. Deng, and A.N. Popper. 2005. Structural variation in the inner ears of four deep-sea elopomorph fishes. Journal of Morphology 265(2):215-225.

Burgess, W.C., P.L. Tyack, B.J. Le Boeuf, and D.P. Costa. 1998. A programmable acoustic recording tag and first results from free-ranging northern elephant seals. Deep-Sea Research Part II 45(7):1327-1351.

Burns, J.J. 1981. Ribbon seal, *Phoca fasciata* Zimmermann, 1783. Pages 89-109 in S.H Ridgway, and R.J. Harrison, editors. Handbook of marine mammals. London, England, Academic Press.

Burns, J.J. 2009. Harbor seal and spotted seal (*Phoca vitulina* and *P. largha*). Pages 533-542 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Busnel, R.G., and A. Dziedzic. 1966. Acoustic signals of the pilot whale *Globicephala melaena* and of the porpoises *Delphinus delphis* and *Phocoena phocoena*. Pages 607–646 in K.S. Norris, ed. Whales, dolphins, and porpoises. Berkeley, California: University of California Press.

Busnel, R.G., and A. Dziedzic. 1968. Caracteristiques physiques des signaux acoustiques do *Pseudorca crassidens* Owen (Cetace Odontocete). Mammalia 32(1):1-5.

Byles, R.A. and P.T. Plotkin. 1994. Comparison of the migratory behavior of the congeneric sea turtles *Lepidochelys olivacea* and *L. kempii.* Page 39 in B.A. Schroeder and B.E. Witherington, eds. Proceedings of the thirteenth annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFSC-341. Southeast Fisheries Science Center, National Marine Fisheries Service.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. Leduc, D. Mattila, L. Rojas-, J.M.S. Bracho, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A., and J.H. Havron, And N. Maloney. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific. Final report for Contract AB133F-03-RP-00078. Report prepared for U.S. Dept of Commerce, Western Administrative Center, Seattle, Washington. Olympia, Washington: Cascadia Research.

Caldwell, D.K., and M.C. Caldwell. 1971. The pygmy killer whale, *Feresa attenuata*, in the western Atlantic, with a summary of world records. Journal of Mammalogy 52(1):206-209.

Caldwell, D.K., and M.C. Caldwell. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838); Dwarf sperm whale *Kogia simus* (Owen, 1866). Pages 235-260 in S.H. Ridgway and R. Harrison, eds. Handbook of marine mammals, Volume 4; River dolphins and the larger toothed whales. New York, New York: Academic Press.

Caldwell, M.C., and D.K. Caldwell. 1968. Vocalization of naive dolphins in small groups. Science 159(3819):1121-1123.

Caldwell, M.C., and D.K. Caldwell. 1969. Simultaneous but different narrow-band sound emissions by a captive eastern pacific pilot whale, *Globicephala scammoni*. Mammalia 33(3):505-508.

Caltrans (California Department of Transportation). 2004. Fisheries and hydroacoustic monitoring program compliance report. Prepared by Strategic Environmental Consulting, Inc. and Illingworth & Rodkin, Inc., San Francisco for the Oakland Bay Bridge East Span Seismic Safety Project.

Campagna, C., R. Werner, W. Karesh, M.R. Marín, F. Koontz, R. Cook, and C. Koontz. 2001. Movements and location at sea of South American sea lions (*Otaria avescens*). Journal of Zoology 257:205-220.

Cappozzo, H.L., and W.F. Perrin. 2009. South American sea lion (*Otaria flavescens*). Pages 1076-1079 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Carder, D., S. Ridgway, B. Whitaker, and J. Geraci. 1995. Hearing and echolocation in a pygmy sperm whale *Kogia*. Page 20 in Abstracts, Eleventh biennial conference on the biology of marine mammals, Orlando, Florida, 14-18 December, 1995.

Carretta, J.V., K.A. Fornery, M.S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, M.M. Muto, D. Lynch, and L. Carswell. 2009. U.S. Pacific marine mammal stock assessments: 2008. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-434. La Jolla, California: Southwest Fisheries Science Center, National Marine Fisheries Service. 340 pages.

Carretta, J.V., K.A. Fornery, M.S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R.L. Brownell, Jr., J. Robbins, D.K. Mattila, K. Rawls, M.M. Muto, D. Lynch, and L. Carswell. 2010. U.S. Pacific marine mammal stock assessments: 2009. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-453. La Jolla, California: Southwest Fisheries Science Center, National Marine Fisheries Service. 341 pages.

Casper, B.M., and D.A. Mann. 2006. Evoked potential audiograms of the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*). Environmental Biology of Fishes 76(1):101-108.

Casper, B.M., and D.A. Mann. 2007. Dipole hearing measurements in elasmobranch fishes. Journal of Experimental Biology 210(1):75-81.

Casper, B.M., P.S. Lobel, and H.Y. Yan. 2003. The hearing sensitivity of the little skate, *Raja erinacea*: A comparison of two methods. Environmental Biology of Fishes 68(4):371-379.

CFMC (Caribbean Fishery Management Council). 2009. Caribbean Fishery Management Council. Accessed September 2009. <http://www.caribbeanfmc.com/>.

Chaloupka, M., P. Dutton, and H. Nakano. 2004. Status of sea turtle stocks in the Pacific. FAO Fisheries Report 738 (Supplement)**:**135-164.

Chapman, C.J. 1973. Field studies of hearing in teleost fish. Helgoland Marine Research 24(1):371-390.

Chapman, C.J., and A.D. Hawkins. 1973. A field study of hearing in the cod, *Gadus morhua* L. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 85(2):147-167.

Chapman, C.J., and O. Sand. 1974. Field studies of hearing in two species of flatfish *Pleuronectes platessa* (L.) and *Limanda limanda* (L.) (Family Pleuronectidae). Comparative Biochemistry and Physiology 47A:371-385.

Charif, R.A., D.K. Mellinger, K.J. Dunsmore, K.M. Fristrup, and C.W. Clark. 2002. Estimated source levels of fin whale (*Balaenoptera physalus*) vocalizations: adjustments for surface interference. Marine Mammal Science 18(1):81-98.

Choong, W. 2007. Asia's arms race goes underwater; China, India lead the pack in buying more sophisticated submarine models. The Straits Times, 09 April 2007 edition. Accessed: <http://www.lexisnexis.com.mutex.gmu.edu/us/lnacademic/frame.do?tokenKey=rsh-20.142758.0230974 5655&target=results_listview_resultsNav&reloadEntirePage=true&rand=1236180906588&returnToKey=2 0_T5946966340&parent=docview>.

Christensen, I., T. Haug, and N. Øien. 1992. A review of feeding and reproduction in large baleen whales (Mysticeti) and sperm whales *Physeter macrocephalus* in Norwegian and adjacent waters. Fauna Norvegica Series A 13: 39–48.

CIA (Central Intelligence Agency). 2011. The world factbook—East and southeast Asia: China. Accessed March 2011. <https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html>.

Cipriano, F. 2009. Atlantic white-sided dolphin (*Lagenorhynchus actutus*). Pages 56-58 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Clapham, P.J. 2009. Humpback whale (*Megaptera novaeangliae*). Pages 582-585 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Clapham, P.J., and D.K. Mattila. 1990. Humpback whale songs as indicators of migration routes. Marine Mammal Science 6(2):155-160.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71(2):440-443.

Clark, C.W. 1980. A real-time direction finding device for determining the bearing to the underwater sounds of southern right whales, *Eubalaena australis*. Journal of the Acoustical Society of America 68(2):508-511.

Clark, C.W. 1982. The acoustic repertoire of the southern right whale, a quantitative analysis. Animal Behaviour 30(4):1060-1071.

Clark, C.W. 1983. Acoustic communication and behavior of the southern right whale (*Eubalaena australis*). Pages 163-198 in R.S. Payne, ed. Communication and behavior of whales. Boulder, Colorado: Westview Press.

Clark, C.W. 1990. Acoustic behavior of mysticete whales. J.A. Thomas, and R.A. Kastelein, eds. Sensory abilities of cetaceans: Laboratory and field evidence. New York, New York: Plenum Press.

Clark, C.W. and R. Charif. 1998. Monitoring the occurrence of large whales off north and west Scotland using passive acoustic arrays. Society of Petroleum Engineers (SPE). SPE/UKOOA European Environmental Conference, Aberdeen, Scotland, April 1997.

Clark, C.W., and W.T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: evidence from models and empirical measurements. Pages 564-582 in J. Thomas, C. Moss, and M. Vater, eds. Echolocation in bats and dolphins. Chicago, Illinois: University of Chicago Press.

Clark, C.W., and K.M. Fristrup. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. Report of the International Whaling Commission 47:583-600.

Clark, C.W., P. Tyack, and W.T. Ellison. 1999. Technical Report 1: Low frequency sound scientific research program technical report (responses of four species of whales to sounds of SURTASS LFA sonar transmissions). Report for the U.S. DoN. Included in Overseas environmental impact statement and environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar.

Clark, C.W., P. Tyack, and W.T. Ellison. 2001. Technical Report 1, revised: low frequency sound scientific research program technical report (responses of four species of whales to sounds of SURTASS LFA sonar transmissions). Report for the U.S., DoN rev. 2001. Included in Overseas environmental impact statement and environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar.

Clark, C.W., J. F. Borsani, and G. Notarbartolo di Sciara. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Marine Mammal Science 18(1):286-295.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Clarke, M.R. 1976. Observation on sperm whale diving. Journal of the Marine Biological Association of the United Kingdom 56:809-810.

Coffin, A, M Kelley, G.A. Manley, and A.N Popper. 2004. Evolution of sensory hair cells. Pages 55-94 in G.A. Manley, A.N. Popper, and R.R. Fay, eds. Evolution of vertebrate auditory systems, Chapter 22. Springer handbook of auditory research. New York, New York: Springer-Verlag.

Coles, W.C., and J.A. Musick. 2000. Satellite sea surface temperature analysis and correlation with sea turtle distribution off North Carolina. Copeia 2000(2)**:**551-554.

Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act. Report of the Loggerhead Biological Review Team to the National Marine Fisheries Service, August 2009. National Marine Fisheries Service. 222 pages.

Considine, D.M., ed. 1995. Van Nostrand's scientific encyclopedia. 8th edition New York, New York: Van Nostrand Reinhold.

Cook, M.L.H., C.A. Manire, and D.A. Mann. 2005. Auditory evoked potential (AEP) measurements in stranded rough-toothed dolphins (*Steno bredanensis*). Journal of the Acoustical Society of America 117(4):2441-2441.

Cook, M.L.H., R.A. Varela, J.D. Goldstein, S.D. McCulloch, G.D. Bossart, J.J. Finneran, D. Houser, and D.A. Mann. 2006. Beaked whale auditory evoked potential hearing measurements. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 192(5):489-495.

Coombs, S., and J.C. Montgomery. 1999. The enigmatic lateral line system. Pages 319–362 in R.R. Fay and A.N. Popper, eds. Comparative hearing: Fish and amphibians. New York, New York: Springer-Verlag.

Coombs, S., and A.N. Popper. 1979. Hearing differences among Hawaiian squirrelfish (family Holocentridae) related to differences in the peripheral auditory system. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 132(3):203-207.

Coombs, S., P. Gorner, and H. Munz, eds. 1989. The mechanosensory lateral line: Neurobiology and evolution. New York, New York: Springer-Verlag.

Coombs, S., J. Janssen, and J. Montgomery. 1992. Functional and evolutionary implications of peripheral diversity in lateral line systems. In The evolutionary biology of hearing. New York, New York: Springer-Verlag.

Costa, D.P., and N.J. Gales. 2003. Energetics of a benthic diver: Seasonal foraging ecology of the Australian sea lion, *Neophoca cinerea*. Ecological Monographs 73(1):27-43.

Cox, M., P.H. Rogers, A.N. Popper, W.M. Saidel, and R.R. Fay. 1986a. Frequency regionalization in the fish ear. Journal of the Acoustical Society of America 79(S1):S80-S80.

Cox, M., P.H. Rogers, A.N. Popper, and W.M. Saidel. 1986b. Anatomical effects of intense tone stimulation in the ear of bony fishes. Journal of the Acoustical Society of America 80(S1):S75-S75.

Cox, M., P.H. Rogers, A.N. Popper, and W.M. Saidel. 1987. Anatomical effects of intense tone stimulation in the goldfish ear: Dependence on sound-pressure level and frequency. Journal of the Acoustical Society of America 81(S1):S7-S7.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vox, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, Y. Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D.C Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner. 2006. Understand the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3):177-187.

Croll, D.A., B.R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical Report for SURTASS LFA EIS. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California, Santa Cruz. 473 pages.

Croll, D.A., A. Acevedo-Gutiérrez, B.R. Tershy, and J. Urbán-Ramírez. 2001a. The diving behavior of blue and fin whales: Is dive duration shorter than expected based on oxygen stores? Comparative Biochemistry and Physiology, Part A: Physiology 129(4):797–809.

Croll, D.A., C.W. Clark, J. Calambokidis, W.T. Ellison, and B.R. Tershy. 2001b. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4**:**13-27.

Croll, D.A., C.W. Clark, A. Acevedo, B. Tershy, S. Flores, J. Gedamke, and J. Urban. 2002. Only male fin whales sing loud songs. Nature 417**:** 809-809.

Cruickshank, R.A., and S.G. Brown. 1981. Recent observations and some historical records of southern right-whale dolphins *Lissodelphis peronii*. Fisheries Bulletin (South Africa) 15(1):109-121.

Culik, B.M. 2010. Odontocetes: the toothed whale: Distribution, behaviour, mitigation and threats. United Nations Environmental Programme (UNEP) Convention on Migratory Species (CMS). Kiel, Germany. Accessed 17 February 2010. <http//www.cms.int/reports>.

Cummings, W.C. 1985. Bryde's whale (*Balaenoptera edeni*) (Anderson, 1878). Pages 137-154 in S.H. Ridgway and R. Harrison, eds. Handbook of marine mammals, Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Cummings, W.C., and D.V. Holliday. 1987. Sounds and source levels from bowhead whales off Pt. Barrow, Alaska. Journal of the Acoustical Society of America 82(3):814-821.

Cummings, W.C., and P.O. Thompson. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. Journal of the Acoustical Society of America 50(4B):1193-1198.

Cummings, W.C., J.F. Fish, and P.O. Thompson. 1972. Sound production and other behavior of southern right whales, *Eubalaena glacialis*. Transactions of the San Diego Society of Natural History 17(1):1-14.

D'Spain, G.L., A. D'Amico, and D.A. Fromm. 2006. Properties of the underwater sound fields during some well documented beaked whale mass stranding events. Journal of Cetacean Research Management 7:223-228.

D'Vincent, C.G., R.M. Nilson, and R.E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. Scientific Reports of the Whales Research Institute 36:41-47.

Dahlheim, M.E. 1987. Bio-acoustics of the gray whale (*Eschrichtius robustus*). Ph.D. dissertation, University of British Columbia.

Dahlheim, M.E., and D.K. Ljungblad. 1990. Preliminary hearing study on gray whales (*Eschrichtius robustus*) in the field. Pages 335–346 in J. Thomas, and R. Kastelein, eds. Sensory abilities of cetaceans, laboratory and field evidence. NATO ASI Series A: Life Sciences. New York, New York: Plenum Press.

Dalen, J., W. Karp, R. Kloser, G. Macaulay, G. Melvin, R. Mitson, R. O'Driscoll, H. Pena, and T. Ryan. 2007a. Collection of acoustic data from fishing vessels. ICES Cooperative Research Report. Copenhagen Denmark: International Council for the Exploration of the Sea.

Davies, A. 2007. The enemy below: Anti-submarine warfare in the Australian Defense Force. Barton, Australian Capitol Territory: Australian Strategic Policy Institute.

Davis, R.W. 2010. Personal communication via email between Dr. Randall W. Davis, Texas A&M University at Galveston, Galveston, Texas, and Ms. Cheryl Schroeder, Marine Acoustics, Inc., Arlington, Virginia, 1 December.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the northcentral and western Gulf of Mexico. Marine Mammal Science 14(3):490-507.

Davis, R.W., L.A. Fuiman, T.M. Williams, and B.J. Le Boeuf. 2001. Three-dimensional movements and swimming activity of a northern elephant seal. Comparative Biochemistry and Physiology, Part A: Physiology 129(4):759-770.

Davis, R.W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino, and W. Gilly. 2007. Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico. Marine Ecology Progress Series 333:291-302.

Dawbin, W.H., and D.H. Cato. 1992. Sounds of a pygmy right whale (*Caperea marginata*). Marine Mammal Science 8(3):213-219.

Dawson, S., J. Barlow, and D.K. Ljungblad. 1998. Sounds recorded from Baird's beaked whale, *Berardius bairdii*. Marine Mammal Science 14(2):335-344.

Dawson, S.M. 2009. *Cephalorhynchus* dolphins (*C. heavisidii, C. eutropia, C. hectori, and C. commersonii*). Pages 191-196 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Delarue, J., M. Laurinolli, and B. Martin. 2009. Bowhead whale (*Balaena mysticetus*) songs in the Chukchi Sea between October 2007 and May 2008. Journal of the Acoustical Society of America 126(6):3319-3328.

Dendrinos, P., A.A. Karamanlidis, E. Androukaki, and B.J. McConnell. 2007. Diving development and behavior of a rehabilitated Mediterranean monk seal (*Monachus monachus*). Marine Mammal Science 23(2):387-397.

Deng, X., J.H. Wagner, and A.N. Popper. 2009. Comparative studies of the auditory periphery in deep-sea fish. Paper presented at the 157th conference of the Acoustical Society of America. Abstract 1pABa10. Journal of the Acoustical Society of America 125(4), Part II:2507-2507.

Di Iorio, L., and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters 6(1):51-54.

Diercks, K.J., R.T. Trochta, C.F. Greenlaw, and W.E Evans. 1971. Recording and analysis of dolphin echolocation signals. Journal of the Acoustical Society of America 49(1A):135-135.

Diercks, K.J., R.T. Trochta, and W.E. Evans. 1973. Delphinid sonar: Measurement and analysis. Journal of the Acoustical Society of America 54(1):200-204.

DoD (U.S. Department of Defense). 2009. Annual report to Congress: Military power of the People's Republic of China. Office of the Secretary of Defense. Accessed: <http://www.defenselink.mil/pubs/pdfs/China_Military_Power_Report_2009.pdf>.

Dodd, C.K. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). U.S. Fish and Wildlife Service Biological Report 88(14):1-110.

Dodd, C.K., Jr., and R. Byles. 2003. Post-nesting movements and behavior of loggerhead sea turtles (*Caretta caretta*) departing from east-central Florida nesting beaches. Chelonian Conservation and Biology 4(3):530-536.

Dodd, K.T., T.G. Mundie, M.S. Lagutchik, and J.R. Morris. 1997. Cardiopulmonary effects of high-impulse noise exposure. Journal of Trauma 43(4):656-666.

Dohl, T.P., R.C. Guess, M.L. Duman, and R.C. Helm. 1983. Cetaceans of central and northern California, 1980-1983: Status, abundance, and distribution. Prepared for the U.S. Minerals Management Service. Santa Cruz, California: Center for Marine Studies, University of California Santa Cruz.

Doksæter, L., O. Rune Godo, N. Olav Handegard, P.H. Kvadsheim, F.A. Lam, C. Donovan, and P.J.O. Miller. 2009. Behavioral responses of herring (*Clupea harengus*) to 1–2 and 6–7 kHz sonar signals and killer whale feeding sounds. Journal of the Acoustical Society of America 125(1):554-564.

Dolar, M.L.L.. 2009. Frasier's dolphin (*Lagenodelphis hosei*). Pages 469-471 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd Edition. San Diego, California: Academic Press.

Dolar, M.L.L., W.A. Walker, G.L. Kooyman, and W.F. Perrin. 2003. Comparative feeding ecology of spinner dolphins (*Stenella longirostris*) and Fraser's dolphins (*Lagenodelphis hosei*) in the Sulu Sea. Marine Mammal Science 19(1):1-19.

Dolman, S.J., P.G.H. Evans, G. Notarbartolo-di-Sciara, and H. Frisch. 2010. Active sonar, beaked whales and European regional policy. Marine Pollution Bulletin. <http://dx.doi.org/10.1016/j.marpolbul.2010.03.034>.

Dolphin, W.F. 1987. Dive behavior and estimated energy expenditure of foraging humpback whales in southeast Alaska. Canadian Journal of Zoology 65(2):354-362.

DoN (U.S. Department of the Navy). 1996. Notice of Intent to prepare environmental impact statements for employment of Surveillance Towed Array Sonar System (SURTASS) Low Frequency Active (LFA) sonar. Department of the Navy, Department of Defense. Federal Register 61(139):37452-37453.

DoN (U.S. Department of the Navy). 2001. Final overseas environmental impact statement and environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Washington, D.C.: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2002. Record of decision for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Department of the Navy, Department of Defense. Federal Register 67(141):48145-48154.

DoN (U.S. Department of the Navy). 2005a. Draft supplemental environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Washington, D.C.: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2005b. Marine resource assessment for the Northeast operating areas: Atlantic City, Narragansett Bay, and Boston. Contract number N62470-02-D-9997, CTO 0018. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic.

DoN (U.S. Department of the Navy). 2006a. Application for letters of authorization under Section 101 (a)(5)(A) of the Marine Mammal Protection Act for activities associated with the employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Washington, D.C.: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2006b. Biological assessment for employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Washington, D.C.: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2007a. Final supplemental environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Washington, D.C: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2007b. Record of Decision for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Department of the Navy, Department of Defense. Federal Register 72(163):48269.

DoN (U.S. Department of the Navy). 2007c Final comprehensive report for the operation of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar onboard the R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23) under the National Marine Fisheries Service Regulations 50 CFR Subpart Q. Washington, D.C: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2007d. Marine resource assessment for the Charleston/Jacksonville operating areas. Contract number N62470-02-D-9997. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic.

DoN (U.S. Department of the Navy). 2007f. Annual report No. 5: Operation of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar onboard the R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23) under the National Marine Fisheries Service Letters of Authorization of 12 August 2006. Washington, D.C: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2008. Annual report No. 1: Operation of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar onboard the R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23) under the National Marine Fisheries Service Letters of Authorization of 16 August 2007. Washington, D.C: Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2008b Final Hawaii range complex environmental impact statement/overseas environmental impact statement. Kauai, Hawaii: U.S. Pacific Fleet, Department of the Navy.

DoN (U.S. Department of the Navy). 2009a. Notice of Intent to Prepare a Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement for Employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Department of the Navy, Department of Defense. Federal Register 74(12):3574-3575.

DoN (U.S. Department of the Navy). 2009b. Annual report No. 2: Operation of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar Onboard the USNS ABLE (T-AGOS 20) and USNS IMPECCABLE (T-AGOS 23) under the National Marine Fisheries Service Letters of Authorization of 15 August 2007. Washington, D.C: U.S. Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2010. Annual report No. 3: Operation of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar Onboard the USNS ABLE (T-AGOS 20) and USNS IMPECCABLE (T-AGOS 23) under the National Marine Fisheries Service Letters of Authorization of 13 August 2009. Washington, D.C: U.S. Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2011. Final comprehensive report for the operation of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar onboard the R/V *Cory Chouest*, USNS ABLE (T-AGOS 20), USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23) under the National Marine Fisheries Service Regulations 50 CFR Subpart Q. Washington, D.C: U.S. Department of the Navy, Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2011a. Application for Letters of Authorization and rulemaking under Section 101 (A)(5)(A) of the Marine Mammal Protection Act for activities associated with the employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Washington, D.C: U.S. Department of the Navy, Chief of Naval Operations.

Donahue, M.A., and W.L. Perryman. 2009. Pygmy killer whale (*Feresa attenuata*). Pages 938-939 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Doney, S.C., W.M. Balch, V.J. Fabry, and R.A. Feely. 2009. Ocean acidification: A critical emerging problem for the ocean sciences. Oceanography 22:16-25.

Dooling, R.J., and M.L. Dent. 2001. New studies on hair cell regeneration in birds. Acoustical Science and Technology 22(2):93-100.

Dorsey, E.M., S.J. Stern, A.R. Hoelzel, and J. Jacobsen. 1990. Minke whales (*Balaenoptera acutorostrata*) from the west coast of North America: Individual recognition and small-scale site fidelity. Special Report of the International Whaling Commission Special Issue 12:357-368.

Dunn, D.E., R.R. Davis, C.J. Merry and J.R. Franks. 1991. Hearing loss in the chinchilla from impact and continuous noise exposure. Journal of the Acoustical Society of America 90(4):1979-1985.

Dziedzic, A., and V. de Buffrenil. 1989. Acoustic signals of the Commerson's dolphin, *Cephalorhynchus commersonii*, in the Kerguelen Islands. Journal of Mammalogy 70(2):449-452.

Eckert, S.A. 1998. Perspectives on the use of satellite telemetry and other electronic technologies for the study of marine turtles, with references to the first year long tracking of leatherback sea turtles. In S.P. Epperly, and J. Braun, eds. Proceedings of the Seventeenth Annual Sea Turtle Symposium, 4-8 March 1997, Orlando, Florida. NOAA technical memorandum NMFS-SEFSC 415. Miami, Florida: National Marine Fisheries Service, Southeast Fisheries Science Center.

Eckert, S.A. 1999. Habitats and migratory pathways of the Pacific leatherback sea turtle. Final Report to the National Marine Fisheries Service, Office of Protected Resources. San Diego, California: Hubbs Sea World Research Institute.

Eckert, S.A., H.C. Liew, K.L. Eckert, and E.H. Chan. 1996. Shallow water diving by leatherback turtles in the South China Sea. Chelonian Conservation and Biology 2(2):237-243.

Edds, P.L. 1982. Vocalizations of the blue whale, *Balaenoptera musculus*, in the St. Lawrence River. Journal of Mammalogy 63(2):345–347.

Edds, P.L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence Estuary. Bioacoustics 1(2):131-149.

Edds, P.L., D.K. Odell, and B.R Tershy. 1993. Vocalizations of a captive juvenile and free-ranging adult-calf pairs of Bryde's whales, *Balaenoptera edeni*. Marine Mammal Science 9(3):269-284.

Edds-Walton, P.L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics 8(1):47-60.

Edds-Walton, P.L. 2000. Vocalizations of minke whales *Balaenoptera acutorostrata* in the St. Lawrence Estuary. Bioacoustics 11(1):31-50.

Eguchi, T., and J.T. Harvey. 2005. Diving behavior of the Pacific harbor seal (*Phoca vitulina richardii*) in Monterey Bay, California. Marine Mammal Science 21(2):283-295.

Eguchi, T., T. Gerrodette, R.L. Pitman, J.A. Seminoff, P.H. Dutton. 2007. At-sea density and abundance estimates of the olive ridley turtle *Lepidochelys olivacea* in the eastern tropical Pacific. Endangered Species Research 3:191-203.

Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: Geographic distribution, abundance, and population status. Pages 157-174 in A.B. Bolten, and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Ellison, W.T., C.W. Clark, and G.C. Bishop. 1987. Potential use of surface reverberation by bowhead whales, Balaena mysticetus, in under-ice navigation: Preliminary considerations. Report of the International Whaling Commission 37:329–332.

Ellison, W., B. Southall, C. Clark, and A. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology 26(1):21-26.

Engås, A., and S. Løkkeborg. 2002. Effects of seismic shooting and vessel-generated noise, on fish behaviour and catch rates. Bioacoustics 12(2):313-315.

Engås, A., S. Løkkeborg, E. Ona, and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock)(*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Sciences 53(10):2238-2249.

Enger, P.S. 1981. Frequency discrimination in teleosts—central or peripheral? In W.N. Tavolga, A.N. Popper, and R.R. Fay, eds. Hearing and sound communication in fishes. Proceedings in life sciences. New York, New York: Springer-Verlag.

Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Evans, P.G.H. 1987. The natural history of whales and dolphins. New York, New York: Facts on File, Inc.

Evans, P.G.H., and J.A. Raga. 2001. Marine mammals: Biology and conservation. New York, New York: Kluwer Academic/Plenum Publishers.

Evans, W.E. 1971. Orientation behavior of delphinids: radio telemetric studies. Annals of the New York Academy of Science 188:142-160.

Evans, W.E. 1973. Echolocation by marine delphinids and one species of fresh-water dolphin. Journal of the Acoustical Society of America 54(1):191-199.

Evans, W.E. 1994. Common dolphin, white-bellied porpoise *Delphinus delphis* Linnaeus, 1758. Pages 191-224 in .H. Ridgeway and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. New York, New York: Academic Press.

Evans, W.E., and F.T. Awbrey. 1984. High frequency pulses of Commerson's dolphin and Dall's porpoise. American Zoologist 24(3):2A.

Fahlman, A., S.K. Hooker, A. Olszowka, B.L. Bostrom, and D.R. Jones. 2009. Estimating the effect of lung collapse and pulmonary shunt on gas exchange during breath-hold diving: The Scholander and Kooyman legacy. Respiratory Physiology & Neurobiology 165(1):28-39.

FAO (Food and Agriculture Organization). 2003. Fishery and aquaculture country profiles: Philippines. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_PH/en>.

FAO (Food and Agriculture Organization). 2004. Fishery and aquaculture country profiles: Chile. National aquaculture sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_CL/es>.

FAO (Food and Agriculture Organization). 2004a. Fishery and aquaculture country profiles: India. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_IN/en>.

FAO (Food and Agriculture Organization). 2005. Fishery and aquaculture country profiles: United States of America. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. < http://www.fao.org/fishery/countrysector/FI-CP_US/en>.

FAO (Food and Agriculture Organization). 2006. Fishery and aquaculture country profiles: Indonesia. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_ID/en>.

FAO (Food and Agriculture Organization). 2007a. The state of world fisheries and aquaculture—2006. Fisheries and Aquaculture Department, FAO of the United Nations, Rome, Italy. 180 pages. Accessed 2009 and March 2011. <ftp://ftp.fao.org/docrep/fao/009/a0699e/a0699e.pdf>.

FAO (Food and Agriculture Organization). 2007b. Fishery and aquaculture country profiles: Russian Federation. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_RU/en>.

FAO (Food and Agriculture Organization). 2008. FAO yearbook; Fishery and aquaculture statistics—2006. Fisheries and Aquaculture Information and Statistics Service, Food and Agriculture Organization of the United Nations, Rome, Italy. 57 pages. Accessed 2009 and March 2011. <ftp://ftp.fao.org/docrep/fao/011/i0400t/i0400t.pdf>.

FAO (Food and Agriculture Organization). 2009a. Fishery and aquaculture country profiles: Japan. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_JP/en>.

FAO (Food and Agriculture Organization). 2009b. Fishery and aquaculture country profiles: Thailand. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_TH/en>.

FAO (Food and Agriculture Organization). 2010. Fishery and aquaculture country profiles: Peru. National fisheries sector overview. Fisheries and Aquaculture Department, FAO of the United Nations. Accessed 2009 and March 2011. <http://www.fao.org/fishery/countrysector/FI-CP_PE/en>.

Farrell, R. 2003. Dance with the one that brought you: Revitalizing antisubmarine warfare to counter Chinese diesel submarines. Ft. Belvoir, Virginia: Defense Technical Information Center.

FAS (Federation of American Scientists). 1998. P-3 Orion overview. Accessed 2010. <http://www.fas.org/programs/ssp/man/uswpns/air/asw/p3.html#top>.

Fay, R.R. 1969. Behavioral audiogram for the goldfish. Journal of Audiological Research 9:112-121.

Fay, R.R. 1974. Masking of tones by noise for the goldfish (*Carassius auratus*). Journal of Comparative and Physiological Psychology 87(4):708-716.

Fay, R.R. 1988a. Hearing in vertebrates: A psychophysics databook. Winnetka, Illinois: Hill-Fay Associates.

Fay, R.R. 1988b Tone-on-tone masking in the goldfish: The effects of signal phase for signal and masker at 500 Hz. Journal of the Acoustical Society of America 84(S1):S78-S78.

Fay, R.R., and A. Megela-Simmons. 1999. The sense of hearing in fish and amphibians. Pages 269-318 in R.R. Fay and A.N. Popper, eds. Comparative hearing: Fish and amphibians. Springer handbook of auditory research. New York, New York: Springer-Verlag.

Fedoseev, G.A 2000. Population biology of ice-associated forms of seals and their roles in the Northern Pacific ecosystems. Center for Russian Environmental Policy, Moscow, Russia.

Fedoseev, G.A. 2009. Ribbon seal. Pages 955-958 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Fernández, A. 2006. Beaked whale (*Ziphius cavirostris*) mass stranding on Almería's coasts in southern Spain, 26–27 January 2006. Report of the University of Las Palmas de Gran Canaria, Canary Islands.

Fernández, A., J.F. Edwards, F. Rodriguez, A.E. de los Monteros, P. Herraez, P. Castro, J.R. Jaber, V. Martin, and M. Arbelo. 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. Veterinary Pathology 42(4):446-457.

Fernández-Juricic, E., C. Campagna, V. Enriquez, and C.L. Ortiz. 1999. Vocal communication and individual variation in breeding South American sea lions. Behaviour 136(4):495–517.

Fertl, D., A.J. Schiro, G.T. Regan, C.A. Beck, N. Adimey, L. Price-May, A. Amos, G.A.J. Worthy, and R. Crossland. 2005. Manatee occurrence in the Northern Gulf of Mexico, west of Florida. Gulf and Caribbean Research 17:69-94.

Ferraroli, S., J.Y. Georges, P. Gaspar, and Y. Le Maho. 2004. Where leatherback turtles meet fisheries. Nature 429:521-522.

FHWG (Fisheries Hydroacoustics Working Group). 2008. Agreement in principle for interim citeria for injury to fish from pile driving activities. Technical/Policy Meeting June 11, 2008, Vancouver, Washington. <http://www.wsdot.wa.gov/NR/rdonlyres/4019ED62-B403-489C-AF05-5F4713D663C9/0/InterimCriteria Agreement.pdf>.

Filadelfo, R., J. Mintz, E. Michlovich, A. D'Amico, P.L. Tyack, and D.R. Ketten. 2009. Correlating military sonar use with beaked whale mass strandings: What do the historical data show? Aquatic Mammals 35(4):435-444.

Finneran, J.J. 2003. Whole-lung resonance in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). The Journal of the Acoustical Society of America 114(1):529-535.

Finneran, J.J. 2008. Modified variance ratio for objective detection of transient evoked potentials in bottlenose dolphins (*Tursiops truncatus*). The Journal of the Acoustical Society of America 124(6):4069-4082.

Finneran, J.J. 2009. Evoked response study tool: A portable, rugged system for single and multiple auditory evoked potential measurements. The Journal of the Acoustical Society of America 126(1):491-500.

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, and S.H. Ridgway. 2000. Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. The Journal of the Acoustical Society of America 108(1):417-431.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111(6):2929-2940.

Finneran, J.J., R. Dear, D.A. Carder, and S.H. Ridgway. 2003. Auditory and behavioral responses of California sea lions (*Zalophus californianus*) to single underwater impulses from an arc-gap transducer. Journal of the Acoustical Society of America 114(3):1667-1677.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. The Journal of the Acoustical Society of America 118(4):2696-2705.

Finneran, J.J., C.E. Schlundt, B. Branstetter, and R.L. Dear. 2007. Assessing temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) using multiple simultaneous auditory evoked potentials. The Journal of the Acoustical Society of America 122(2):1249-1264.

Finneran, J.J., D.S. Houser, B. Mase-Guthrie, R.Y. Ewing, and R.G. Lingenfelser. 2009. Auditory evoked potentials in a stranded Gervais' beaked whale (*Mesoplodon europaeus*). Journal of the Acoustical Society of America 126(1):484-490.

Finneran, J.F., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010. Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. Journal of the Acoustical Society of America 127(5):3256-3266.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010a. Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. Journal of Acoustical Society of America 127(5):3267-3272.

Fish, F.E., and C.A. Hui. 1991. Dolphin swimming—A review. Mammal Review 21(4)**:**181-195.

Fish, F.E., A.J. Nicastro, and D. Weihs. 2006. Dynamics of the aerial maneuvers of spinner dolphins. Journal of Experimental Biology 209(4):590-598.

Fish, J.F., and C.W. Turl. 1976. Acoustic source levels of four species of small whales. Naval Undersea Center Report. San Diego, California: U.S. Naval Undersea Center.

Fitch, J.E., and R.L. Brownell. 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. Journal of the Fisheries Research Board of Canada 25(12):2561–2574.

Fletcher, E.R., J.T. Yelverton, and D.R. Richmond. 1976. The thoraco-abdominal system's response to underwater blast. Final Technical Report. Albuquerque, New Mexico: Lovelace Foundation for Medical Education and Research.

Fletcher, H. 1929. Speech and hearing. New York, New York: Van Nostrand.

Fletcher, J.L., and R.G. Busnel. 1978. Effects of noise on wildlife. New York, New York: Academic Press.

Fletcher, S., B.J. Le Boeuf, D.P. Costa, P.L. Tyack, and S.B. Blackwell. 1996. Onboard acoustic recording from diving northern elephant seals. Journal of the Acoustical Society of America 100(4):2531-2539.

Folkow, L.P., E.S. Nordoy, and A.S. Blix. 2004. Distribution and diving behaviour of harp seals (*Pagophilus groenlandicus*) from the Greenland Sea stock. Polar Biology 27**:**281-298.

Ford, J.K.B. 1989. Acoustic behaviour of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. Canadian Journal of Zoology 67(3):727-745.

Ford, J.K.B. 2009. Killer whale (*Orcinus orca*). Pages 650-657 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Ford, J.K.B., and H.D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Report of the International Whaling Commission 32:671-679.

Francis, J., D. Boness, and H. Ochoa-Acuna. 1998. A protracted foraging and attendance cycle in female Juan Fernandez fur seals. Marine Mammal Science 14(3):552-574.

Frankel, A.S. 2009. Sound production. Pages 1056-1071 in W. F. Perrin, B. Würsig and J. G. M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Frankel, A.S., J. Mobley, and L. Herman. 1995. Estimation of auditory response thresholds in humpback whales using biologically meaningful sounds. Pages 55–70 in R.A. Kastelein, J.A. Thomas, and P.E. Nachtigall, eds. Sensory systems of aquatic mammals. Woerden, Netherlands: De Spil Publication.

Frantzis, A., J.C. Goold, E.K. Skarsoulis, M.I. Taroudakis, and V. Kandia. 2002. Clicks from Cuvier’s beaked whales, *Ziphius cavirostris* (L). Journal of the Acoustical Society of America 112(1):34-37.

Friedman, N. 2007a. Sonar technology review. Military Technology 31(5):59.

Friedman, N. 2007b. Indian Navy growing. U.S. Naval Institute, Proceedings 133/10/1,256:90-91.

Friedman, N. 2007c. Back in the surveillance game. U.S. Naval Institute, Proceedings 133/1/1, 247:90-91.

Fristrup, K.M., L.T. Hatch, and C.W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. The Journal of the Acoustical Society of America 113(6):3411-3424.

Fujieda, S., Y. Matsuno, and Y. Yamanaka. 1996. The auditory threshold of the bastard halibut (*Paralichthys olivaceus*). Nippon Suisan Gakkaishi 62(2):201-204.

Fujino, K. 1960. Immunogenetic and marking approaches to identifying subpopulations of the North Pacific whales. Scientific Reports of the Whales Research Institute 15:85-142.

Funnel, C. 2009. Jane's underwater warfare systems 2009-2010, 21st edition. Alexandria, Virginia: Janes Information Group.

Gabriele, C., and A.S. Frankel. 2002. The occurrence and significance of humpback whale songs in Glacier Bay, southeastern Alaska. Arctic Research of the United States 16:42-47.

Gabriele, C.M., J.M. Straley, L.M. Herman, and R.J. Coleman. 1996. Fastest documented migration of a North Pacific humpback whale. Marine Mammal Science 12(3):457-464.

Gagnon, C. 2004. NORLANT 04 Experiment status report. Presentation given in September 2004. Department of the Navy, Integrated Undersea Surveillance Systems. 11 pages.

Gagnon, C. 2005. IUSS marine mammal observations in support of NORLANT-05 S2087 acceptance trials in the northwest approaches to the UK, July 2005. Department of the Navy, Integrated Undersea Surveillance Systems. 14 pages.

Gagnon, C. 2006. Marine mammal observations in support of NORLANT 06-01 S2087 operations in the northwest approaches to the UK, February 2006. Department of the Navy, Integrated Undersea Surveillance Systems. 14 pages.

Gagnon, C. 2006a. Marine mammal observations in support of NORLANT 06-02 S2087 operations in the northwest approaches to the UK, September 2006. Department of the Navy, Integrated Undersea Surveillance Systems. 14 pages.

Gagnon, C. 2007. IUSS Marine mammal observations NORLANT 07. Department of the Navy, Integrated Undersea Surveillance Systems. 23 pages.

Gales, N.J. 2009. New Zealand sea lion (*Phocarctos hookeri*). Pages 763-765 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Gallo-Reynoso, J.P. 1994. Factors affecting the population status of Guadalupe fur seal, *Arctocephalus townsendi* (Merriam, 1897), at Isla de Guadalupe, Baja California, Mexico. Ph.D. dissertation, University of California, Santa Cruz.

Gambell, R. 1985. Sei whale (*Balaenoptera borealis*) Lesson, 1828. Pages 155-170 in S.H. Ridgeway and R. Harrison, eds. Handbook of marine mammals, Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Gaskin, D.E. 1992. Status of the harbour porpoise, *Phocoena phocoena*. Canadian Field-Naturalist 106(1):36–54.

Gaskin, D.E., P.W. Arnold, and B.A. Blair. 1974. *Phocoena phocoena*. Mammalian Species 42:1-8.

Gaspin, J.B. 1975. Experimental investigations of the effects of underwater explosions on swimbladder fish, I. 1973 Chesapeake Bay tests. Final Report. Silver Spring, Marland: Naval Surface Weapons Center, White Oak Laboratory.

Gausland, I. 2003. Seismic survey impact on fish and fisheries. Report for Norwegian Oil Industry Association (OLF). Stavinger Report.

Gazo, M., and A. Aguilar. 2005. Maternal attendance and diving behavior of a lactating Mediterranean monk seal. Marine Mammal Science 21(2):340-345.

Gedamke, J., D.P. Costa, and A. Dunstan. 2001. Localization and visual verification of a complex minke whale vocalization. Journal of the Acoustical Society of America 109(6):3038-3047.

Gentry, R.L. 1998. Behavior and ecology of the northern fur seal. Princeton, New Jersey: Princeton University Press.

Gentry, R.L. 2009. Northern fur seal (*Callorhinus ursinus*). Pages 788-791 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Gentry, R.L. 2009a. Eared seals. Pages 339-348 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition San Diego, California: Academic Press.

George, J.C., C. Clark, G.M. Carroll, and W.T. Ellison. 1989. Observations on the ice-breaking and ice navigation behavior of migrating bowhead whales (*Balaena mysticetus*) near Point Barrow, Alaska, spring 1985. Arctic 42(1):24-30.

Geraci, J.R., and V.J. Lounsbury. 2005. Marine mammals ashore: A field guide for strandings. 2nd edition Baltimore, Maryland: National Aquarium in Baltimore.

Gerstein, E.R., L. Gerstein, S.E. Forsythe, and J.E. Blue. 1999. The underwater audiogram of the West Indian manatee (*Trichechus manatus*). Journal of the Acoustical Society of America 105(6):3575-3583.

Gewalt, W. 1990. The Jacobita, or Commerson's dolphin (*Cephalorhynchus commersoni*). Aquatic Mammals 16.2:53-64.

Giles, J.C. 2005. The underwater acoustic repertoire of the long-necked, freshwater turtle *Chelodina oblonga*. Ph.D. dissertation, Murdoch University, Perth, Australia.

Giles, J.C, J.A. Davis, R.D. McCauley, and G. Kuchling. 2009. Voice of the turtle: The underwater acoustic repertoire of the long-necked freshwater turtle, *Chelodina oblonga*. Journal of the Acoustical Society of America 126: 434-443.

Gilles, A., H. Herr, K. Lehnert, M. Scheidat, and U. Siebert. 2008. Harbour porpoises abundance estiamtes and seasonal distribution patterns. Pages 19-36 in Marine mammals and seabirds in front of offshore wind energy. Wiesbaden: BG Teuber Verlag/GWV Fachverlage GmbH.

Gilmartin, W.G., and J. Forcada. 2009. Monk seals *Monachus monachus, M. tropicalis,* and *M. schauinslandi*. Pages 741-744 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

GMFMC (Gulf of Mexico Fishery Management Council). 2009. Gulf of Mexico fishery management council. Accessed September 2009. <http://www.gulfcouncil.org/>.

Godley, B.J., S. Richardson, A.C. Broderick, M.S. Coyne, F. Glen, and G.C. Hays. 2002. Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. Ecography 25(3):352-362.

Goebel, M.E. 1998. Female foraging behavior: Inter-and intraannual variation in individuals. Pages 243-259 in R.L. Gentry, ed. Behaviour and ecology of the northern fur seal. Princeton, New Jersey: Princeton University Press.

Goldstein, L., and B. Murray. 2003. China's subs lead the way. U.S. Naval Institute, Proceedings 129/3/1,201:58-61.

Goodall, R.N.P. 1994a. Commerson's dolphin *Cephalorhynchus commersonii* (Lacepede, 1804). Pages 241-267 in S.H. Ridgeway and R. Harrison, eds. Handbook of marine mammals*,* Volume 5: The first book of dolphins. New York, New York: Academic Press.

Goodall, R.N.P. 1994b. Chilean dolphin *Cephalorhynchus eutropia* (Gray, 1846). Pages 269-287 in S.H. Ridgeway and R. Harrison, eds. Handbook of marine mammals*,* Volume 5: The first book of dolphins. New York, New York: Academic Press.

Goodall, R.N.P. 2009. Peale's dolphin (*Lagenorhunchus australis*). Pages 844-847 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Goodall, R.N.P. 2009a. Hourglass dolphin (*Lagenorhunchus cruciger*). Pages 573-576 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Goodall, R.N.P. 2009b. Spectacled porpoise (*Phocoena dioptrica*). Pages 1087-1091 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Goodall, R.N.P, A.R. Galeazzi, S. Leatherwood, K.W. Miller, I.S. Cameron, R.K. Kastelein, and A.P. Sobral. 1988. Studies of Commerson's dolphins, *Cephalorhynchus commersonii*, off Tierra del Fuego, 1976-1984, with a review of information on the species in the South Atlantic. Report of the International Whaling Commission 9:3-70.

Goold, J.C., and S.E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98(3):1279-1291.

Gordon, J.D.C., D. Gillespie, L.E. Rendell, and R. Leaper. 1996. Draft report on the playback of ATOC like sounds to sperm whales *(Physeter macrocephalus)* off the Azores. Unpublished manuscript submitted to the ATOC Marine Mammal Research Program Bioacoustics Research Program. Ithaca, New York: Laboratory of Ornithology, Cornell University.

Gordon, J.D.C., J.N. Matthews, S. Panigada, A. Gannier, J.F. Borsani, and G.N. Di Sciara. 2000. Distribution and relative abundance of striped dolphins, and distribution of sperm whales in the Ligurian Sea cetacean sanctuary: Results from a collaboration using acoustic monitoring techniques. Journal of Cetacean Research and Management 2(1):27-36.

Gore, M.A., D. Rowat, J. Hall, F.R. Gell, and R.F. Ormond. 2008. Transatlantic migration and deep mid-ocean diving by basking shark. Biology Letters 4(4):395-398.

Götz, T., R. Antunes, S. Heinrich. 2010. Echolocation clicks of free-ranging Chilean dolphins (*Cephalorhynchus eutropia*) (L). Journal of the Acoustical Society of America 128(2)**:** 563-566.

Gowans, S. 2009. Bottlenose whales *Hyperoodon ampullatus* and *H. planifrons*.Pages 129-131 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Hall, A., and D. Thompson. 2009. Gray seal (*Halichoerus grypus*). Pages 500-503 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Hall, J.D., and C.S. Johnson. 1972. Auditory thresholds of a killer whale *Orcinus orca* Linnaeus. Journal of the Acoustical Society of America 51(2):515-517.

Halvorsen, M.B., L.E. Wysocki, and A.N. Popper. 2006. Effects of high-intensity sonar on fish. Journal of the Acoustical Society of America 119: 3283.

Halvorsen, M.B., D.G. Zeddies, W.T. Ellison, D.R. Chicoine, and A.N. Popper. 2012. Effects of mid-frequency active sonar on hearing in fish. Journal of the Acoustical Society of America 131(1):599-607.

Hamernik, R.P., W.A. Ahroon, K.D. Hsueh, S.F. Lei and R.I. Davis. 1993. Audiometric and histological differences between the effects of continuous and impulsive noise exposures. Journal of the Acoustical Society of America 93(4):2088-2095.

Hamilton, P.K., G.S. Stone, and S.M. Martin. 1997. Note on a deep humpback whale *Megaptera novaeangliae* dive near Bermuda. Bulletin of Marine Science 61(2):491-494.

Hammond, P.S., P. Berggren, H. Benke, D.L. Borchers, A. Collet, M.P. Heide-Jørgensen, S. Heimlich, A.R. Hiby, M.F. Leopold and N. Øien. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology 39**:**361-376.

Hanggi, E.B., and R.J. Schusterman. 1994. Underwater acoustic displays and individual variation in male harbour seals, *Phoca vitulina*. Animal Behaviour 48:1275-1283.

Hamann, M., C.J. Limpus, and D.W. Owens. 2003. Reproductive cycles of males and females. Pages 135-161 in P.L. Lutz, J.A. Musick, and J. Wyneken, eds. The biology of sea turtles, Volume II. Boca Raton, Florida: CRC Press.

Hansen, D.J., and Hubbard, J.D. 1999. Distribution of Cook Inlet beluga whales (*Delphinapterus leucas*) in winter. U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region. Final Report, OCS Study MMS 99-0026. 72 pages.

Hanson, M.B., R.W. Baird, and R.L. DeLong. 1998. Short-term movements and dive behavior of tagged Dall's porpoise in Haro Strait, Washington. Pages 59-60 in Abstracts, World Marine Mammal Science Conference, Monaco, 22-24 January 1998.

Harris, D.E., B. Lelli, and G. Jakush. 2002. Harp seal records from the southern Gulf of Maine: 1997-2001. Northeastern Naturalist 9(3)**:**331-340.

Hassel, A., T. Knutsen, J. Dalen, K. Skaar, S. Lokkeborg, O.A. Misund, O. Ostensen, M. Fonn, and E.K. Haugland. 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). ICES Journal of Marine Science 61(7):1165-1173.

Hastings, M.C. 2008. Coming to terms with the effects of ocean noise on marine animals. Acoustics Today 4(2):22-34.

Hastings, M.C., A.N. Popper, J.J. Finneran, and P.J. Lanford. 1996. Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish (*Astronotus ocellatus*). Journal of Acoustical Society of America 99(3):1759-1766.

Hastings, M.C., C.A. Reid, C.C. Grebe, R.L. Hearn, and J.G. Colman. 2008. The effects of seismic airgun noise on the hearing sensitivity of tropical reef fishes at Scott Reef, Western Australia. Proceedings of the Institute of Acoustics 30(Part 5).

Hatakeyama, Y., and H. Soeda. 1990. Studies on echolocation of porpoises taken in salmon gillnet fisheries. Pages 269–28 in J.A. Thomas and R.A. Kastelein, eds. Sensory abilities of cetaceans: Laboratory and field evidence. New York, New York: Plenum Press.

Hatakeyama, Y., K. Ishii, T. Akamatsu, H. Soeda, T. Shimamura, and T. Kojima. 1994. A review of studies on attempts to reduce the entanglement of the Dall's porpoise, *Phocoenoides dalli*, in the Japanese salmon gillnet fishery. Report of the International Whaling Commission 15:549-563.

Hatch L, C. Clark, R. Merrick, S. Van Parijs, D. Ponirakis, K. Schwehr, M. Thompson, D. Wiley. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management 42:735-752.

Hawkes, L.A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, and B.J. Godley. 2007. Only some like it hot--Quantifying the environmental niche of the loggerhead sea turtle. Diversity and Distributions 13**:** 447-457.

Hays, G.C., S. Hochscheid, A.C. Broderick, B.J. Godley, and J.D. Metcalfe. 2000. Diving behaviour of green turtles: Dive depth, dive duration and activity levels. Marine Ecology Progress Series 208**:** 297-298.

Hays, G.C., J.D.R. Houghton, and A.E. Myers. 2004. Pan-Atlantic leatherback turtle movements. Nature 429**:** 522.

Hays, G.C., V.J. Hobson, J.D. Metcalfe, D. Righton, and D.W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. Ecology 87:2647-2656.

Heath, C.B., and W.F. Perrin. 2009. California, Galapagos, and Japanese sea lions (*Zalophus californianus, Z. wollebaeki,* and *Z. japonicus*). Pages 170-176 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Heatwole, H. 1999. Sea snakes. Second edition Malabar, Florida: Krieger Publishing Company.

Heide-Jørgensen, M.P., K.L. Laidres, Ø. Wiig, M.V. Jensen, L. Dueck, L.D. Maiers, H.C. Schmidt, and R.C. Hobbs. 2003. From Greenland to Canada in ten days: Tracks of bowhead whales, *Balaena mysticetus*, across Baffin Bay. Arctic 58(1):21-31.

Heide-Jørgensen, M.P., K.L. Laidre, M.V. Jensen, L. Dueck, L.D. Postma. 2006. Dissolving stock discreteness with satellite tracking: bowhead whales in Baffin Bay. Marine Mammal Science 22(1):34-45.

Heimlich-Boarn, J.R., P.G.H. Evans, J.B. Reid, and S. Northridge. 1998. Cetaceans in northwest European waters: using diverse sightings to study ecological distribution and related abundance. Abstract in Proceedings of The World Marine Mammal Science Conference, Monaco, 22-24 January 1998.

Henderson, D. 2008. Creation of noise standards for man: 50 Years of research. Bioacoustics 17(1):10-12.

Herberholz, J., and B. Schmitz. 2001. Signaling via water currents in behavioral interactions of snapping shrimp (*Alpheus heterochaelis*). The Biological Bulletin 201(1):6-16.

Herzing, D.L. 1996. Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis* and bottlenose dolphins, *Tursiops truncatus*. Aquatic Mammals 22(2)**:**61-79.

Hester, K.C., E.T. Peltzer, W.J. Kirkwood, and P.G. Brewer. 2008. Unanticipated consequences of ocean acidification: A noisier ocean at lower pH. Geophysical Research Letters 35:L19601.

Heyning, J.E. 1989. Cuvier's beaked whale—*Ziphius cavirostris* (G. Cuvier, 1823). Pages 289-308 in S.H. Ridgway, and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. San Diego, California: Academic Press.

Heyning, J.E., and J.G. Mead. 2009. Cuvier's beaked whale (*Ziphius cavirostris*). Pages 294-295 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Heyning, J.E., and W.F. Perrin. 1994. Evidence for two species of common dolphins (genus *Delphinus*) from the eastern North Pacific. Contributions in Science 442:1-35.

Higgs, D.M., M.J. Souza, H.R. Wilkins, J.C. Presson, and A.N. Popper. 2002. Age- and size-related changes in the inner ear and hearing ability of the adult zebrafish (*Danio rerio*). Journal of the Association for Research in Otolaryngology 3(2):174-184.

Hildebrand, J.A. 2005. Impacts of anthropogenic sound. Pages 101-124 in J.E. Reynolds, W.F. Perrin, R.R. Reeves, S. Montgomery, and T.J. Ragen, eds. Marine mammal research: Conservation beyond crisis. Baltimore, Maryland: Johns Hopkins University Press.

Hill, R.D. 1985. Investigation of lightning strikes to water surfaces. Journal of the Acoustical Society of America 78(6):2096-2099.

Hill, R.J. 2005. Standardizing the auditory evoked potential technique: Ground-truthing against behavioral conditioning in the goldfish *Carassius auratus.* Ph.D. dissertation, University of South Florida. 175 pages.

Hindell, M.A., and W.F. Perrin. 2009. Elephant seals (*Mirounga angustirostris* and *M. leonina*). Pages 364-368 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Hobson, R.P., and A.R. Martin. 1996. Behaviour and dive times of Arnoux's beaked whales, *Berardius arnuxii*, at narrow leads in fast ice. Canadian Journal of Zoology 74(2):388-393.

Hochscheid, S., B.J. Godley, A.C. Broderick, and R.P. Wilson. 1999. Reptilian diving: Highly variable dive patterns in the green turtle *Chelonia mydas*. Marine Ecology Progress Series 185**:**101-112.

Hochscheid, S., F. Bentivegna, and G.C. Hays. 2005. First records of dive durations for a hibernating sea turtle. Biology Letters 1**:** 82-86.

Hofman, R.J. 2003. Marine sound pollution: Does it merit concern? Marine Technology Society Journal 37(4):66-77.

Holt, M.M., D.P. Noren, V. Veirs, C.K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. Journal of Acoustical Society of America 125(1):EL27-EL32.

Hooker, S.K., and R.W. Baird. 1999. Deep-diving behaviour of the northern bottlenose whale, *Hyperoodon ampullatus* (Cetacea: Ziphiidae). Proceedings of the Royal Society B: Biological Sciences 266(1420):671-676.

Hooker, S.K., and H. Whitehead. 1998. Echolocation of northern bottlenose whales—an analysis of click characteristics and their implications for foraging. Abstracts of World Marine Mammal Science Conference, Monaco, 20-24 January 1998.

Hooker, S.K., H. Whitehead, and S. Gowans. 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. Conservation Biology 13(3):592-602.

Hooker, S.K., R.W. Baird, and A. Fahlman. 2009. Could beaked whales get the bends? Effect of diving behaviour and physiology on modelled gas exchange for three species: *Ziphius cavirostris, Mesoplodon densirostris* and *Hyperoodon ampullatus*. Respiratory Physiology & Neurobiology 167(3):235-246.

Horwood, J. 2009. Sei whale (*Balaenoptera borealis*). Pages 1001-1003 in W.F. Perrin, B.G. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Houser, D.S. 2007. Assessing the potential for nitrogen bubble formation in diving odontocetes. San Diego, California: Space and Naval Warfare Systems Center.

Houser, D.S., and J.J. Finneran. 2006. Variation in the hearing sensitivity of a dolphin population determined through the use of evoked potential audiometry. The Journal of the Acoustical Society of America 120(6):4090-4099.

Houser, D.S., and J.J. Finneran. 2006a. A comparison of underwater hearing sensitivity in bottlenose dolphins (*Tursiops truncatus)* determined by electrophysiological and behavioral methods. Journal of the Acoustical Society of America 120(3):1713-1722.

Houser, D.S., D.A. Helweg, and P.W. Moore. 1999. Classification of dolphin echolocation clicks by energy and frequency distributions. Journal of the Acoustical Society of America 106(3, Part I):1579-1585.

Houser, D.S., D.A. Helweg, and P.W.B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27(2):82-91.

Houser, D.S., A. Gomez-Rubio, and J.J. Finneran. 2008. Evoked potential audiometry of 13 Pacific bottlenose dolphins (*Tursiops truncatus gilli*). Marine Mammal Science 24(1):28-41.

Houston, J. 1991. Status of Cuvier's beaked whale, *Ziphius cavirostris*, in Canada. Canadian Field-Naturalist 105(2):215-218.

Hoyt, E. 2001. Whale watching 2001: Worldwide tourism numbers, expenditures, and expanding socioeconomic benefits. Crowborough, United Kingdom: International Fund for Animal Welfare.

Hoyt, E. 2005. Marine protected areas for whales, dolphins and porpoises. Sterling, Virginia: Earthscan.

Hoyt, E. 2011. Marine protected areas for whales, dolphins and porpoises. 2nd edition. New York, New York: Earthscan.

Hu, M.Y., H.Y. Yan, W-S. Chung, J-C. Shiao, P-P. Hwang. 2009. Acoustically evoked potentials in two cephalopods inferred using the auditory brainstem response (ABR) approach. Comparative Biochemistry and Physiology, Part A 153:278-283.

Hui, C.A. 1987. Power and speed of swimming dolphins. Journal of Mammalogy 68(1):126-132.

ICES (International Council for the Exploration of the Sea). 2005. Report of the ad-hoc group on the impacts of sonar on cetaceans and fish (AGISC). International Council for the Exploration of the Sea. Accessed: <http://www.ices.dk/advice/Request/EC/DG%20Env/sonar/agisc05.pdf>.

IFAW (International Fund for Animal Welfare). 2001. Report of the workshop on right whale acoustics: Practical applications in conservation. Technical Report. Yarmouth Port, Massachusetts: International Fund for Animal Welfare.

IFFO (International Fishmeal and Fish Oil Organisation). 2009. Fact sheet: The production of fishmeal and fish oil from Peruvian anchovy. IFFO Limited, Hertfordshire, United Kingdom. Accessed March 2011. <http://www.iffo.net/downloads/67.pdf>.

Ilyina, T., R.E. Zeebe, and P.G. Brewer. 2010. Future ocean increasingly transparent to low-frequency sound owing to carbon dioxide emissions. Nature Geoscience 3:18-22.

Indian Express. 2007. Lifting the veil of secrecy, China shows off new class of n-powered attack subs. Indian Express, 25 September 2007 edition. Accessed: <http://www.indianexpress.com/news/lifting-veil-of-secrecy-china-shows-off-new-class-of-npowered-attack-subs/221273/>.

Insley, S.J. 2000. Long-term vocal recognition in the northern fur seal. Nature 406(6794):404.

Iranian State Television. 2008. Iran launches submarine production line. Accessed: <http://www.myvideo.de/watch/4972279/25_08_08_Iran_launches_Submarine>.

Itano, D.G. 1999. Hawai`i offshore handline fishery: A seamount fishery for juvenile bigeye tuna. Paper presented at the 11th Meeting of the Secretariat of the Pacific Community's Standing Committee on Tuna and Billfish, 6 June 1999. <http://www2008.spc.int/DigitalLibrary/Doc/FAME/Meetings/ SCTB/11/WP44.pdf>.

IUCN (International Union for the Conservation of Nature and Natural Resources). 2010. IUCN red list of threatened sea turtle species. Version 2010.4. Accessed November 2010. <http://www.iucnredlist.org>.

Ivashchenko, Y., and P. Clapham. 2010. Bowhead whales *Balaena mysticetus* in the Okhotsk Sea. Mammal Review 40(1):65-89.

Iverson, R.T.B. 1967. Response to yellow fin tuna to underwater sound. Pages 105-121 in W.N. Tavolga, ed. Marine bioacoustics. Oxford, England: Pergamon Press.

IWC (International Whaling Commission). 2004. General principles for whalewatching. Accessed 2009 and March 2011. <http://iwcoffice.org/conservation/wwguidelines.htm#manage>.

IWC (International Whaling Commission). 2009. Population estimates. Accessed March 2010. <http:www.iwcoffice.org/conservation/estimate.htm>.

IWC (International Whaling Commission). 2009a. Revised management procedure. Accessed April 15, 2009. <http://www.iwcoffice.org/conservation/rmp.htm>.

IWC (International Whaling Commission). 2009b. Aboriginal subsistence whaling. Accessed April 15, 2009. <http://www.iwcoffice.org/conservation/aboriginal.htm>.

IWC (International Whaling Commission). 2012. Aboriginal subsistence whaling catches since 1985. Accessed April 2012. <http://www.iwcoffice.org/conservation/table_aboriginal.htm>.

IWC (International Whaling Commission). 2010. Status of whales. Accessed September 2010. <http://iwcoffice.org/conservation/status.htm>.

James, M.C., R.A. Myers, and C.A. Ottensmeyer. 2005. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society B 272:1547-1555.

James, M.C., J. Davenport, and G.C. Hays. 2006. Expanded thermal niche for a diving vertebrate: A leatherback turtle diving into near-freezing water. Journal of Experimental Marine Biology and Ecology 335:221-226.

Jaquet, N., S. Dawson, and L. Douglas. 2001. Vocal behavior of male sperm whales: Why do they click? Journal of the Acoustical Society of America 109(5), Part I: 2254-2259.

Jefferson, T.A. 2009. Clymene dolphin (*Stenella clymene*). Pages 241-243 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Jefferson, T.A. 2009a. Rough-toothed dolphin (*Steno bredanensis*). Pages 990-992 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Jefferson, T.A. 2009b. Dall's porpoise (*Phocoenoides dalli*). Pages 296-297 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Jefferson, T. A., and N. B. Barros. 1997. *Peponocephala electra*. Mammalian Species 553:1-6.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide: Marine mammals of the world. Rome, Italy: Food and Agriculture Organization of the United Nations.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world a comprehensive guide to their identification. San Diego, California: Elsevier.

Jensen, A. S, and G. K Silber. 2004. Large whale ship strike database. National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. Accessed 2009. <http://alaskafisheries.noaa.gov/protectedresources/whales/publications/lwssdata.pdf>.

Jepson, P.D., and R. Deaville. 2009. Investigation of the common dolphin mass stranding event in Cornwall, 9th June 2008. United Kingdom Cetacean Strandings Investigation Programme (CSIP). Contract Number CR0364. Accessed April 2010. <http://randd.defra.gov.uk/Document.aspx?Document=WC0601_8031_TRP.pdf>

Jepson, P.D., M. Arbelo, R. Deaville, I.a.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herráez, A.M. Pocknell, F. Rodríguez, F.E. Howie, A. Espinosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham, and A. Fernández. 2003. Gas-bubble lesions in stranded cetaceans. Nature 425:575-576.

Jepson, P.D., R. Deaville, I.A.P. Patterson, A.M. Pocknell, H.M. Ross, J.R. Baker, F.E. Howie, R.J. Reid, A. Colloff, and A.A. Cunningham. 2005. Acute and chronic gas bubble lesions in cetaceans stranded in the United Kingdom. Veterinary Pathology Online 42(3):291-305.

Jérémie, S., A. Gannier, S. Bourreau, and J.-C. Nicolas. 2006. Acoustic monitoring of cetaceans in territorial waters off La Martinique (FWI), Lesser Antilles: Global abundance and first description of *Kogia simus* vocalisations (November-December 2004). Page 91 in Abstracts, Twentieth annual conference of the European Cetacean Society, 2-7 April 2006, Gdynia, Poland.

JNCC. 2010. Offshore Special Area of Conservation: Dogger Bank, SAC Selection Assessment. Version 9.0 (26th August 2011). (pp. 32). Peterborough, Cambridgeshire, UK: Marine Protected Sites, Joint Nature Conservation Committee.

Jochens, A., D. Biggs, D. Engelhaupt, J. Gordon, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, J. Wormuth, and B. Würsig. 2006. Sperm whale seismic study in the Gulf of Mexico, Summary Report, 2002-2004. OCS Study MMS 2006-034. Minerals Management Service: New Orleans, Louisiana. 345 pages.

Jochens, A. D. Biggs, K. Benoit-Bird, D. Engelhardt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig. 2008. Sperm whale seismic study in the Gulf of Mexico: Synthesis report. OCS Study MMS 2008-006. Gulf of Mexico OCS Region, Minerals Management Service: New Orleans, Louisiana. 341 pages.

Johnson, C.S. 1967. Sound detection thresholds in marine mammals. Pages 247-255 in W.N. Tavolga, ed. Marine bioacoustics. New York, New York: Pergamon Press.

Johnson, C.S., M.W. McManus, and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. Journal of the Acoustical Society of America 85(6):2651-2654.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N.A. De Soto, and P.L. Tyack. 2004. Beaked whales echolocate on prey. Proceedings: Biological Sciences 271:383-386.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N.A. de Soto, and P.L. Tyack. 2006. Foraging Blainville's beaked whales (*Mesoplodon densirostris*) produce distinct click types matched to different phases of echolocation. Journal of Experimental Biology 209(24):5038-5050.

Johnston, D. W., Chapla, M. E., Williams, L. E., & Mattila, D. K. 2007. Identification of humpback whale Megaptera novaeangliae wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. *Endangered Species Research,* 3(3), 249-257.

Johnston, D.W., M. Mcdonald, J. Polovina, R. Domokos, S. Wiggins, and J. Hildebrand. 2008. Temporal patterns in the acoustic signals of beaked whales at Cross Seamount. Biology Letters 4:208-211.

Jones, G.J., and L.S. Sayigh. 2002. Geographic variation in rates of vocal production of free-ranging bottlenose dolphins. Marine Mammal Science 18(2):374-393.

Jones, M.L., and S.L. Swartz. 2009. Gray whale (*Eschrichtius robustus*). Pages 503-511 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Jørgensen, R., K.K. Olsen, I.B Falk-Petersen, and P. Kanapthippilai. 2005. Investigations of potential effects of low frequency sonar signals on survival, development and behaviour of fish larvae and juveniles. Tromso, Norway: The Norwegian College of Fisheries Science, University of Tromso.

Joseph, J.E., C.-S. and Chiu. 2010. A computational assessment of the sensitivity of ambient noise level to ocean acidification. Journal of the Acoustical Society of America 128:EL144-EL149.

Kahn, B., and J. Pet. 2003. Long-term visual and acoustic cetacean surveys in Komodo National Park, Indonesia 1999-2001: Management implications for large migratory marine life. In: Proceedings and Publications of the World Congress on Aquatic Protected Areas 2002. Australian Society for Fish Biology. 28 pp.

Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, S. Hagino, M. Hayami, M. Ishii, T. Iwamoto, T. Kamata, H. Kato, J. Kodama, Y. Kondo, I. Miyawaki, K. Mizobuchi, Y. Nakamura, Y. Nakashima, H. Naruse, K. Omuta, M. Samejima, H. Suganuma, H. Takeshita, T. Tanaka, T. Toji, M. Uematsu, A. Yamamoto, T. Yamato, and I. Wakabayashi. 2003. Loggerhead turtles nesting in Japan. Pages 210-217 in Bolten, A.B. and B.E. Witherington, editors. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Kamminga, C., and J.G. van Velden. 1987. Investigations on cetecean sonar. VIII: Sonar signals of *Pseudorca crassidens* in comparison with *Tursiops truncatus*. Aquatic Mammals 13(2):43-49.

Kane. A.S. 2007. Gross and histopathologic observations from fish exposed to low frequency active sonar at Seneca Lake Sonar Test Facility, Dresdan, NY. Report prepared for Marine Acoustics, Inc. Agreement 05-04-064. 36 pages.

Kane, A.S., J. Song, M.B. Halvorsen, D.L. Miller, J.D. Salierno, L.E. Wysocki, D. Zeddies, and A.N. Popper. 2010. Exposure of fish to high-intensity sonar does not induce acute pathology. Journal of Fish Biology 76(7):1825-1840.

Kaplan, R.D. 2009. Center stage for the twenty-first century. Foreign Affairs 88(2):16-32.

Karlsen, H.E. 1992a. Infrasound sensitivity in the plaice (*Pleuronectes platessa*). Journal of Experimental Biology 171(1):173-187.

Karlsen, H.E. 1992b. The inner ear is responsible for detection of infrasound in the perch (*Perca fluviatilis*). Journal of Experimental Biology 171(1):163-172.

Karlsen, J., A. Bisther, C. Lydersen, T. Haug, and K. Kovacs. 2002. Summer vocalisations of adult male white whales (*Delphinapterus leucas)* in Svalbard, Norway. Polar Biology 25(11):808-817.

Kasamatsu, F., and G. Joyce. 1995. Current status of odontocetes in the Antarctic. Antarctic Science 7(4):365-379.

Kastak, D., and R.J. Schusterman. 1996. Temporary threshold shift in a harbor seal (*Phoca vitulina*). Journal of Acoustical Society of America 100(3):1905-1908.

Kastak, D., and R.J. Schusterman. 1998. Low-frequency amphibious hearing in pinnipeds: Methods, measurements, noise, and ecology. Journal of the Acoustical Society of America 103(4):2216-2228.

Kastak, D., and R.J. Schusterman. 1999. In-air and underwater hearing sensitivity of a northern elephant seal (*Mirounga angustirostris*). Canadian Journal of Zoology 77(11):1751-1758.

Kastak, D., B.L. Southall, R.J. Schusterman, and C.R. Kastak. 2005. Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. The Journal of the Acoustical Society of America 118(5):3154-3163.

Kastelein, R.A. 2009. Walrus (*Odobenus rosmarus*). Pages 1212-1217 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Kastelein, R.A., and N.M. Gerrits. 1991. Swimming, diving and respiration patterns of a northern bottlenose whale (*Hyperoodon ampullatus*, Forster 1770). Aquatic Mammals 17:20-30.

Kastelein, R.A., P. Bunskoek, M. Hagedoorn, W.W.L Au, and D. de Haan. 2002. Audiogram of a harbor porpoise (*Phocoena phocoena*) measured with narrow-band frequency-modulated signals. The Journal of the Acoustical Society of America 112(1)**:**334-344.

Kastelein, R.A., M. Hagedoorn, W.W.L. Au, and D. de Haan. 2003. Audiogram of a striped dolphin (*Stenella coeruleoalba*). Journal of the Acoustical Society of America 113(2)**:**1130-1137.

Kastelein, R.A., R. Van Schie, W.C. Verboom, and D. De Haan. 2005. Underwater hearing sensitivity of a male and a female Steller sea lion (*Eumetopias jubatus*). Journal of the Acoustical Society of America 118(3)**:**1820-1829.

Kastelein, R.A., S. Heul, W.C. Verboom, N. Jennings, J. Veen, and D. Haan. 2008. Startle response of captive North Sea fish species to underwater tones between 0.1 and 64kHz. Marine Environmental Research 65(5):369–377.

Kastelein, R.A., P.J. Wensveen, L. Hoek, W.C. Verboom, and J.M. Terhune. 2009. Underwater detection of tonal signals between 0.125 and 100 kHz by harbor seals (*Phoca vitulina*). The Journal of the Acoustical Society of America 125(2):1222-1229.

Kasuya, T. 1971. Consideration of distribution and migration of toothed whales off the Pacific coast of Japan based upon aerial sighting record. Scientific Report of the Whales Research Institute 23:37-60.

Kasuya, T. 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. Scientific Reports of the Whales Research Institute 37:61-83.

Kasuya, T. 2009. Giant beaked whales *Berardius bairdii and B. arnuxii.* Pages 498-500 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Kato, H., and W.F. Perrin. 2009. Bryde's whale (*Balaenoptera edeni*). Pages 158-163 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Keinath, John. 1993. Movements and behavior of wild and head-started sea turtles. Ph.D. dissertation, College of William and Mary, Williamsburg, Virginia.

Kelleher, G. 1999. Guidelines for marine protected areas. Gland, Switzerland and Cambridge, United Kingdom:IUCN World Commission on Protected Areas.

Kelly, J.C., and D.R. Nelson. 1975. Hearing thresholds of the horn shark, *Heterodontus francisci*. Journal of the Acoustical Society of America 58(4):905-909.

Kemper, C.M. 2009. Pygmy right whale. Pages 939-941 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Kenney, R.D. 2009. North Atlantic, North Pacific, and Southern Right whales (*Eubalaena glacialis, E. japonica, and E. australis*). Pages 962-971 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Kenney, R.D. 2012. Personal communication via email between Dr. Robert D. Kenney, Marine Research Scientist/Adjunct Professor, Graduate School of Oceanography, University of Rhode Island, and Ms. Cheryl Schroeder, Senior Scientist, Marine Acoustics, Inc. on 1 February 2012.

Ketten, D.R. 1992. The cetacean ear: Form, frequency, and evolution. Pages 53-75 in Thomas, J.A., R.A. Kastelein and A.Y. Supin, eds. Marine mammal sensory systems. New York, New York: Plenum Press.

Ketten, D.R. 1992. The marine mammal ear: Specializations for aquatic audition and echolocation. Pages 717-750 in Webster, D.B., R.R. Fay and A.N. Popper, eds. The evolutionary biology of hearing. Berlin, Germany: Springer-Verlag.

Ketten, D.R. 1994. Functional analyses of whale ears: Adaptations for underwater hearing. Proceedings in Underwater Acoustics 1. IEEE:264-270.

Ketten, D.R.. 1997. Structure and function in whale ears. Bioacoustics 8(1):103-136.

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NMFS-SWFSC-256. Southwest Fisheries Science Center, National Marine Fisheries Service: La Jolla, California. 74 Pages.

Ketten, D.R. 2000. Cetacean ears. Pages 43-108 in W.W.L. Au, A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Ketten, D.R. 2008. Underwater ears and the physiology of impacts: Comparative liability for hearing loss in sea turtles, birds, and mammals. Bioacoustics 17(1):312-315.

Ketten, D, and S.M. Bartol. 2006. Functional measures of sea turtle hearing. ONR Final Project Report, ONR Award N00014-02-1-0510. Office of Naval Research, Boston, Massachusetts. Accessed: <http://www.worldcat.org/wcpa/oclc/74289401?page=frame&url=http%3A%2F%2Fhandle.dtic.mil%2F100.2%2FADA446809%26checksum%3D1dcfc9ca7e347b3bb85cd194e3f75468&title=&linktype=digitalObject&detail=>.

Kharin, V.E. 2004. A review of the sea snakes of the group *Hydrophis sensu stricto* (Serpentes, Hydrophiidae). Russian Journal of Marine Biology (Biologiya Morya) 30(6):387-394.

Kidd, G., Jr., C. Mason, V.M. Richards, F.J. Gallun, and N.I. Durlach. 2007. Informational masking. Pages 143-190 in W.A. Yost, A.N. Popper, R.R. Fay, eds. Auditory perception of sound sources. Springer Handbook of Auditory Research, Volume 29. New York, New York: Springer.

King, J., K, and M. M. Bryden. 1981. Southern elephant seal *Mirounga leonina* Linnaeus, 1758. Pages 297-327 in S. H. Ridgway, and R. J. Harrison, eds. Handbook of marine mammals. Volume 2: Seals. New York, New York: Academic Press.

Kinze, C.C. 2009. White-beaked dolphin (*Lagenorhynchus albirostris*). Pages 1255-1258 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Kiraç, C.O., Y. Savas, H. Güçlüsoy, N.O. Veryeri. 2002. Observations on diving behaviour of free ranging Mediterranean monk seals Monachus monachus on Turkish coasts. Monachus Guardian 5(1):1-8. <http://www.monachus-guardian.org/mguard09/09scien2.htm>.

Klimley, A.P., and S.C. Beavers. 1998. Playback of acoustic thermometry of ocean climate (ATOC)-like signal to bony fishes to evaluate phonotaxis. Journal of the Acoustical Society of America 104(4):2506-2510.

Klimley, A.P., and A.A. Myrberg. 1979. Acoustic stimuli underlying withdrawal from a sound source by adult lemon sharks, *Negaprion brevirostris* (Poey). Bulletin of Marine Science 29:447-458.

Knudsen, F.R., P.S. Enger, and O. Sand. 1992. Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo salar* L. Journal of Fish Biology 40(4):523-534.

Komatsu, T., T. Sugimoto, K. Isida, P. Mishra, and T. Miura. 2002. Importance of the Shatsky Rise area in the Kuroshio Extension as an offshore nursery ground for Japanese anchovy (*Engraulis japonicus*) and sardine (*Sardinops melanostictus*). Fisheries Oceanography 11:354-360.

Konigaya, T. 1980. The sound field of Lake Biwa and the effects of the constructing sound on the behavior of the fish. Nippon Suisan Gakkaishi 46(2):129-132.

Kooyman, G.L., and R.L. Gentry. 1986. Diving behavior of South African fur seals. Pages 142-152 in R.L. Gentry and G.L. Kooyman, eds. Fur seals: Maternal strategies on land and sea. Princeton, New Jersey: Princeton University Press.

Kovacs, K.M. 2009. Hooded seal (*Cystophora cristata*). Pages 569-573 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Kraght, P.E. 1995. Fronts and storms. Van Nostrand's Scientific Encyclopedia, 8th edition. D.M. Considine, ed. New York, New York: Van Nostrand Reinhold.

Kritzler, H., and L. Wood. 1961. Provisional audiogram for the shark, *Carcharhinus leucas*. Science 133:1480-1482.

Krutzikowsky, G.K., and B.R. Mate. 2000. Dive and surfacing characteristics of bowhead whales (*Balaena mysticetus*) in the Beaufort and Chukchi seas. Canadian Journal of Zoology 78(7):1182-1198.

Kryter, K. 1985. The effects of noise on man. 2nd edition. New York, New York: Academic Press.

Kujawa, S.G., and M.C. Liberman. 2009. Adding insult to injury: Cochlear nerve degeneration after "temporary" noise-induced hearing loss. The Journal of Neuroscience 29(45):14077-14085.

Kyhn, L.A., J. Tougaard, F. Jensen, M. Wahlberg, G. Stone, A. Yoshinaga, K. Beedholm, and P.T. Madsen. 2009. Feeding at a high pitch: Source parameters of narrow band, high-frequency clicks from echolocating off-shore hourglass dolphins and coastal Hector's dolphins. Journal of the Acoustical Society of America 125(3):1783-1791.

Kyhn, L.A., F.H. Jensen, K. Beedholm, J. Tougaard, M. Hansen, and P. T. Madsen. 2010. Echolocation in sympatric Peale's dolphins (*Lagenorhynchus australis*) and Commerson's dolphins (*Cephalorhynchus commersonii*) producing narrow-band high-frequency clicks. The Journal of Experimental Biology 213:1940-1949.

Ladich, F., and A.N. Popper. 2004. Parallel evolution in fish hearing organs. Pages 95-127 in G.A. Manley, A.N. Popper, and R.R. Fay, eds. Evolution of the vertebrate auditory system. Springer handbook of auditory research. New York, New York: Springer-Verlag.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35-75.

Lammers, M.O., W.W.L. Au, and D.L. Herzing. 2003. The broadband social acoustic signaling behavior of spinner and spotted dolphins. Journal of the Acoustical Society of America 114(3):1629.

Lang, T.G. 1966. Hydrodynamic analysis of cetacean performance. In K.S. Norris, ed. Whales, dolphins, and porpoises. Berkeley, California: University of California Press.

Latha, G., S. Senthilvadivu, R. Venkatesan, and V. Rajendran. 2005. Sound of shallow and deep water lobsters: Measurements, analysis, and characterization. Journal of the Acoustical Society of America 117(5):2720-2723.

Lavigne, D.M. 2009. Harp seal (*Pagophilus groenlandicus*). Pages 542-546 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Laws, R.M. 1994. History and present status of southern elephant seal populations. Pages 49-65 in B.J. Le Boeuf and R.M. Laws. Elephant seals: population ecology, behavior and physiology. Berkeley, California: University of California Press.

Lazell, J.D. 1980. New England waters: Critical habitat for marine turtles. Copeia 1980:290-295.

LDEO (Lamont-Doherty Earth Observatory). 2004. Marine mammal protection and earth science research. Accessed 2009. <http://www.ldeo.columbia.edu/res/fac/oma/mmp/>.

Leatherwood, J.S., and M.E. Dalheim. 1978. Worldwide distribution of pilot whales and killer whales. NOSC Technical Note 443. Naval Ocean Systems Center (NOSC), San Diego, California.

Leatherwood, S., and R.R. Reeves. 1983. The Sierra Club handbook of whales and dolphins. San Francisco, California: Sierra Club Books.

Leatherwood, S., and W.A. Walker. 1979. The northern right whale dolphin (*Lissodelphis borealis*) in the eastern north pacific. H.E. Winn and B.L. Olla, eds. Behavior of marine animals, Volume 3. New York, New York: Plenum Press.

Leatherwood, S., W.F. Perrin, V.L. Kirby, C.L. Hubbs, and M. Dahlheim. 1980. Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific. Fishery Bulletin 77(4):951-963.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans. 1988. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification. New York, New York: Dover Publications.

Leatherwood, S., T.A. Jefferson, J.C. Norris, W.E. Stevens, L.J. Hansen, and K.D. Mullin. 1993. Occurrence and sounds of Fraser's dolphins (*Lagenodelphis hosei*) in the Gulf of Mexico. Texas Journal of Science 45(4):349-353.

Le Boeuf, B.J. 1994. Variation in the diving pattern of northern elephant seals with age, mass, sex and reproductive condition. Pages 237–252 in B.J. Le Boeuf and R.M. Laws, eds. Elephant seals: Population ecology, behavior and physiology. London, England: Univeristy of California Press.

Le Boeuf, B.J., and R.M. Laws. 1994. Elephant seals: population ecology, behavior, and physiology. Berkeley, California: University of California Press.

Le Boeuf, B.J., and R.S. Peterson. 1969. Dialects in elephant seals. Science 166(3913):1654-1656.

Le Boeuf, B.J., and L.F. Petrinovich. 1974. Dialects of northern elephant seals, *Mirounga angustirostris*: Origin and reliability. Animal Behaviour 22(3):656-663.

LeDuc, R.G. 2009. Delphinids, overview. Pages 298-302 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Lenfant, C. 1969. Physiological properties of blood of marine mammals. Pages 95-116 in H.T. Andersen, ed. The biology of marine mammals. New York, New York: Academic Press.

LGL (LGL Limited, Environmental Research Associates). 2003. Request by Lamont-Doherty Earth Observatory for an incidental harrassment authorization to allow the incidental take of cetaceans during marine seismic testing in the northern Gulf of Mexico, May-June 2003. 23 February 2003. King City, Ontario.

Limpus, C.J. 2007. A biological review of Australian marine turtle species; 5. Flatback turtle, *Natator depressus* (Garman). Environmental Protection Agency, State of Queensland, Australia. Report accessed <http://www.derm.qld.gov.au/services_resources/item_details.php?item_id=200005>.

Limpus, C.J., and D.J. Limpus. 2003. Loggerhead turtles in the Equatorial and Southern Pacific Ocean. Pages 199-209 in Bolten, A.B. and B.E. Witherington, editors. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Limpus, C.J., C.J. Parmenter, V. Baker, and A. Fleay. 1983. The flatback turtle, *Chelonia depressa*, in Queensland: Post-nesting migration and feedling ground distribution. Australian Wildlife Research 10(3):557-561.

Ling, J.K. 2009. Australian sea lion. Pages 58-61 in W. F. Perrin, B. Würsig, and H. G. M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Lipsky, J.D. 2009. Right whale dolphins (*Lissodelphis borealis and L. peronii*). Pages 958-962 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Liton, S. 2009. Navy eyes sub, new frigates—Prepares Tk 6,000cr plan to turn it into '3-dimesional' force. The Daily Star, Internet edition, June 24, 2009. Accessed: <http://www.thedailystar.net/story.php?nid=93936>.

Ljungblad, D.K., P.D. Scoggins, and W.G. Gilmartin. 1982. Auditory thresholds of a captive eastern Pacific bottle-nosed dolphin, *Tursiops* spp. Journal of the Acoustical Society of America 72(6):1726-1729.

Lockyer, C. 1981. Growth and energy budgets of large baleen whales from the southern hemisphere. Pages 379–487 in Mammals in the seas: General papers and large cetaceans 3, Number 5. Food and Agriculture Organization Fisheries Series.

Lockyer, C. 1984. Review of baleen whale (Mysticeti) reproduction and implications for management. Report of the International Whaling Commission, Special Issue 6:27-50.

Lohmann, K.J., C.M.F. Lohmann, N.F. Putman. 2007. Magnetic maps in animals: Nature's GPS. The Journal of Experimental Biology 210:3697-3705.

Lombarte, A., and A.N. Popper. 1994. Quantitative analyses of postembryonic hair cell addition in the otolithic endorgans of the inner ear of the european hake, *Merluccius merluccius* (Gadiformes, Teleostei). Journal of Comparative Neurology 345(3):419-428.

Lombarte, A., H.Y. Yan, A.N. Popper, J.S. Chang, and C Platt. 1993. Damage and regeneration of hair cell ciliary bundles in a fish ear following treatment with gentamicin. Hearing Research 64(2):166-174.

Loughlin, T.R. 2009. Stellar's sea lion (*Eumetopias jubatus*). Pages 1107-1110 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Lovell, J.M., M.M. Findlay, R.M. Moate, and H.Y. Yan. 2005. The hearing abilities of the prawn *Palaemon serratus*. Comparative Biochemistry and Physiology, Part A 140:89-100.

Lu, Z., and Z. Xu. 2002. Effects of saccular otolith removal on hearing sensitivity of the sleeper goby (*Dormitator latifrons*). Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 188(8):595-602.

Lucke, K., U. Siebert, P.A. Lepper, and M.A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. The Journal of the Acoustical Society of America 125(6):4060-4070.

Lutcavage, M.E., and P.L. Lutz. 1997. Diving physiology. Pages 277-296 in Lutz, P.L., and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Lydersen, C., and K.M. Kovacs. 1993. Diving behaviour of lactating harp seal, *Phoca groenlandica*, females from the Gulf of St Lawrence, Canada. Animal Behaviour 46:1213-1221.

Lynn, S.K., and D.L. Reiss. 1992. Pulse sequence and whistle production by two captive beaked whales, *Mesoplodon* species. Marine Mammal Science 8(3):299-305.

Madsen, P.T., and B. Mohl. 2000. Sperm whales (*Physeter catodon* L. 1758) do not react to sounds from detonators. Journal of the Acoustical Society of America 107(1):668-671.

Madsen, P.T., R. Payne, N.U. Kristiansen, M. Wahlberg, I. Kerr, and B. Mohl. 2002. Sperm whale sound production studied with ultrasound time/depth-recording tags. Journal of Experimental Biology 205(13):1899-1906.

MAFMC (Mid-Atlantic Fishery Management Council). 2009. Mid-Atlantic fishery management council. Accessed September 2009. <http://www.mafmc.org/>.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior, Phase II, January 1984 Migration. Prepared by Bolt, Beranek and Newman, Inc., Cambridge, Massachusetts, for U.S. Department of Interior, Minerals Management Service, Alaska OCS Office.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. Prepared by Bolt, Beranek and Newman, Inc., Cambridge, Massachusetts for U.S. Department of Interior, Minerals Management Service, Alaska OCS Office.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. Pages 55–73 in W.M. Sackinger and M.O. Jeffries, eds. Port and ocean engineering under arctic conditions. Fairbanks, Alaska: The Geography Institute.

Maniwa, Y. 1971. Effects of vessel noise on purse sensing. In H. Kristjonsson, ed. Modern fishing gear of the world. London, United Kingdom: Fishing News (Books) Ltd.

Mann, D. A., and S.M. Jarvis. 2004. Potential sound production by a deep-sea fish. Journal of the Acoustical Society of America 115(5)**:**2331-2333.

Mann, D.A., Z. Lu, and A.N. Popper. 1997. A clupeid fish can detect ultrasound. Nature 389(6649):341-341.

Mann, D.A., D.M. Higgs, W.N. Tavolga, M.J. Souza, and A.N. Popper. 2001. Ultrasound detection by clupeiform fishes. Journal of the Acoustical Society of America 109(6):3048-3054.

Mann, D.A., P.A. Cott, B.W. Hanna, and A.N. Popper. 2007. Hearing in eight species of northern Canadian freshwater fishes. Journal of Fish Biology 70(1):109-120.

Mann, D.A., C.D. Wilson, J. Song, and A.N. Popper. 2009. Hearing sensitivity of the walleye pollock, *Theragra chalcogramma*. Transactions of the American Fisheries Society 138(5):1000-1008.

Margaritoulis, D., R. Argano, I. Baran, F. Bentivegna, M.N. Bradai, J.A. Camiñas, P. Casale, G. De Metrio, A. Demetropoulos, G. Gerosa, B.J. Godley, D.A. Haddoud, J. Houghton, L. Laurent, and B. Lazar. 2003. Loggerhead turtles in the Mediterranean Sea: Present knowledge and conservation perspectives. ` Pages 175-198 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C., Smithsonian Institution Press.

Marquez-M.,R. 1994. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempi* (Garman, 1880). NOAA Technical Memorandum NMFS-SEFSC-343. Southeast Fisheries Science Center, National Marine Fisheries Service.

Mate, B.R., S. Nieukirk, R. Mesecar, and T. Martin. 1992. Application of remote sensing methods for tracking large cetaceans: North Atlantic right whales *(Eubalaena glacialis)*. U.S. Departmant of the Interior, Minerals Management Service, Alaska and Atlantic OCS Regional Offices, Herndon, Virginia. Herndon, VA: U.S. Departmant of the Interior, Minerals Management Service, Alaska and Atlantic OCS Regional Offices, Herndon, Virginia.

Mate, B.R., K.M. Stafford, R. Nawojchik, and J.L. Dunn. 1994. Movements and dive behavior of a satellite-monitored Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the Gulf of Maine. Marine Mammal Science 10(1):116-121.

Mate, B.R., K.A. Rossbach, S.L. Nieukirk, R.S. Wells, A.B. Irvine, M.D. Scott, and A.J. Read. 1995. Satellite-monitored movements and dive behavior of a bottlenose dolphin (*Tursiops truncatus*) in Tampa Bay, Florida. Marine Mammal Science 11(4):452-463.

Mate, B.R., S.L. Nieukirk, and S.D. Kraus. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61(4):1393-1405.

Mate, B.R., B.A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. Marine Mammal Science 15(4):1246-1257.

Mate, B.R., G.K. Krutzikowsky, M.H. Winsor. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi seas during the late-summer feeding season and fall migration. Canadian Journal of Zoology 78(7):1168-1181.

Matthews, J.N., S. Brown, D. Gillespie, M. Johnson, R. McLanaghan, A. Moscrop, D. Nowacek, R. Leaper, T. Lewis, and P. Tyack. 2001. Vocalisation rates of the North Atlantic right whale (*Eubalaena glacialis*). Journal of Cetacean Research and Management 3(3):271-282.

McAlpine, D.F. 2009. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. Pages 936-939 in W.F. Perrin, B.G. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

McAlpine, D.F., and R.J. Walker. 1999. Additional extralimital records of the harp seal, *Phoca groenlandica*, from the Bay of Fundy, New Brunswick. Canadian Field-Naturalist 113**:**290-292.

McAlpine, D.F., P.T. Stevick, and L.D. Murison. 1999. Increase in extralimital occurrences of ice-breeding seals in the northern Gulf of Maine region: More seals or fewer fish? Marine Mammal Science 15(3)**:**906-911.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Nenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Nurdoch, and K. McCabe. 2000. Marine seismic surveys: A study of environmental implications. Canberra, Australia: Australian Petroleum Production and Exploration Association.

McCauley, R.D., J. Fewtrell, and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113(1):638-642.

McCowan, B., and D. Reiss. 1995. Quantitative comparison of whistle repertoires from captive adult bottlenose dolphins (Delphinidae, *Tursiops truncatus*): A re-evaluation of the signature whistle hypothesis. Ethology 100(3):194-209.

McDonald, M.A., and S.E. Moore. 2002. Calls recorded from North Pacific right whales (*Eubalaena japonica*) in the eastern Bering Sea. Journal of Cetacean Research and Management 4(3):261-266.

McDonald, M.A., J.A. Hildebrand, and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. Journal of the Acoustical Society of America 98(2):712-721.

McDonald, M.A., J.A. Hildebrand, S.M. Wiggins, D. Thiele, D. Glasgow and S.E. Moore. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America 118(6)**:**3941-3945.

McDonald, M.A., J.A. Hildebrand, and S.M. Wiggins. 2006a. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America 120(2): 711-718.

McDonald, M. A, S. L Mesnick, and J. A Hildebrand. 2006b. Biogeographic characterization of blue whale song worldwide: using song to identify populations. Journal of Cetacean Research and Management 8(1):55-65.

McEwen, B.S., and E. Stellar. 1993. Stress and the individual: Mechanisms leading to disease. Archives of Internal Medicine 153:2093-2101.

McEwen, B.S., and J.C. Wingfield. 2003. The concept of allostatsis in biology and biomedicine. Hormones and Behavior 43:2-15.

McLeod, P.J. 1986. Observations during the stranding of one individual from a pod of pilot whales, *Globicephala melaena*, in Newfoundland. Canadian Field-Naturalist 100:137-139.

McMahon, C.R., C.J.A. Bradshaw, and G.C. Hays. 2007. Satellite tracking reveals unusual diving characteristics for a marine reptile, the olive ridley turtle *Lepidochelys olivacea*. Marine Ecology Progress Series 329**:**239-252.

Mead, J.G. 2009a. Beaked whales, overview. Pages 94-97 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Mead, J.G. 2009b. Shepherd's beaked whale. Pages 1011-1014 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Mellinger, D.K., and C.W. Clark. 2000. Recognizing transient low-frequency whale sounds by spectrogram correlation. Journal of the Acoustical Society of America 107(6):3518-3529.

Mellinger, D.K. and C.W. Clark. 2003. Blue whale (*Balaenoptera musculus*) sounds from the North Atlantic. Journal of the Acoustical Society of America 114(2)**:**1108-1119.

Mellinger, D.K., C.D. Carson, and C.W. Clark. 2000. Characteristics of minke whale (*Balaenoptera acutorostrata*) pulse trains recorded near Puerto Rico. Marine Mammal Science 16(4):739-756.

Mendonça, M.T., and P.C.H. Pritchard. 1986. Offshore movements of post-nesting Kemp's ridley sea turtles (*Lepidochelys kempi*). Herpetologica 42**:**373-381.

Mignucci-Giannoni, A.A., and D.K. Odell. 2001. Tropical and subtropical records of hooded seals (*Cystophora cristata*) dispel the myth of extant Caribbean monk seals (*Monachus tropicalis*). Bulletin of Marine Science 68(1)**:**47-58.

Miller, E.H., and D.A. Job. 1992. Airborne acoustic communication in the Hawaiian monk seal, *Monachus schauinslandi*. Pages 485-531 in J.A. Thomas, R.A. Kastelein, and A.Y. Supin, eds. Marine mammal sensory systems. New York: Plenum Press.

Miller, P.J.O., and D.E. Bain. 2000. Within-pod variation in the sound production of a pod of killer whales, *Orcinus orca*. Animal Behaviour 60(5):617-628.

Miller, P.J.O., N. Biassoni, A. Samuels, and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405(6789):903-903.

Milton, S.L., and P.L. Lutz. 2003. Physiological and genetic responses to environmental stress. Pages 163-198 in Lutz, P.L., J.A. Musick, andJ. Wyneken, eds. The biology of sea turtles, Volume II. Boca Raton, Florida: CRC Press.

Minamikawa, S., T. Iwasaki, and T. Kishiro. 2007. Diving behaviour of a Baird's beaked whale, *Berardius bairdii*, in the slope water region of the western North Pacific: First dive records using a data logger. Fisheries Oceanography 16(6):573-577.

Mitchell, E.D., ed. 1975. Review of biology and fisheries for smaller cetaceans. Report of the meeting on smaller cetaceans in Montreal, April 1-11, 1974. Journal of the Fisheries Research Board of Canada 32:889-983.

Mitchell, E.D. 1977. Initial population size of bowhead whale *Balaena mysticetus* stocks: cumulative estimates. Paper SC/29/33 presented to the Internationl Whaling Commission Scientific Committee, London 1976 (unpublished).

Mitson, R. 1995. Underwater noise of research vessels: Review and recommendations. ICES Cooperative Research Report 209. Copenhagen, Denmark: International Council for the Exploration of the Sea.

Miyashita, T. 1993. Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery. International Whaling Commission 43:417-437.

Miyashita, T., V. L. Vladimirov, and H. Kato. 2005. Current status of cetaceans in the Sea of Okhotsk, Japanese and Russian survey results. (S3-2489). Presentation and abstract, North Pacific Marine Science Organization (PICES) fourteen annual meeting, September 29–October 9, 2005, Valdivostock, Russia: <http://www.pices.int/publications/presentations/PICES_14/S3/Miyashita.pdf>.

Miyazaki, N., and W.F. Perrin. 1994. Rough-toothed dolphin, *Steno bredanensis* (Lesson, 1828). Pages 1-21 in S.H. Ridgeway and R. Harrison, eds. Handbook of marine mammals, Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Mizroch, S.A., D.W. Rice, D. Zwiefelhofer, J.M. Waite, and W.L. Perryman. 2009. Distribution and movements of fin whales in the North Pacific Ocean. Mammal Review 39(3):193-227.

Mizuno, A.W., A. Wada, T. Ishinazaka, K. Hattori, Y. Watanabe, and N. Ohtaishi. 2002. Distribution and abundance of spotted seals *Phoca largha* and ribbon seals *Phoca fasciata* in the southern Sea of Okhotsk. Ecological Research 17**:**79-96.

MMC (U.S. Marine Mammal Commission). 2007. Marine Mammal Cmmission: Annual report to Congress—2006. Bethesda, Maryland: U.S. Marine Mammal Commission.

MMS (Minerals Management Service). 2009. Survey of available data on OCS resources and identification of data gaps. Report to the Secretary, U.S. Department of the Interior. OCS Report MMS 2009-15. 219 pp. <http://www.boemre.gov/5-year/PDFs/45-DayReportAvailableDataOnOffshoreResources.pdf>.

MMS (Minerals Management Service). 2010. 2009 oil production: Federal OCS vs. U.S. total. Accessed March 2011. <http://www.boemre.gov/stats/PDFs/OCSProductionTemplate2009.pdf>.

Mohl, B. 1968a. Hearing in seals. R.J. Harrison, R.C. Hubbard, S.B. Peterson, C.E. Rice, and R.J. Schusterman, eds. The behavior and physiology of pinnipeds. New York, New York: Appleton-Century-Crofts.

Mohl, B. 1968b. Auditory sensitivity of the common seal in air and water. Journal of Auditory Research 8(1):27-38.

Mohl, B., M. Wahlberg, P.T. Madsen, L.A. Miller, and A. Surlykke. 2000. Sperm whale clicks: Directionality and source level revisited. Journal of the Acoustical Society of America 107(1):638-648.

Mohl, B., M. Wahlberg, P.T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. Journal of the Acoustical Society of America 114(2):1143-1154.

Montgomery, John, Sheryl Coombs, and Matthew Halstead. 1995. Biology of the mechanosensory lateral line in fishes. Reviews in Fish Biology and Fisheries 5(4):399-416.

Montie, E.W., C.A. Manire, and D.A. Mann. 2011. Live CT imaging of sound reception anatomy and hearing measurements in the pygmy killer whale, *Feresa attenuata*. The Journal of Experimental Biology 214:945-955.

Mooney, T.A., P.E. Nachtigall, M. Castellote, K.A. Taylor, A.F. Pacini, and J.A Esteban. 2008. Hearing pathways and directional sensitivity of the beluga whale, *Delphinapterus leucas*. Journal of Experimental Marine Biology and Ecology 362(2):108-116.

Mooney, T.A., P.E. Nachtigall, and S. Vlachos. 2009a. Sonar-induced temporary hearing loss in dolphins. Biology Letters 5(4):565-567.

Mooney, T.A., P.E. Nachtigall, M. Breese, S. Vlachos, and W.W.L. Au. 2009b. Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. Journal of the Acoustical Society of America 125(3)**:** 1816-1826.

Mooney, T.A., R.T. Hanlon, J. Chistensen-Dalsgaard, P.T. Madsen, D.R. Ketten, and P.E. Nachtigall. 2010. Sound detection by the longfin squid (*Loglio pealeii*) studied with auditory evoked potentials: sensitivity to low-frequency particle motion and not pressure. The Journal of Experimental Biology 213:3748-3759.

Moore, M.J., and G.A. Early. 2004. Cumulative sperm whale bone damage and the bends. Science 306(5705):2215-2215.

Moore, M.J., A.L. Bogomolni, S.E. Dennison, G. Early, M.M. Garner, B.A. Hayward, B.J. Lentell, and D.S. Rotstein. 2009. Gas bubbles in seals, dolphins, and porpoises entangled and drowned at depth in gillnets. Veterinary Pathology Online 46(3):536-547.

Moore, P.W.B, and R.J. Schusterman. 1987. Audiometric assessment of northern fur seals, *Callorhinus ursinus*. Marine Mammal Science 3(1):31-53.

Moore, S., and J.T. Clarke. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus)*. Journal of Cetacean Research and Management 4(1):19-25.

Moore, S.E. and R.R. Reeves. 1993. Distribution and movement. Pages 313-386 *in* J. J. Burns, J. J. Montague and C. J. Cowles, eds. The bowhead whale*.* Lawrence, Kansas: Society for Marine Mammalogy.

Moore, S.E., and S.H. Ridgway. 1995. Whistles produced by common dolphins from the Southern California Bight. Aquatic Mammals 21:55-55.

Moore, S.E., M.E. Dahlheim, K.M. Stafford, C.G. Fox, H.W. Braham, M.A. McDonald, and J. Thomason. 1999. Acoustic and visual detection of large whales in the eastern North Pacific Ocean. NOAA Technical Memorandum. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Moore, S.E., W.A. Watkins, J.R. Davies, M.E. Dahlheim. 2002. Blue whale habitat associations in the Northwest Pacific: analysis of remotely-sensed data using a geographic information system. Oceanography 15:20-25.

Morisaka, T., M. Shinohara, F. Nakahara, T. Akamatsu. 2005. Effects of ambient noise on the whistles of Indo-Pacific bottlenose dolphin populations. Journal of Mammalogy 86(3):541-546.

Morisaka, T., M. Shinohara, F. Nakahara, and T. Akamatsu. 2005a. Geographic variations in the whistles among three Indo-Pacific bottlenose dolphin *Tursiops aduncus* populations in Japan. Fisheries Science 71:568–576.

Morreale, Stephen J., Edward A. Standora, James R. Spotila, and Frank V. Paladino. 1996. Migration corridor for sea turtles. Nature 384(6607):319-320.

Mortimer, J.A. 1982. Feeding ecology of sea turtles. Pages 103-109 in K.A. Bjorndal, ed. Biology and conservation of sea turtles. Washington, D.C.: Smithsonian Institute Press.

Mortimer, J.A., and A. Carr. 1987. Reproduction and migrations of the Ascension Island green turtle (*Chelonia mydas*). Copeia 1987(1):103-113.

Mrosovsky, N. 1972. The water-finding ability of sea turtles. Brain, Behavior and Evolution 5(2): 202-225.

Mullin, K.D., and G.L. Fulling. 2004. Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996-2001. Marine Mammal Science 20(4):787-807.

Mullin, K., W. Hoggard, C. Roden, R. Lohoefener, C. Rogers, and B. Taggart. 1991. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. OCS Study MMS 91-0027. Minerals Management Service: New Orleans, Louisiana. 108 pages.

Mullin, K.D., L.V. Higgins, T.A. Jefferson, and L.J. Hansen. 1994. Sightings of the Clymene dolphin (*Stenella clymene*) in the Gulf of Mexico. Marine Mammal Science 10(4):464-470.

Mulsow, J., and C. Reichmuth. 2010. Psychophysical and electrophysiological aerial audiograms of a Steller sea lion (*Eumetopias jubatus*). The Journal of the Acoustical Society of America 127(4):2692-2701.

Murray, S.O., E. Mercado, and H.L. Roitblat. 1998. Characterizing the graded structure of false killer whale (*Pseudorca crassidens*) vocalizations. Journal of the Acoustical Society of America 104(3, Part I):1679-1688.

Mustika, P.L.K. 2006. Marine mammals in the Savu Sea (Indonesia): Indigenous knowledge, threat analysis and management options. Master's thesis, James Cook University, Australia.

Myrberg, A.A. 1978. Underwater sound—its effect on the behavior of sharks. Pages 391-417 in E.S. Hodgson and R. Mathewson, eds. Sensory biology of sharks, skates, and rays. Arlington, Virgina: Department of the Navy, Office of Naval Research.

Myrberg, A.A. 1981. Sound communication and interception in fishes. Pages 395-425 in W.N. Tavolga, A.N. Popper, and R.R. Fay, eds. Hearing and sound communication in fishes. Proceedings in Life Sciences. New York, New York: Springer-Verlag.

Myrberg, Jr., A.A. 1990. The effects of man-made noise on the behavior of marine mammals. Environment International 16:575-586.

Myrberg, A.A., and J.Y. Spires. 1980. Hearing in damselfishes: An analysis of signal detection among closely related species. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 140(2):135-144.

Myrberg, A.A., C.R. Godron, and A.P. Klimley. 1976. Attraction of free ranging sharks by low frequency sound, with comments on its biological significance. Pages 205-228 in A. Schuijf and A.D. Hawkins, eds. Sound reception in fish. Developments in aquaculture and fisheries science. Amsterdam: Elsevier.

Nachtigal, P.E., W.W.L. Au, J.L. Pawloski, and P.W.B. Moore. 1995. Risso's dolphin (*Grampus griseus*) hearing thresholds in Kaneohe Bay, Hawaii. Pages 49-53 in R.A. Kastelein, J.A. Thomas, and P.E. Nachtigall, eds. Sensory systems of aquatic mammals. Woerden, Netherlands: De Spil Publication.

Nachtigall, P.E., D.W. Lemonds, and H.L. Roitblat. 2000. Psychoacoustic studies of dolphin and whale hearing. Pages 330-363 in Au, W.W.L., A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). The Journal of the Acoustical Society of America 113(6):3425-3429.

Nachtigall, P.E., A.Y. Supin, J. Pawloski, and W.W.L. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using evoked auditory potentials. Marine Mammal Science 20(4):673-687.

Nachtigall, P.E., T.A. Mooney, K.A. Taylor, L.A. Miller, M.H. Rasmussen, T. Akamatsu, J. Teilmann, M. Linnenschmidt, and G.A. Vikingsson. 2008. Shipboard measurements of the hearing of the white-beaked dolphin *Lagenorhynchus albirostris*. Journal of Experimental Biology 211(4):642-647.

National Geographic News. 2006. Deepwater drilling may open new oil frontiers. Accessed April 16, 2009. <http://news.nationalgeographic.com/news/2006/09/090911-gulf-oil.html>.

NARWC (North Atlantic Right Whale Consortium). 2009. North Atlantic right whale report card for 1 November 2007 to 30 April 2009. International Whaling Commission's Scientific Committee Report #SC/61/BRG11.

Naval Oceanographic Office. 1999. Fleet oceanographic and acoustic reference manual, RP 33. Stennis Space Center, Mississippi: Naval Meteorology and Oceanography Command.

Nedwell, J.R., B. Edwards, A.W.H. Turnpenny, and J. Gordon. 2004. Fish and marine mammal audiograms: A summary of available information. Subacoustech Report Number 534R0214. 281 pp.

NEFMC (New England Fishery Management Council). 2009. New England fishery management council. Accessed September 2009. <http://www.nefmc.org/>.

Nelson, D.R. 1967. Hearing thresholds, frequency discrimination, and acoustic orientation in the lemon shark, *Negaprion brevirostris* (Poey). Bulletin of Marine Science 17:741-768.

Nelson, D.R., and S.H. Gruber. 1963. Sharks: Attraction by low-frequency sounds. Science 142(3594), New Series: 975-977.

Nelson, D.R., and R.H. Johnson. 1970. Acoustic studies on sharks, Rangiroa Atoll, July 1969. ONR Technical Report 2, No. N00014-68-C-0138. Defense Technical Information Center.

Nelson, D.R., and R.H. Johnson. 1972. Acoustic attraction of Pacific reef sharks: Effects of pulse intermittency and variability. Comparative Biochemistry and Physiology, Part A: Physiology 42(1):85-95.

Nelson, D.R., and R.H. Johnson. 1976. Some recent observations on acoustic attraction of Pacific reef sharks. Pages 229-239 in A. Schuijf and A.D. Hawkins, eds. Sound reception in fish. Developments in aquaculture and fisheries science. Amsterdam: Elsevier.

Nelson, D.R., and J. Lien. 1996. The status of the long-finned pilot whale, *Globicephala melas*, in Canada. Canadian Field-Naturalist 110(3):511-524.

Nelson, J. 2006. Fishes of the world. 4th edition. Hoboken, New Jersey: John Wiley & Sons.

Nishiwaki, M. 1972. General biology. In S.H. Ridgway, ed. Mammals of the Sea: Biology and Medicine. Springfield, Illinois: Charles C.Thomas Publisher.

Nissen, J. 2011. Personal communication via email between Mr. Jene Nissen, U.S. Navy Fleet Forces Command, and Commander Neil Smith, U.S. Navy N2/N6F216.

Nitschke, S. 2007. Underwater detection systems: for surface ships, submarines, and naval aircraft. Naval Forces 28(3):78-86.

NMFS (National Marine Fisheries Service). 1995. Status reviews of sea turtles listed under the Endangered Species Act of 1973. P.T. Plotkin, ed. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2002. Magnuson-Stevens Act provisions; Essential fish habitat (EFH), Final rule. Federal Register 67(12):2343-2383.

NMFS (National Marine Fisheries Service). 2002a. Supplemental Biological Opinion: Proposed Letter of Authorization to authorize Navy to take marine mammals incidental to its employment of Surveillance Towed Array Sensor System Low Frequency Active Sonar for the period August 16, 2002, through August 15, 2003. Silver Spring, MD: U.S. Department of Commerce, NOAA National Marine Fisheries Service. <http://www.nmfs.noaa.gov/publications/NMFS2001.PDF>.

NMFS (National Marine Fisheries Service). 2005. Environmental impact statement for essential fish habitat identification and conservation in Alaska. National Marine Fisheries Service, Alaska Region, Juneau, Alaska. Accessed <http://www.fakr.noaa.gov/habitat/seis/efheis.htm>.

NMFS (National Marine Fisheries Service). 2007a. Biological opinion on the proposed letter of authorization to authorize the Navy to take marine mammals incidental to the employment of Surveillance Towed Array Sensor System Low Frequency Active for the period August 16, 2007 through August 15, 2012. Silver Spring, Maryland: Departmant of Commerce, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2007b. Biological opinion and incidental take statement on the proposed letter of authorization to authorize the Navy to take marine mammals incidental to its employment of Surveillance Towed Array Sensor System Low Frequency Active for the period Auguest 16, 2007, through August 15, 2008. Silver Spring, Maryland: Department of Commerce, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2007c. Biological opinion and incidental take statement on the proposed letter of authorization to authorize the Navy to take marine mammals incidental to its employment of Surveillance Towed Array Sensor System Low Frequency Active for the period August 15, 2007, through August 16, 2008 (Amended). Silver Spring, Maryland: Department of Commerce, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service).2007d. Statistical highlights: Fisheries of the United States, 2006. Fisheries Statistics Division, Office of Science and Technology, NMFS, Silver Spring, Maryland. Accessed February 2010 and March 2011. <http://www.st.nmfs.noaa.gov/st1/fus/fus06/highlight2006.pdf>.

NMFS (National Marine Fisheries Service). 2007e. Fisheries of the United States, 2006. Current Fishery Statistics No. 2006. Fisheries Statistics Division, Office of Science and Technology, NMFS, Silver Spring, Maryland. Accessed February 2010 and March 2011. <http://www.st.nmfs.noaa.gov/st1/fus/fus06/index.html>.

NMFS (National Marine Fisheries Service). 2008. Endangered and threatened species: Endangered status for the Cook Inlet beluga whale, Final rule. Federal Register 73(205):62919-62930.

NMFS (National Marine Fisheries Service). 2009. Bowhead whale (*Balaena mysticetus).* Office of Protected Species. Accessed September 2010. <http://www.nmfs.gov/pr/species/mammals/cetaceans/bowheadwhale.htm>.

NMFS (National Marine Fisheries Service). 2009a. Atlantic highly migratory species. Accessed September 2009. <http://www.nmfs.noaa.gov/sfa/hms/>.

NMFS (National Marine Fisheries Service). 2009b. Essential fish habitat—EFH text descriptions and GIS data inventory. Accessed September 2009. <http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/GIS_inven.htm>.

NMFS (National Marine Fisheries Service). 2009c. Marine mammal unusual mortality events. National Marine Fisheries, Office of Protected Resources. Accessed October 2010. <http://www.nmfs.noaa.gov/pr/health/mmume/>.

NMFS (National Marine Fisheries Service). 2011. Marine mammal species listed under the Endangered Species Act (ESA). National Marine Fisheries, Office of Protected Resources. Accessed June 2011. <http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 1998a. Recovery plan for U.S. Pacific populations of the hawksbill turtle (*Eretmochelys imbricata*). Pacific Sea Turtle Recovery Team, National Marine Fisheries Service, Silver Spring, Maryland and the U.S. Fish and Wildlife Service, Pacific Region, Portland, Oregon.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 1998b. Recovery plan for U.S. Pacific populations of the leatherback turtle (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, Maryland and the U.S. Fish and Wildlife Service, Pacific Region, Portland, Oregon.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007. Green sea turtle (*Chelonia mydas*), 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville, Florida. 105 pages.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007a. Hawksbill sea turtle (*Eretmochelys imbricata*), 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville, Florida. 93 pages.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007b. Loggerhead sea turtle (*Caretta caretta*), 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville, Florida. 67 pages.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007c. Kemp's ridley sea turtle (*Lepidochelys kempii*), 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico. 50 pages.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007d. Leatherback sea turtle (*Dermochelys coriacea*), 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville, Florida. 81 pages.

NMNS (Natural Museum of Nature and Science). 2009. Marine mammals stranding database. Natural Museum of Nature and Science, Tokyo, Japan. Accessed February 2010. <http://svrsh2.kahaku.go.jp/drift/E/>.

NMPAC (National Marine Protected Areas Center). 2009a. National marine protected areas center: All about marine protected areas—The basics. Accessed October 2009. <http://mpa.gov/all_about_mpa/basics.html>.

NMPAC (National Marine Protected Areas Center). 2009b. National marine protected areas center: Inventory of marine protected areas in the United States. Accessed September 2009. <http://mpa.gov/helpful_resources/inventory.html>.

NMPAC (National Marine Protected Areas Center). 2009c. National marine protected areas center: Charter members of the national system of marine protected areas. Accessed September 2009. <http://mpa.gov/helpful_resources/chartersitesmap.gif>.

NOAA (National Oceanic and Atmospheric Administration). 1979. Determination of critical habitat for the leatherback sea turtle. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 44(58):17710-17712.

NOAA (National Oceanic and Atmospheric Administration). 1994. Designated critical habitat; northern right whale. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 59(106):28793-28808.

NOAA (National Oceanic and Atmospheric Administration). 1998. Designated critical habitat; green and hawksbill sea turtles; Final rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 63(170):46693-46701.

NOAA (National Oceanic and Atmospheric Administration). 2002a. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active Sonar. Notice of issuance of a Letter of Authorization. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 67(169):55818.

NOAA (National Oceanic and Atmospheric Administration). 2002b. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Final Rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 67(136):46712-46789.

NOAA (National Oceanic and Atmospheric Administration). 2003a. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Notice of issuance of two Letters of Authorization. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 68(161):50123-50124.

NOAA (National Oceanic and Atmospheric Administration). 2004. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Notice of issuance of two Letters of Authorization. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 69(163):51996-51998.

NOAA (National Oceanic and Atmospheric Administration). 2005. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Notice of issuance of two Letters of Authorization. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 70(164):49914-49915.

NOAA (National Oceanic and Atmospheric Administration). 2005a. Endangered and threatened wildlife and plants: Endangered status for Southern Resident Killer whales; Final rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 70(222):69903-69912.

NOAA (National Oceanic and Atmospheric Administration). 2006a. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Notice on issuance of two Letters of Authorization. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 71(161):48537-4858.

NOAA (National Oceanic and Atmospheric Administration). 2006b. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Notice of Receipt of Application. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 71(188):56965-56968.

NOAA (National Oceanic and Atmospheric Administration). 2006c. Endangered and threatened species; Designation of critical habitat for southern resident killer whale. Final rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 71(229):69054-69070.

NOAA (National Oceanic and Atmospheric Administration). 2007a. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Notice; issuance of two Letters of Authorization. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 72(198):58289-58290.

NOAA (National Oceanic and Atmospheric Administration). 2007b. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Proposed rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 72(130):37404-37418.

NOAA (National Oceanic and Atmospheric Administration). 2007c. Taking and importing marine mammals; taking marine mammals incidental to Navy operations of Surveillance Towed Array Sensor System Low Frequency Active sonar. Final rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 72(161):46846-46893.

NOAA (National Oceanic and Atmospheric Administration). 2008. Endangered and threatened species; Designation of critical habitat for North Pacific right whale, Final rule. 50 CFR Part 226. National Marine Sanctuary Program, National Ocean Service, National Oceanic and Atmospheric Administration. Federal Register 73(68):19000-19014.

NOAA. (National Oceanic and Atmospheric Administration). 2008a. Gulf of Farallones National Marine Sanctuary regulations; Monterey Bay National Marine Sanctuary regulations; and Cordell Bank National Marine Sanctuary regulations; Final rule. 15 CFR Part 922. National Marine Sanctuary Program, National Ocean Service, National Oceanic and Atmospheric Administration. Federal Register 73(225):70488-70540.

NOAA (National Oceanic and Atmospheric Administration). 2009. National marine sanctuary geographic information system data. Accessed October 2009. <http://sanctuaries.noaa.gov/library/imast_gis.html>.

NOAA (National Oceanic and Atmospheric Administration). 2009a. Remotely operated vehicle (ROV). National Oceanographic and Atmospheric Administration, Office of Ocean Exploration and Research. Accessed April 28, 2009. <http://explore.noaa.gov/remotely-operated-vehicle-rov>.

NOAA (National Oceanic and Atmospheric Administration). 2009b. Autonomous underwater vehicles. National Oceanographic and Atmospheric Administration, Office of Ocean Exploration and Research. Accessed April 28, 2009. http://explore.noaa.gov/autonomous-underwater-vehicles-auv.

NOAA (National Oceanic and Atmospheric Administration). 2009c. Human occupied vehicles (HOV). National Oceanographic and Atmospheric Administration, Office of Ocean Exploration and Research. Accessed Apriil 28, 2009. <http://explore.noaa.gov/human-occupied-vehicle-hov>.

NOAA (National Oceanic and Atmospheric Administration). 2009d. Taking and importing marine mammals; U.S. Navy training in the Hawaii Range Complex, Final rule. 50 CFR Part 216. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 74(7):1456-1491.

NOAA (National Oceanic and Atmospheric Administration). 2009e. Taking and importing marine mammals; U.S. Navy training in the Southern California Range Complex, Final rule. 50 CFR Part 216. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 74(12):3882-3918.

NOAA (National Oceanic and Atmospheric Administration). 2009f. Taking and importing marine mammals; U.S. Navy's Atlantic Fleet Active Sonar Training, Final rule. 50 CFR Part 216. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 74(16):4844-4885.

NOAA (National Oceanic and Atmospheric Administration). 2010. Endangered and threatened wildlife and plants: Proposed endangered status for the Hawaiian Insular false killer whale distinct population segment; Proposed rule. 50 CFR Part 224. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 75(221):70169-70187.

NOAA (National Oceanic and Atmospheric Administration). 2011. Endangered and threatened wildlife and plants: Proposed rulemaking to revise critical habitat for Hawaiian monk seals; Proposed rule. 50 CFR Part 226. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 76(106):32026-32063.

NOAA (National Oceanic and Atmospheric Administration). 2012. Endangered and threatened species: final rule to revise the critical habitat designation for the endangered leatherback sea turtle; Final rule.

National Marine Fisheries Service, National Oceanic and Atmospheric Administration and U.S. Fish and Wildlife Service. Federal Register 77(17):4170-4201.

NOAA (National Oceanic and Atmospheric Administration). 2012a. Taking and importing marine mammals: Taking marine mammals incidental to U.S. Navy operations of Surveillance Towed Array Sensor System Low Frequency Active Sonar; Proposed rule. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Federal Register 77(4):842-894.

NOAA (National Oceanic and Atmospheric Administration) and USFWS (U.S. Fish and Wildlife Service). 2011. Endangered and threatened species; Determination of nine distinct population segments of loggerhead sea turtles as endangered or threatened; Final rule. 50 CFR Part 17 and 50 CFR Parts 223 and 224. National Marine Fisheries Service, National Oceanic and Atmospheric Administration and U.S. Fish and Wildlife Service. Federal Register 76(184):58868-58952.

Norris, J.C., and S. Leatherwood. 1981. Hearing in the bowhead whale, *Balaena mysticetus*, as estimated by cochlear morphology. Pages 745-787 in T.F. Albert, ed. Tissue structural studies and other investigations on the biology of endangered whales in the Beaufort Sea. Volume II. Contract number AA851-CTO-22.. Prepared for Bureau of Land Management, Alaska OCS Office, Anchorage, Alaska by Department of Veterinary Science, University of Maryland, College Park, Maryland, Research unit 1580.

Norris, K.S. 1969. The echolocation of marine mammals. Pages 391-423 in H.T. Andersen, ed. The biology of marine mammals. New York, New York: Academic Press.

Norris, K.S., and W.E. Evans. 1967. Directionality of echolocation clicks in the rough-toothed porpoise, *Steno bredanensis*. Pages 305-316 in W.N. Tavolga, ed. Marine bio-acoustics, Volume 2. Proceedings of the 2nd symposium on marine bio-acoustics held at the American Museum of Natural History, New York, New York, April 13-15, 1966. Oxford, United Kingdon: Pergamon Press.

Norris, K.S., and J.H. Prescott. 1961. Observations on Pacific cetaceans of Californian and Mexican waters. Berkeley, California: University of California Press.

Norris, K.S., B. Würsig, R.S. Wells, and M. Würsig. 1994. The Hawaiian spinner dolphin. Berkeley, California: University of California Press.

Notarbartolo di Sciara, G. 2010. Personal communication. Tethys Research Institute. Milano, Italy.

Notarbotolo di Sciara, G., M. Venturino, M. Zanardelli, G. Bearzi, F. Borsani, and B. Cavalloni. 1993. Cetaceans in the central Mediterranean Sea: distribution and sighting frequencies. Italian Journal of Zoology 60(1):131-138.

Notarbartolo-Di-Sciara, G., M. Zanardelli, M. Jahoda, S. Panigada, and S. Airoldi. 2003. The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea. Mammal Review 33(2):105-150.

Nowacek, D.P., L.H. Thorne, D.W. Johnson, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

NPAL (North Pacific Acoustic Laboratory). 2009. NPAL acoustic thermometry. Accessed May 4, 2009. <http://npal.ucsd.edu/thermometry/index.htm>.

NPFMC (North Pacific Fishery Management Council). 2009. North Pacific fishery management council. Accessed September 2009. <http://www.fakr.noaa.gov/npfmc/>

NRC (National Research Council). 2000a. Marine mammals and low-frequency sound progress since 1994. Washington, DC: National Academy Press.

NRC (National Research Council). 2000b. Marine protected areas: Tools for sustaining ocean ecosystems. Prepublication version. Washington, D.C.: National Academy Press.

NRC (National Research Council). 2003. Ocean noise and marine mammals. Washington, D.C.: National Academies Press.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects. Washington, D.C.: National Academies Press.

OAML (Ocean and Atmospheric Master Library). 2000. Database description for the General Digital Enviornmental Model—variable resolution (GDEM-V) Version 2.5, June 2000.

O'Connor, S., R. Campbell, H. Cortez., and T. Knowles. 2009. Whale watching worldwide: Tourism numbers, expenditures and expanding economic benefits. A special report from the International Fund for Animal Welfare, Yarmouth Massachusetts. Prepared by Economists at Large, Australia. 295 pages.

O'Corry-Crowe, G.M. 2009. Beluga whale (*Dephinapterus leucas*). Pages 108-112 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Odell, D.K., and K.M. McClune. 1999. False killer whale (*Pseudorca crassidens* [Owen, 1846]). Pages 213-243 in S.H. Ridgeway and R. Harrison, eds. Handbook of marine mammals, Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Offshore-Technology. 2008. Passionate about surveying the seas. Offshore-Technology.com: The Website for the Oil and Gas Industry. Accessed May 4, 2009. <http://www.offshore-technology.com/features/feature1784/>.

Ogren, L. and C. McVea, Jr. 1995. Apparent hibernation in turtles in North American waters. Pages 127-132 in K.A. Bjorndal, ed. Biology and conservation of sea turtles. Washington, D.C.: Smithsonian Press.

O'Hara, J., and J.R. Wilcox. 1990. Avoidance responses to loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia 1990(2):564-567.

Ohizumi, H., T. Isoda, T. Kishiro, and H. Kato. 2003. Feeding habits of Baird's beaked whale *Berardius bairdii*, in the western North Pacific and Sea of Okhotsk off Japan. Fisheries Science 69(1):11-20.

Øien, N. 2009. Distribution and abundance of large whales in Norwegian and adjacent waters based on ship surveys 1995-2001. NAMMCO Scientific Publications 7:31-47.

Oleson, E.M., J. Barlow, J. Gordon, S. Rankin, and J.A. Hildebrand. 2003. Low frequency calls of Bryde's whales. Marine Mammal Science 19(2):407-419.

Oliver, G.W. 1978. Navigation in mazes by a grey seal, *Halichoerus grypus* (Fabricius). Behaviour 67(1):97-114.

Olla, B. 1962. The perception of sound in small hammerhead sharks *Sphyrna lewini*. M.S. thesis, University of Hawaii.

Olson, P.A. 2009. Pilot whales (*Globicephata melas* and *G. macrorhynchus*). Pages 847-851 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen. eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

OMP and MAI (Office of Marine Programs and Marine Acoustics, Inc.). 2010. Discovery of sound in the sea (DOSITS). Office of Marine Programs, University of Rhode Island. <http:www.dosits.org>.

Omura, H. 1959. Bryde's whale from the coast of Japan. Scientific Reports of the Whales Research Institute 14:1-33.

Omura, H., K. Fujino, and S. Kimura. 1955. Beaked whale *Berardius bairdi* of Japan, with notes on *Ziphius cavirostris*. Scientific Reports of the Whales Research Institute 10:89-132.

ONI (Office of Naval Intelligence). 2009a. The People's Liberation Army Navy: A modern navy with Chinese characteristics. Suitland, Maryland: Office of Naval Intelligence.

ONI (Office of Naval Intelligence). 2009b. Iran's naval forces: From guerrilla warfare to a modern naval strategy. Suitland, Maryland: Office of Naval Intelligence.

ONR (Office of Naval Research). 2008. ONR fact sheet: Multi-mode magnetic detection system (3MDS)—Office of Naval Research. Accessed: <http://www.onr.navy.mil/en/Media-Center/Fact-Sheets/Multi-Mode-Magnetic-Detection-System.aspx>.

Ort, C., P. Beerens, and P. de Theije. 2003. From low-frequency active sonar to netcentric underwater warfare: remedy for silent subs? Naval Forces 24(5):41-48.

Oswald, J.N., J. Barlow, and T.F. Norris. 2003. Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. Marine Mammal Science 19(1):20-37.

Pacini, A.F., P.E. Nachtigall, L.N. Kloepper, M. Linnenschmidt, A. Sogorb, and S. Matias. 2010. Audiogram of a formerly stranded long-finned pilot whale (*Globicephala melas*) measured using auditory evoked potentials. The Journal of Experimental Biology 213:3138-3143.

Packard, A., H.E. Karlsen, and O. Sand. 1990. Low frequency hearing in cephalopods. Journal of Comparative Physiology A 166:501-505.

PADI (Professional Association of Divers). 2008a. PADI statistics—PADI worldwide certification history. Accessed 2009. <http://www.padi.com/scuba/about-padi/padi-statistics/default.aspx#Graph_1>.

PADI (Professional Association of Divers). 2008b. PADI statistics—PADI worldwide certifications and experiences: Median ages worldwide. Accessed 2009. <http://www.padi.com/scuba/about-padi/padi-statistics/default.aspx#Graph_1>.

Page, B., S.D. Goldsworthy, M.A. Hindell, and J. Mckenzie. 2002. Interspecific differences in male vocalizations of three sympatric fur seals (*Arctocephalus* spp.). Journal of Zoology 258(01):49-56.

Page, B., J. McKenzie, and S.D. Goldsworthy. 2005. Inter-sexual differences in New Zealand fur seal diving behaviour. Marine Ecology Progress Series 304:249-264.

Pakistan Newswire. 2008. PN will commission 2nd Agosta 90B submarine HAMZA on Sept 26. The Pakistan Newswire, 23 September 2008 edition, sec. Nationwide International News. Accessed: <http://www.lexisnexis.com.mutex.gmu.edu/us/lnacademic/frame.do?tokenKey=rsh-20.724740.7635193532&target=results_listview_resultsNav&reloadEntirePage=true&rand=1244580055550&returnToKey=20_T6736568621&parent=docview>.

Panigada, S., G. Notarbartolo di Sciara., M. Zanardelli, S. Airoldi, J.F. Borsani, M. Jahoda, G. Pesante, E. Revelli. 2004. Distribution and occurrence of fin whales in the Ligurian Sea between 1990-99. European Research on Cetaceans 15:194-194.

Papastavrou, V., S.C. Smith, and H. Whitehead. 1989. Diving behaviour of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands. Canadian Journal of Zoology 67(4):839-846.

Parham, J.F. and G.R. Zug. 1996. *Chelonia agassizii*: Valid or not? Marine Turtle Newsletter 72:2-5.

Park, Y.S., K. Iida, T. Mukai, and Y.K. Sakura. 1995. Auditory characteristics of walleye pollock *Theragra chalcogramma* (Pallas). Nippon Suisan Gakkaishi 61(2):159-163.

Parks, S.E., and P.L. Tyack. 2005. Sound production by North Atlantic right whales (*Eubalaena glacialis*) in surface active groups. Journal of the Acoustical Society of America 117(5):3297-3306.

Parks, S.E., D.R. Ketten, J.T. O'Malley, and J. Arruda. 2007. Anatomical predictions of hearing in the North Atlantic right whale. The Anatomical Record 290:734-744.

Parks, S.E., C.W. Clark, and P.L. Tyack. 2007a. Short-and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6):3725-3731.

Parrish, F.A., K. Abernathy, G.J. Marshall, and B.M. Buhleier. 2002. Hawaiian monk seals (*Monachus schauinslandi*) foraging in deep-water coral beds. Marine Mammal Science 18(1):244-258.

Patterson, B., and G.R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. In W.M. Tavolga, ed. Marine bio-acoustics, Volume 1. Oxford, England: Pergamon Press.

Pavan, G., T.J. Hayward, J.F. Borsani, M. Priano, M. Manghi, C. Fossati, and J. Gordon. 2000. Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. Journal of the Acoustical Society of America 107(6):3487-3495.

Payne, R., and K. Payne. 1971. Underwater sounds of southern right whales. Zoologica 58:159-165.

Perrin, W.F. 2009. Common dolphins (*Delphinus delphis* and *D. capensis*). Pages 255-259 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Perrin, W.F. 2009a. Pantropical spotted dolphin (*Stenella attenuata*). Pages 819-821 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Perrin, W.F. 2009b. Atlantic spotted dolphin (*Stenella frontalis*). Pages 54-56 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Perrin, W.F. 2009c. Spinner dolphin (*Stenella longirostris*). Pages 1100-1103 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Perrin, W.F., B.G. Wursig, and J.G.M. Thewissen, eds. 2009. Encyclopedia of marine mammals. 2nd edition. San Diego, California: Academic Press.

Pet-Soede, L. 2002. The Solor and Alor Islands: Expedition results, data collected during 2 reconnaissance trips; 9-12 September 2001 and 7-19 May, 2002. Report of a joined activity by The Nature Conservancy, Southeast Asia Center for Marine Protected Areas and World Wide Fund for Nature Wallacea Bioregional Program.

PFMC (Pacific Fishery Management Council). 2009. Pacific fishery management council. Accessed September 2009. <http://www.pcouncil.org/>.

Pham, N. 2009. Vietnam to buy Russian submarines. BBC Vietnamese Service, Section Asia-Pacific. Accessed: <http://news.bbc.co.uk/2/hi/8415380.stm>.

Phillips, A.V., and I. Stirling. 2000. Vocal individuality in mother and pup South American fur seals, *Arctocephalus australis*. Marine Mammal Science 16(3):592-616.

Philips, J.D., P.E. Nachtigall, W.W.L. Au, J.L. Pawloski, and H.L. Roitblat. 2003. Echolocation in the Risso's dolphin, *Grampus griseus*. Journal of the Acoustical Society of America 113(1):605-616.

Pierson, M.O. 1987. Breeding behavior of the Guadalupe seal (*Arctocephalus townsendi*). Pages 83-94 in J.P. Croxall and R.L. Gentry, eds. Status, biology, and ecology of fur seals. NOAA Technical Report NMFS 51. Seattle, Washington: Northwest Regional Office.

Pitman, R. 2009a. Indo-Pacific beaked whale (*Indopacetus pacificus*). Pages 600-602 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Pitman, R. 2009b. Mesoplodont whales (*Mesoplodon* spp.). Pages 721-726 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Pitman, R.L., D.M. Palacios, P.L. Rodriguez, B.J. Brennan, K.C. Balcomb, and T. Miyashita. 1998. Probable sightings of Longman's beaked whale (*Indopacetus [Mesoplodon] pacificus*) from the equatorial Indian and Pacific oceans. Abstracts of the World Marine Mammal Science Conference, Monaco, 24-28 January 1998.

Plotkin, P.T. 2003. Adult migrations and habitat. Pages 225-241 in P.L. Lutz, J.A. Musick, and J. Wyneken, eds. The biology of sea turtles, Volume 2. Boca Raton, Florida: CRC Press.

Poggendorf, D. 1952. Die aboluten horschwellwn des zwergwelses (*Amiurus nebulosus*) und beitrage zur physik des weberschen apparatus der ostariophysen. Zeitschrift für Vergleichende Physiologie 34:222-257.

Pollack, I. 1975. Auditory informational masking. The Journal of the Acoustical Society of America 57(S1):S5-S5.

Polovina, J.J., E. Howell, D.R. Kobayashi, M.P. and Seki. 2001. The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography 49:469-483.

Polovina, J.J., E. Howell, D.M. Parker, and G.H. Balazs. 2003. Dive-depth distribution of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin 101(1):189-193.

Polovina, J., I. Uchida, G. Balazs, E.A. Howell, D. Parker, and P. Dutton. 2006. The Kuroshio Extension bifurcation region: A pelagic hotspot for juvenile loggerhead turtles. Deep-sea Research Part II 53:326-339.

Popov, V.V., A.Y. Supin, D. Wang, K. Wang, L. Dong, and S. Wang. 2011. Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises *Neophocaena phocaenoides asiaeorientalis.* Journal of the Acoustical Society of America 130(1):574-584.

Popper, A.N. 1980a. Scanning electron microscopic study of the sacculus and lagena in several deep-sea fishes. American Journal of Anatomy 157(2):115-136.

Popper, A.N. 1980b. Sound emission and detection by delphinids. Pages 1-52 in Herman, L.M., ed. Cetacean behavior: Mechanisms and functions. New York, New York: John Wiley and Sons.

Popper, A.N. 2009. Personal communication between Dr. A.N. Popper, Director of Neuroscience and Cognitive Science Program and Biology Professor, University of Maryland, and Dr. C.W. Weir, Ketos Ecology, Aberdeen, United Kingdom.

Popper, A.N., and N.L. Clarke. 1976. The auditory system of the goldfish (*Carassius auratus*): Effects of intense acoustic stimulation. Comparative Biochemistry and Physiology Part A: Physiology 53(1):11-18.

Popper, A.N. and S. Coombs. 1982. The morphology and evolution of the ear in Actinopterygian fishes. American Zoologist 22:311-328.

Popper, A.N., and R.R. Fay. 1973. Sound detection and processing by teleost fishes: A critical review. Journal of the Acoustical Society of America 53(6):1515-1529.

Popper, A.N., and R.R. Fay. 1993. Sound detection and processing by fish: Critical review and major research questions. Brain, Behavior and Evolution 41:14-38.

Popper, A.N., and R.R. Fay. 1997. Evolution of the ear and hearing: Issues and questions. Brain, Behavior and Evolution 50:213-221.

Popper, A.N., and R.R. Fay. 1999. The auditory periphery in fishes. Pages 43-100 in R.R. Fay and A.N. Popper, eds. Chapter 11. Comparative hearing: Fish and amphibians. Springer Handbook of Auditory Research. New York, New York: Springer-Verlag.

Popper, A.N., and R.R. Fay. 2009a. The future of fish bioacoustics. Journal of the Acoustical Society of America 125(4):2485-2485.

Popper, A.N., and R.R. Fay. 2009b. Rethinking sound detection by fishes. Hearing Research 273(1-2):25-36.

Popper, A.N., and M.C. Hastings. 2009a. The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology 75(3):455-489.

Popper, A.N., and M.C. Hastings. 2009b. The effects of human-generated sound on fish. Integrative Zoology 4(1):43-52.

Popper, A.N., and C.R. Schilt. 2008. Hearing and acoustic behavior: Basic and applied considerations. Chapter 2. Pages 17-48 in in J.F. Webb, A.N. Popper, and R.R. Fay, eds. Fish bioacoustics. Springer Handbook of Auditory Research, Volume 32, R.R. Fay and A.N. Popper, series eds. New York, New York: Springer Science+Business Media, LLC.

Popper, A.N., R.R. Fay, C. Platt, and O. Sand. 2003. Sound detection mechanisms and capabilities of teleost fishes. Pages 3-38 in P. Collin and N.J. Marshall, eds. Sensory processing in aquatic environments. New York, New York: Springer-Verlag.

Popper, A.N., J. Fewtrell, M.E. Smith, and R.D. McCauley. 2004. Anthropogentic sound: Effects on the behavior and physiology of fishes. Marine Technology Society Journal 37:35-40.

Popper, A.N., M.B. Halvorsen, D. Miller, M.E. Smith, J. Song, L.E. Wysocki, M.C. Hastings, A.S. Kane, and P. Stein. 2005a. Effects of Surveillance Towed Array Sensor System (SURTASS) low frequency active sonar on fish. Paper presented at the 149th Meeting of the Acoustical Society of America. Journal of the Acoustical Society of America 117(4):2440-2440.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGillivray, M.E. Austin, and D.A. Mann. 2005b. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6):3958-3971.

Popper, A.N., T.J. Carlson, A.D. Hawkins, B.L. Southall, and R.L. Gentry. 2006. Interim criteria for injury of fish exposed to pile driving operations; A white paper. Draft presented to the Fisheries Hydroacoustic Working Group. Accessed from <http://www.wsdot.wa.gov/NR/rdonlyres/84A6313A-9297-42C9-BFA6-750A691E1DB3/0/BA_PileDrivingInterimCriteria.pdf.>

Popper, A.N., M.B. Halvorsen, A. Kane, D.L. Miller, M.E. Smith, J. Song, P. Stein, and L.E. Wysocki. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustical Society of America 122(1):623-635.

Porter, M. B. 1992. The KRAKEN normal mode program. Naval Research Laboratory, May 22, 1992.

Poulter, T.C. 1968. Underwater vocalization and behavior of pinnipeds. Pages 69-84 in R.J. Harrison, R.C. Hubbard, S.B. Peterson, C.E. Rice, and R.J. Schusterman, eds. The behavior and physiology of pinnipeds. New York, New York: Appleton-Century-Crofts.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. Pages 1-28 in Lutz, P.L., and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

PRLog. 2006. The world AUV & ROV Report 2004-2008. PRLog online press release service. Accessed May 4, 2009. <http://www.prlog.org/10001971-the-world-auv-rov-report-2004-2008.html>.

Protect Planet Ocean. 2009. Protect Planet Ocean: Saving the World's Last Frontier. Accessed October 2009. <http://www.protectplanetocean.org/>.

Pryor, T., K. Pryor, and K.S. Norris. 1965. Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii. Journal of Mammalogy 46(3):450-461.

Rai, R.B. 2009. ATV INS "ARIHANT" nuclear submarine launched, India joining 'The Big Five' nuclear submarine club. Naval Forces 30(5):22-25.

Rankin, S., and J. Barlow. 2005. Source of the North Pacific “boing” sound attributed to minke whales. Journal of the Acoustical Society of America 118(5):3346-3351.

Rankin, S., and J. Barlow. 2007. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawai’ian Islands. Bioacoustics 16:137-145.

Rasmussen, M.H., L.A. Miller, and W.W.L. Au. 2002. Source levels of clicks from free-ranging white-beaked dolphins (*Lagenorhynchus albirostris* Gray 1846) recorded in Icelandic waters. Journal of the Acoustical Society of America 111(2):1122-1125.

Ray, G. C., and W. A. Watkins. 1975. Social function of underwater sounds in the walrus *Odobenus rosmarus*. Rapports et Proces-Verbaux des Reunions Conseil International pour l'Exploration de la Mer 169:524-526.

Read, A.J., and A.J. Westgate. 1997. Monitoring the movements of harbour porpoises (*Phocoena phocoena*) with satellite telemetry. Marine Biology 130(2):315-322.

Read, A.J., P. Drinker, and S. Northridge. 2006. Bycatch of marine mammals in U.S. and global fisheries. Conservation Biology 20(1):163-169.

Ream, R.R., J.T. Sterling, and T.R. Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. Deep-Sea Research Part II 52(5):823-843.

Redfern, J.V., M.C. Ferguson, E.A. Becker, K.D. Hyrenbach, C. Good, J. Barlow, K. Kaschner, M.F. Baumgartner, K.A. Forney, L.T. Ballance, P. Fauchald, P. Halpin, T. Hamazaki, A.J. Pershing, S.S. Qian, A. Read, S.B. Reilly, L. Torres, and F. Werner. 2006. Techniques for cetacean-habitat modeling. Marine Ecology Progress Series 310:271–295.

Reeder, D.B., and C.-S. Chiu. 2010. Ocean acidification and its impact on ocean noise: Phenomenology and analysis. Journal of the Acoustical Society of America 128:EL137-EL143.

Reeves, R.R., and S. Leatherwood. 1994. Dolphins, porpoises, and whales: 1994-1998 action plan for the conservation of cetaceans. Gland, Switzerland: International Union for Conservation of Nature (IUCN).

Reeves, R.R., and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. Canadian Field-Naturalist 111(2):293-307.

Reeves, R.R., A.J. Read, and G. Notarbartolo Di Sciara, eds. 2001. Report of the Workshop on Interactions between Dolphins and Fisheries in the Mediterranean: Evaluation of Mitigation Alternatives, Roma, 4-5 May 2001. Istituto Centrale per la Ricerca Applicata al Mare, Rome, Italy.

Reeves, R., M. Mckenzie, and T. Smith. 2006. History of Bermuda shore whaling, mainly for humpback whales. Journal of Cetacean Research and Management 8(1):33-33.

Rehberg, M.J., R.D. Andrews, U.G. Swain, and D.G. Calkins. 2009. Foraging behavior of adult female Steller sea lions during the breeding season in Southeast Alaska. Marine Mammal Science 25(3):588-604.

Reid, J.P., G.B. Rathburn, and J.R. Wilcox. 1991. Distribution patterns of individually identifiable west Indian manatees (*Trichechus manatus*) in Florida. Marine Mammal Science 7(2):180-190.

Reilly, S.B., J.L.Bannister, P.B. Best, M. Brown, R.L. Brownell Jr., D.S. Butterworth, P.J. Clapham, J. Cooke, G.P. Donovan, J. Urbán, and A.N. Zerbini. 2008. *Balaena mysticetus,* Okhotsk Sea subpopulation. In: IUCN 2010. IUCN red list of threatened species. Version 2010.3. Downloaded on 09 September 2010.<http://www.iucnredlist.org/>.

Renaud, M.L. 1995. Movements and submergence patterns of Kemp's ridley turtles (*Lepidochelys kempii*). Journal of Herpetology 29:370-374.

Rendell, L.E., J.N. Matthews, A. Gill, J.C.D. Gordon, and D.W. Macdonald. 1999. Quantitative analysis of tonal calls from five odontocete species, examining interspecific and intraspecific variation. Journal of Zoology 249(4):403-410.

Rice, D. 1998. Marine mammals of the world: Systematics and distribution. Special Publication Number 4. Lawrence, Kansas: The Society for Marine Mammalogy.

Richardson, W. J. 1995. Marine mammal hearing. Pages 205-240 *in* W. J. Richardson, C. R. Greene, Jr., C. I. Malme and D. H. Thomson, eds. Marine mammals and noise. San Diego, California: Academic Press.

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thompson. 1995. Marine mammals and noise. San Diego, California: Academic Press.

Ridgway, S.H. 1966. Dall's porpoise, *Phocoenoides dalli* (True): Observations in captivity and at sea. Norsk Hvalfangst-Tidende 55(5):97-110.

Ridgway, S.H. 1986. Diving by cetaceans. Pages 33-62 in A.O. Brubakk, J.W. Kanwisher, and G. Sundress, eds. Diving in animals and man. Trondheim, Norway: The Royal Norwegian Society of Science and Letters.

Ridgway, S.H., and D.A. Carder. 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. Aquatic Mammals 27(3):267-276.

Ridgway, S.H., and P.L. Joyce. 1975. Studies on seal brain by radiotelemetry. Rapports et Proces-Verbaux des Reunions Conseil International pour I'Exploration de la Mar 169:81-91.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtles. Journal of the Acoustical Society of America 59(1):S46-S46.

Ridgway, S.H., C.A. Bowers, D. Miller, M.L. Schultz, C.A. Jacobs, and C.A. Dooley. 1984. Diving and blood oxygen in the white whale. Canadian Journal of Zoology 62(11):2349-2351.

Ridgway, S.H., D.A. Carder, T. Kamolnick, R.R. Smith, C.E. Schlundt, and W.R. Elsberry. 2001. Hearing and whistling in the deep sea: Depth influences whistle spectra but does not attenuate hearing by white whales (*Delphinapterus leucas*) (Odontoceti, Cetacea). Journal of Experimental Biology 204(22):3829-3841.

Riedman, M.L. 1990. The pinnipeds: Seals, sea lions, and walruses. Berkeley, California: University of California Press.

Ritter, F. 2002. Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. Aquatic Mammals 28(1):46-59.

Rivers, J.A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.

Rogachev, K.A., E.C. Carmack, and M.G.G. Foreman. 2008. Bowhead whales feed on plankton concentrated by estuarine and tidal currents in Academy Bay, Sea of Okhotsk. Continental Shelf Research 28:1811-1826.

Rogers, P.H., and M. Cox. 1988. Underwater sound as a biological stimulus. Pages 131-149 in J. Atema, R.R. Fay, A.N. Popper, W.N. Tavolga, eds. Sensory biology of aquatic animals. New York, New York: Springer-Verlag.

Rogers, T.L., and S.M. Brown. 1999. Acoustic observations of Arnoux's beaked whale (*Berardius arnuxii*) off Kemp Land, Antarctica. Marine Mammal Science 15(1):192-198.

Rohr, J.J., F.E. Fish, and J.W. Gilpatrick. 2002. Maximum swim speeds of captive and free-ranging delphinids: critical analysis of extraordinary performance. Marine Mammal Science 18(1):1-19.

Ronald, K., and P.J. Healey. 1981. Harp seal, *Phoca groenlandica* Erxleben, 1777. Pages 55-87 in Ridgway, S.H., and R.J. Harrison, eds. Handbook of marine mammals. Volume 2: Seals. New York, New York: Academic Press.

Rosenbaum, H.C., R.L. Brownell, M.W. Brown, C. Schaeff, V. Portway, B.N. White, S. Malik, L.A. Pastene, N.J. Patenaude, C.S. Baker, M. Goto, P.B. Best, P.J. Clapham, P. Hamilton, M. Moore, R. Payne, V. Rowntree, C.T. Tynan, J.L. Bannister, and R. DeSalle. 2000. World-wide genetic differentiation of *Eubalaena*: questioning the number of right whale species. Molecular Ecology 9:1793-1802.

Ross, D. 1976. Mechanics of underwater noise. New York, New York: Pergamon Press.

Ross, D. 2005. Ship sources of ambient noise. IEEE Journal of Oceanic Engineering 30(2):257-261.

Ross, G.J.B., P.B. Best, and B.G. Donnelly. 1975. New records of the pygmy right whale (*Caperea marginata*) from South Africa, with comments on distribution, migration, appearance, and behavior. Journal of the Fisheries Research Board of Canada 32:1005-1017.

Rudolph, P., C. Smeenk, and S. Leatherwood. 1997. Preliminary checklist of Cetacea in the Indonesian Archipelago and adjacent waters. Zoologische Verhandelingen 312**:**1-48.

Rugh, D., D. DeMaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore. 2003. A review of bowhead whale (*Balaena mysticetus*) stock identity. Journal of Cetacean Research and Management 5(3):67-279.

SAFMC (South Atlantic Fishery Management Council). 1998. Final habitat plan for the South Atlnatic Region: Essential fish habitat requirements for fishery management plans of the south atlantic fishery management council, the shrimp management plan, the red drum fishery management plan, the snapper grouper fishery management plan, the coastal migratory pelagics fishery management plan, the golden crab fishery management plan, the spiny lobster fishery management plan, the coral, coral reefs, and live/hard bottom habitat fishery managemnet plan, the sargassum habitat fishery management plan, and the calico scallop fishery management plan. Charleston, South Carolina: South Pacific Fishery Management Council. Accessed 2005. <http://www.safmc.net/ecosystem/EcosystemManagement/HabitatProtection/SAFMCHabitatPlan/tabid/80/Default.aspx>.

SAFMC (South Atlantic Fishery Management Council). 2009. South Atlantic fishery management council. Accessed September 2009. <http://www.safmc.net/>.

Sale, A., P. Luschi, R. Mencacci, P. Lambardi, G.R. Hughes, G.C. Hays, S. Benvenuti, and F. Papi. 2006. Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. Journal of Experimental Marine Biology and Ecology 328**:**197-210.

Salvi, R. J.D. Henderson, R.P. Hamernik, and V. Colletti, eds. 1986. Basic and applied aspects of noise-induced hearing loss. New York, New York: Plenum Press.

Samuel, Y., S.J. Morreale, C.W. Clark, C.H. Greene, and M.E. Richmond. 2005. Underwater, low-frequency noise in a coastal sea turtle habitat. Journal of the Acoustical Society of America 117(3):1465-1472.

Sand, O, and HE Karlsen. 1986. Detection of infrasound by the Atlantic cod. Journal of Experimental Biology 125(1):197-204.

Sand, O., P.S. Enger, H.E. Karlsen, F. Knudsen, and T. Kvernstuen. 2000. Avoidance responses to Infrasound in downstream migrating European silver eels, *Anguilla anguilla*. Environmental Biology of Fishes 57(3):327-336.

Santoro, A.K., K.L. Martin, and T.W. Cranford. 1989. Pygmy sperm whale sounds (*Kogia breviceps*). In Abstracts of the 8th biennial conference on the biology of marine mammals, Pacific Grove, California, December 1989.

Sarà, G, J.M. Dean, D D'Amato, G Buscaino, A Oliveri, S Genovese, S Ferro, G Buffa, M.I. Martire, and S Mazzola. 2007. Effect of boat noise on the behaviour of bluefin tuna Thunnus thynnus in the Mediterranean Sea. Marine Ecology Progress Series 331:243-253.

Saunders, J.C., Y.E. Cohen, and Y.M. Szymko. 1991. The structural and functional consequences of acoustic injury in the cochlea and peripheral auditory system: A five year update. Journal of the Acoustical Society of America 90(1):136-146.

Scheer, M., B. Hofmann, and P.I. Behr. 1998. Discrete pod-specific call repertoires among short-finned pilot whales (*Globicephala macrorhynchus*) off the SW coast of Tenerife, Canary Islands. Abstracts of the World Marine Mammal Science Conference, Monaco, 22-24 January 1998.

Scheifele, P.M., S. Andrew, R.A. Cooper, M. Darre, F.E. Musiek, and L. Max. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. The Journal of the Acoustical Society of America 117(3, Part I):1486-1492.

Schellart, N.A.M., and A.N. Popper. 1992. Functional aspects of the evolution of the auditory system of actinopterygian fish. In D.B. Webster, R.R. Fay, and A.N. Popper, eds. Comparative evolutionary biology of hearing. New York, New York: Springer-Verlag.

Schevill, W.E. 1964. Underwater sounds of cetaceans. Pages 307-366 in W.N. Tavolga, ed. Marine bio-acoustics. Oxford, United Kingdom: Pergamon Press.

Schevill, W.E, and B. Lawrence. 1949. Underwater listening to the white porpoise (*Delphinapterus leucas*). Science 109(2824):143-144.

Schevill, W.E., and W.A. Watkins. 1966. Sound structure and directionality in *Orcinus* (killer whale). Zoologica 51(6):71-76.

Schilling, M.R., I. Seipt, M.T. Weinrich, S.E. Frohock, A.E. Kuhlberg, and P.J. Clapham. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. Fishery Bulletin 90:749-755.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. The Journal of the Acoustical Society of America 107(6):3496-3508..

Schlundt, C.E., R.L. Dear, L. Green, D.S. Houser, and J.J. Finneran. 2007. Simultaneously measured behavioral and electrophysiological hearing thresholds in a bottlenose dolphin (*Tursiops truncatus*). The Journal of the Acoustical Society of America 122(1):615-622.

Schlundt, C.E., R.L. Dear, D.S. Houser, T. Reidarson, J.J. Finneran. 2011. Auditory evoked potentials in two short-finned pilot whales (*Globicephala macrorhynchus*). Journal of the Acoustical Society of America 129(2):1111-1116.

Schmidly, D.J. 1981. Marine mammals of the southeastern United States coast and the Gulf of Mexico. FWS/OBS-80/41. Washington, D.C.: Office of Biological Services Program, U.S. Fish and Wildlife Service. 177 pages.

Scholik, A.R., and H.Y. Yan. 2001. Effects of underwater noise on auditory sensitivity of a cyprinid fish. Hearing Research 152:17-24.

Scholik, A.R., and H.Y. Yan. 2002. The effects of noise on the auditory sensitivity of the bluegill sunfish, *Lepomis macrochirus*. Comparative Biochemistry and Physiology, Part A: Physiology 133:43-52.

Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney, and R.D. Andrews. 2009. Movements of satellite-tagged Blainville's beaked whales off the island of Hawai'i. Endangered Species Research 10:203-213.

Schotten, M., W.W.L. Au, M.O. Lammers, and R. Aubauer. 2004. Echolocation recordings and localization of wild spinner dolphins (*Stenella longirostris*) and pantropical spotted dolphins (S. *attenuata*) using a four-hydrophone array. Pages 393-400 in Thomas, J.A., C.F. Moss and M. Vater, eds. Echolocation in bats and dolphins. Chicago, Illinois: University of Chicago Press.

Schreer, J.F., and K.M. Kovacs. 1997. Allometry of diving capacity in air-breathing vertebrates. Canadian Journal of Zoology 75(3):339-358.

Schultz, K.W., D.H. Cato, P.J. Corkeron, and M.M. Bryden. 1995. Low frequency narrow-band sounds produced by bottlenose dolphins. Marine Mammal Science 11(4):503-509.

Schusterman, R.J. 1967. Perception and determinants of underwater vocalization in the California sea lion. In R.G. Busnel, ed. Les systemes sonars amimaux, biologie et bionique. Jouy-en-Josas, France: Laboratoire de Physiologie Acoustique.

Schusterman, R.J. 1978. Vocal communication in pinnipeds. Pages 247-308 in H. Markowitz and V.J. Stevens, eds. Behavior of captive wild animals. Chicago, Illinois: Nelson-Hall.

Scott, M.D., and S.J. Chivers. 1990. Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. Pages 387-402 in S.H. Ridgeway and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and porpoises. New York, New York: Academic Press.

Scott, M.D., S.J. Chivers, R.J. Olson, and R.J. Lindsay. 1993. Radiotracking of spotted dolphins associated with tuna in the eastern tropical Pacific. Abstract in Page 10, Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, TX.

Scott, M.D., A.A. Hohn, A.J. Westgate, J.R. Nicolas, B.R. Whitaker, and W.B. Campbell. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). Journal of Cetacean Research and Management 3(1):87-94.

Scuba Travel, Ltd. 2009. 100 best dive sites of the world. Accessed 2009. <http://www.scubatravel.co.uk/topdiveslong.html>.

Sears, R., and W.F. Perrin. 2009. Blue whale (*Balaenoptera musculus*). Pages 120-124 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Sekiguchi, K., N. Klages, K. Findlay, and P.B. Best. 1993. Feeding habits and possible movements of southern bottlenose whales (*Hyperoodon planifrons*). Proceedings of the NIPR Symposium on Polar Biology 6:84-97.

Sekiguchi, K., M.A. Meyer, P.B. Best, R. Davis, and J.H.M. David. 1998. Satellite-monitored movements and diving patterns of Heaviside's dolphin (*Cephalorhynchus heavisidii*) off St. Helena Bay, South Africa. Pages 122–123 in Proceedings for World Marine Mammal Science Conference, Monaco.

Sergeant, D.E. 1962. The biology of the pilot or pothead whale *Globicephala melaena* (Traill) in Newfoundland waters. Bulletin of the Fisheries Research Board of Canada 132:1-84.

Serrano, A. 2001. New underwater and aerial vocalizations of captive harp seals (*Pagophilus groenlandicus*). Canadian Journal of Zoology 79**:**75-81.

Serrano, A., and J.M. Terhune. 2002. Antimaksing aspects of harp seal (*Pagophilus groenlandicus*) underwater vocalizations. Journal of the Acoustical Society of America 112(6)**:**3083-3090.

Shane, S.H. 1995. Behavior patterns of pilot whales and Risso's dolphins off Santa Catalina Island, California. Aquatic Mammals 21(3):195-198.

Sharpe, F.A., and L.M. Dill. 1997. The behavior of Pacific herring schools in response to artificial humpback whale bubbles. Canadian Journal of Zoology 75(5):725-730.

Shillinger, G.L., D.M. Palacios, H. Bailey, S.J. Bograd, A.M. Swithenbank, P. Gaspar, B.P. Wallace, J.R. Spotila, F.V. Paladino, R. Piedra, S.A. Eckert, B.A. Block. 2008. Persistent leatherback migrations present opportunities for conservation. Public Library of Science Biology 6(7):0001-0009.

Silber, G.K., S. Bettridge, and D. Cottingham. 2009. Report of a workshop to identify and assess technologies to reduce ship strikes of large whales; Providence, Rhode Island, 8-10 July 2008. NOAA Technical Memorandum NMFS-OPR-42. Silver Spring, Maryland: National Oceanic and Atmospheric Administration, National marine Fisheries Service. 55 pages.

Simmonds, M.P., and J.D. Hutchinson, eds. 1996. The conservation of whales and dolphins: science and practice. Chichester, United Kingdom: John Wiley and Sons.

Sjare, B.L., and T.G. Smith. 1986. The vocal repertoire of white whales, *Delphinapterus leucas*, summering in Cunningham Inlet, Northwest Territories. Canadian Journal of Zoology 64(2):407-415.

Slooten, E., and S.M. Dawson. 1994. Hector's dolphin, *Cephalorhynchus hectori* (van Beneden, 1881). Pages 311-333 in S.H. Ridgeway and R.J. Harrison, eds. Handbook of Marine Mammals. Volume 5: The first book of dolphins. New York, New York: Academic Press.

Slooten, E., S. Dawson and W. Rayment. 2002. Quantifying abundance of Hector's dolphins between Farewell Spit and Milford Sound. DOC Science Internal Series 35**:**5-18. Department of Conservation, Wellington, New Zealand.

Slotte, K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research 67(2):143-150.

Smith, M.E., A.S. Kane, and A.N. Popper. 2004a Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). Journal of Experimental Biology 207:427-435.

Smith, M.E., A.S. Kane, and A.N. Popper. 2004b Acoustical stress and hearing sensitivity in fishes: Does the linear threshold shift hypothesis hold water? Journal of Experimental Biology 207:3591-3602.

Smith, M.E., A.B. Coffin, D.L. Miller, and A.N. Popper. 2006. Anatomical and functional recovery of the goldfish (*Carassius auratus*) ear following noise exposure. Journal of Experimental Biology 209(21): 4193-4202.

Song, J., D.A. Mann, P.A. Cott, B.W. Hanna, and A.N. Popper. 2008. The inner ears of northern Canadian freshwater fishes following exposure to seismic air gun sounds. Journal of the Acoustical Society of America 124(2):1360-1366.

Soria, M., T. Bahri, and F. Gerlotto. 2003. Effect of external factors (environment and survey vessel) on fish school characteristics observed by echosounder and multibeam sonar in the Mediterranean Sea. Aquating Living Resources 16(3):145-157.

Sorokin, M.A., S.V. Donskoi, and A.N. Lebedva. 1988. Sound reception in Clupeidae. Russian Journal of Marine Biology (Biologiya Morya) 2:24-40.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4)**:**411-522.

Southall, B., J. Berkson, D. Bowen, R. Brake, J. Eckman, J. Field, R. Gisiner, S. Gregerson, W. Lang, J. Lewandoski, J. Wilson, and R. Winokur. 2009. Addressing the effects of human-generated sound on marine life: An integrated research plan for U.S. federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology, Washington, D.C.

Spalding, M. 1998. Workshop on legal aspects of whale watching, Punta Arenas, Chile. The Journal of Environment and Development 7(2):184-188.

Sperling, J.B. 2007. The behaviour and physiology of the gravid flatback turtle (*Natator depressus*). Ph.D. thesis. The University of Queensland, Australia.

Sperling, J.B. 2008. Two new dive types with a gradual ascent phase in flatback turtles (*Natator depressus*). Marine Turtle Newsletter 120:9-11. Accessed October 2010. <http://www.seaturtle.org/mtn/archives/mtn120/mtn120p9.shtml>.

Spotila, J.R. 2004. Sea turtles: A complete guide to their biology, behavior, and conservation. Baltimore, Maryland: John Hopkins University Press.

Spotila, J.R., M.P. O'Conner, and F.V. Paladino. 1997. Thermal biology. Pages 297-314 in P.L. Lutz and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press, Inc.

Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405**:**529-530.

Stacey, P.J., S. Leatherwood, and R.W. Baird. 1994. *Pseudorca crassidens*. Mammalian Species 456:1-6.

Starbird, C.H., Z. Hillis-Starr, J.T. Harvey, and S.A. Eckert. 1999. Internesting movements and behavior of hawksbill turtles (*Eretmochelys imbricata*) around Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Chelonian Conservation and Biology 3(2)**:** 237-243.

Stafford, K.M., C.G. Fox, and D.S. Clark. 1998. Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean. The Journal of the Acoustical Society of America 104(6): 3616-3625.

Stafford, K.M, S.L. Nieukirk, and C.G. Fox. 1999a. An acoustic link between blue whales in the eastern tropical Pacific and the northeast Pacific. Marine Mammal Science 15(4):1258–1268.

Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 1999b. Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. The Journal of the Acoustical Society of America 106(6):3687-3698.

Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific. Journal of Cetacean Research and Management 3(1):65-76.

Stafford, K.M., S.E. Moore, K.L. Laidre, and M.P. Heide- Jørgensen. 2008. Bowhead whale springtime song off West Greenland. Journal of the Acoustical Society of America 124(5):3315-3323.

Steiner, W.W. 1981. Species-specific differences in pure tonal whistle vocalizations of five western North Atlantic dolphin species. Behavioral Ecology and Sociobiology 9(4):241-246.

Steiner, W.W., J.H. Hain, H.E. Winn, and P.J. Perkins. 1979. Vocalizations and feeding behavior of the killer whale (*Orcinus orca*). Journal of Mammalogy 60(4):823-827.

Sterling, J.T., and R.R. Ream. 2004. At-sea behavior of juvenile male northern fur seals (*Callorhinus ursinus*). Canadian Journal of Zoology 82(10):1621-1637.

Stevick, P.T., J. Allen, P.J. Clapham, N. Friday, S.K. Katona, F. Larsen, J. Lien, et al. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258: 263-273.

Stewart, B.S. 2009. Diving behavior. Pages 321-327 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition San Diego, California: Academic Press.

Stewart, B. S, and R. L DeLong. 1994. Postbreeding foraging migrations of northern elephant seals. Pages 290-309 in B.J. Le Boeuf and R.M. Laws, eds. Elephant seals: population, ecology, bBehavior and physiology. Berkeley, California: University of California Press.

Stirling, I. 1971. Studies on the behaviour of the South Australian fur seal, *Arctocephalus forsteri* (Lesson). I. Annual cycles, postures, and call of adult males during the breeding season. Australian Journal of Zoology 19:267-273.

Stone, G.S., S.K. Katona, and E.B. Tucker. 1987. History, migration and present status of humpback whales *Megaptera novaeangliae* at Bermuda. Biological Conservation 42(2)**:**133-145.

Strong, C.S. 1990. Ventilation patterns and behavior of Balaenopterid whales in the Gulf of California, Mexico. San Francisco, California: San Francisco State University.

Sudara, S., and S. Mahakunayanakul. 1998. Distribution and river intrusion of dolphins in the inner Gulf of Thailand. Abstract in World Marine Mammal Science Conference, Monaco, 22-24 January 1998.

Sutherland, R.W., and E.G. Sutherland. 2003. Status of the flatback sea turtle (*Natator depressus*) rookery on Crab Island, Australia, with notes on predation by crocodiles. Chelonian Conservation and Biology 4(3):612-619.

Suzuki, H., E. Hamada, K. Saito, Y. Maniwa, and Y. Shirai. 1979. Underwater sound produced by ships to influence marine organisms. In Man & navigation: An international congress, 10-14 September 1979. The International Association of Institutes of Navigation. London, United Kingdom: Royal Institute of Navigation.

Szymanski, M.D., D.E. Bain, K. Kiehl, S. Pennington, S. Wong, and K.R. Henry. 1999. Killer whale (*Orcinus orca*) hearing: auditory brainstem response and behavioral audiograms. The Journal of the Acoustical Society of America 106(2):1134-1141.

Taruski, A.G. 1979. The whistle repertoire of the North Atlantic pilot whale (*Globicephala melaena*) and its relationship to behavior and environment. Pages 345-368 in H.E. Winn and B.L. Olla, eds. Behavior of marine animals: current perspectives in research: Volume 3. Cetaceans. New York: Plenum Press.

Tavolga, W.N., and J. Wodinsky. 1965. Auditory capacities in fishes: threshold variability in the blue-striped grunt, *Haemulon sciurus*. Animal Behaviour 13(2):301-11.

Terhune, J.M. 1989. Underwater click hearing thresholds of a harbour seal, *Phoca vitulina*. Aquatic Mammals 15(1):22-26.

Terhune, J.M. 1991. Masked and unmasked pure tone detection thresholds of a harbour seal listening in air. Canadian Journal of Zoology 69(8):2059-2066.

Terhune, J.M., and K. Ronald. 1972. The harp seal, *Pagophilus groenlandicus* (Erxleben, 1777). Part 3: The underwater ethogram. Canadian Journal of Zoology 49:385-390.

Terhune, J.M., and K. Ronald. 1973. Some hooded seal (*Cystophora cristata*) sounds in March. Canadian Journal of Zoology 51(3):319-321.

Terhune, J.M., and K. Ronald. 1975a. Masked hearing thresholds of ringed seals. The Journal of the Acoustical Society of America 58(2):515-516.

Terhune, J.M., and K. Ronald. 1975b. Underwater hearing sensitivity of two ringed seals (*Pusa hispida*). Canadian Journal of Zoology 53(3):227-231.

Terhune, J., and S. Turnbull. 1995. Variation in the psychometric functions and hearing thresholds of a harbour seal. Pages 81-93 in R.A. Kastelein, J.A. Thomas, and P.E. Nachtigal, eds. Sensory systems of aquatic mammals. Woerden, The Netherlands: De Spil.

Tershy, B.R. 1992. Body size, diet, habitat use, and social behavior of *Balaenoptera* whales in the Gulf of California. Journal of Mammalogy 73(3):477-486.

Tervo, O.M., S.E. Parks, and L.A. Miller. 2009. Seasonal changes in the vocal behavior of bowhead whales (*Balaena mysticetus*) in Disko Bay, Western-Greenland. Journal of the Acoustical Society of America 126(3):1570-1580.

Thewissen, H.G.M. 2002. Hearing. Pages 570-574 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Thode, A., D.K. Mellinger, S. Stienessen, A. Martinez, and K. Mullin. 2002. Depth-dependent acoustic features of diving sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico. The Journal of the Acoustical Society of America 112(1):308-321.

Thomas, J.A., and C.W. Turl. 1990. Echolocation characteristics and range detection threshold of a false killer whale (*Pseudorca crassidens*). Pages 321-334 in J.A. Thomas and R.A. Kastelein, eds. Sensory abilities of cetaceans: Laboratory and field evidence. New York, New York: Plenum Press.

Thomas, J.A., P.W.B. Moore, P.E. Nachtigall, and W.G. Gilmartin. 1990. A new sound from a stranded pygmy sperm whale. Aquatic Mammals 16:28-30.

Thomas, J., P. Moore, R. Withrow, and M. Stoermer. 1990a. Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). 1990a The Journal of the Acoustical Society of America 87(1):417-420.

Thomas, T., W.J. Richardson, W.R. Koski, and B. Würsig. 2003. Surfacing, respiration and dive cycles of bowhead whales (*Balaena mysticetus*) in the Beaufort Sea: Calves, subadults and adults. Page 162 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Thompson, D., S.E.W. Moss, and P. Lovell. 2003. Foraging behaviour of South American fur seals *Arctocephalus australis*: Extracting fine scale foraging behaviour from satellite tracks. Marine Ecology Progress Series 260**:**285-296.

Thompson, P.O., and W.A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Thompson, P.O., W.C. Cummings, and S.J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. The Journal of the Acoustical Society of America 80(3):735-740.

Thompson, P.O., L.T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. The Journal of the Acoustical Society of America 92(6):3051-3057.

Thompson, T.J., H.E. Winn, and P.J. Perkins. 1979. Behavior of marine animals, Vol. 3. H.E. Winn and B.L. Olla, eds. New York, New York: Plenum Press.

Thomson, D.H., and W.J. Richardson. 1995. Marine mammal sounds. Pages 159-204 in Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson, eds. Marine mammals and noise. San Diego, California: Academic Press.

Thorpe, C.W., and C.W. Dawson. 1991. Automatic measurement of descriptive features of Hector's dolphin vocaliations. The Journal of the Acoustical Society of America 89(1):435-443.

Tougaard, J., and L.Y. Kyhn. 2010. Echolocation sounds of hourglass dolphins (*Lagenorhynchus cruciger*) are similar to the narrow band high-frequency echolocation sounds of the dolphin genus *Cephalorhynchus*. Marine Mammal Science 26(1):239-245.

Tremel, D.P., J.A. Thomas, K.T. Ramirez, G.S. Dye, W.A. Bachman, A.N. Orban and K.K. Grimm. 1998. Underwater hearing sensitivity of a Pacific white-sided dolphin, *Lagenorhynchus obliquidens*. Aquatic Mammals 24(2)**:**63-69.

Tripovich, J.S., R. Canfield, T.L. Rogers, and J.P.Y. Arnould. 2008. Characterization of Australian fur seal vocalizations during the breeding season. Marine Mammal Science 24(4):913-928.

Trukhin, A.M. 2005. Spotted seal. Russian Academy of Sciences, Dalnauka, Vladivostok (In Russisan).

Trukhin, A.M., and A.W. Mizuno. 2002. Distribution and abundance of the largha seal (*Phoca largha* Pall.) on the coast of Primorye Region (Russia): A literature review and survey report. Mammal Study 27**:**1-14.

Turnpenny, A.W.H, K.P. Thatcher, and J.R. Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound. Southampton SO45 ITW. Hampshire, United Kingdom: Fawley Aquatic Research Laboratories, Ltd.

Tyack, P. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. Behavioral Ecology and Sociobiology 8(2):105-116.

Tyack, P., and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. Behaviour 83:132-154.

Tyack, P.L. 2000. Functional aspects of cetacean communication. Pages 270-307 in J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead, eds. Cetacean societies: Field studies of dolphins and whales. Chicago, Illinois: University of Chicago Press.

Tyack, P.L. 2008. Implications for marine mammals of large-scale changes in the marine acoustic environment. Journal of Mammalogy 89(3):549–558.

Tyack, P.L., and C.W. Clark. 2000. Communication and acoustic behavior of dolphins and whales. Pages 156–224 in W.W.L. Au, A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Tyler, G. 1992. The emergence of low-frequency active acoustics as a critical antisubmarine warfare technology. Johns Hopkins APL Technical Digest 13(1):145-159. Accessed <http://www.fas.org/man/dod-101/sys/ship/weaps/tyler.pdf>.

Udovydchenkov, I.A., T.F. Duda, S.C. Doney, and I.D. Lima. 2010. Modeling deep ocean shipping noise in varying acidity conditions. Journal of the Acoustical Society of America 128:EL130-EL136.

UNESCO (United Nations Educational, Scientific, and Cultural Organization). 2009. Pelagos: The cetacean sanctuary. Accessed September 2009. <http://whc.unesco.org/en/tentativelists/2032/>.

Unnithan, S. 2009. Deep impact; The historic launch of India's nuclear submarine adds a new member to what was an exclusive Big Five club. India Today, No. 3.

UNOLS (University-National Oceanographic Laboratory System). 2009. What is UNOLS? Accessed May 1, 2009. <http://www.unols.org/info/unols.html>.

Urick, R.J. 1983. Principles of underwater sound, 3rd edition. New York, New York: McGraw-Hill.

USDC-NDC (U.S. District Court for the Northern District of California). 2002. Opinion and order granting plaintiff's motion for a preliminary injunction. No. C-02-3805 EDL. USDC-NDC, San Francisco, California.

USDC-NDC (U.S. District Court for the Northern District of California). 2003. Opinion and order on cross-motions for summary judgment. No. C-02-3805 EDL. USDC-NDC, San Francisco, California.

Van Bree, P.J.H. 1997. On extralimital records of Arctic seals (*Mammalia, Pinnipedia*) on the Westeuropean continental coast in the past and at present—A summary. Beaufortia 47(5)**:**153-156.

Van den Berg, A.V., and A. Schuijf. 1983. Discrimination of sounds based on the phase difference between particle motion and acoustic pressure in the shark *Chiloscyllium griseum*. Proceedings of the Royal Society of London, Series B, Biological Sciences 218(1210):127-134.

Van Parijs, S.M., V.M. Janik, and P.M. Thompson. 2000. Display-area size, tenure length, and site fidelity in the aquatically mating male harbour seal, *Phoca vitulina*. Canadian Journal of Zoology 78(12):2209-2217.

Van Parijs, S.M., and K.M. Kovacs. 2002. In-air and underwater vocalizations of eastern Canadian harbour seals, *Phoca vitulina*. Canadian Journal of Zoology 80(7):1173-1179.

Van Waerebeek, K., and B. Würsig. 2009. Dusky dolphin (*Lagenorhynchus obscurus*). Pages 335-338 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego, California: Academic Press.

Vanderlaan, A.S.M., A.E. Hay, and C.T. Taggart. 2003. Characterization of North Atlantic right-whale (*Eubalaena glacialis*) sounds in the Bay of Fundy. IEEE Journal of Oceanic Engineering 28(2):164-173.

Vasconcelos, R.O., M.C.P. Amorim, and F. Ladich. 2007. Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish. Journal of Experimental Biology 210(12):2104-2112.

Verboom, W.C., and R.A. Kastelein. 2007. Structure of harbor porpoise (*Phocoena phocoena*) click train signals. Pages 343-363 in A.J. Read, P.R. Wiepkema, and P.E. Nachtigall, eds. The biology of the harbor porpoise. Woerden, The Netherlands: De Spil Publishers.

Viada, S.T., R.M. Hammer, R. Racca, D. Hannay, M.J. Thompson, B.J. Balcom, and N.W. Phillips. 2008. Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. Environmental Impact Assessment Review 28**:** 267-285.

Villadsgaard, A., M. Wahlberg, and J. Tougaard. 2007. Echolocation signals of wild harbour porpoises, *Phocoena phocoena*. Journal of Experimental Biology 210(1):56-64.

Villegas-Amtmann, S., D.P. Costa, Y. Tremblay, D. Aurioles-Gamboa, and S. Salazar. 2008. Multiple foraging strategies in a marine apex predator, the Galápagos sea lion. Marine Ecology Progress Series 363:299-309.

Wade, P., M.P. Heide-Jørgensen, K. Shelden, J. Barlow, J. Caretta, J. Durban, R. Leduc, L. Munger, S. Rankin, and C. Stinchcomb. 2006. Acoustic detection and satellite-tracking leads to discovery of rare concentration of endangered North Pacific right whales. Biology Letters 2(3):417-419.

Wade, P.R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Report of the International Whaling Commission 43:477-493.

Wahlberg, M. 2002. The acoustic behaviour of diving sperm whales observed with a hydrophone array. Journal of Experimental Marine Biology and Ecology 281(1):53-62.

Walker, T.A., and C.J. Parmenter. 1990. Absence of a pelagic phase in the life cycle of the flatback turtle, *Natator depressa* (Garman). Journal of Biogeography 17:275-278.

Wallace, B.P., C.L. Williams, F.V. Paladino, S.J. Morreale, R.T. Lindstrom, and J.R. Spotila. 2005. Bioenergetics and diving activity of internesting leatherback turtles *Dermochelys coriacea* at Parque Nacional Marino Las Baulas, Costa Rica. Journal of Experimental Biology 208:3873-3884.

Wang, J.Y., and S.C. Yang. 2009. Indo-Pacific bottlenose dolphin. Page 602-608 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego: Academic Press.

Ward, W.D. 1997. Effects of high-intensity sound. Pages 1497-1507 in M.J. Crocker, ed. Encyclopedia of acoustics. New York, New York: J. Wiley and Sons, Inc.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21(8):1005-1027.

Waring, G.T., E. Josephson, C.P. Fairfield-Walsh, and K. Maze-Foley, eds. 2009. US Atlantic and Gulf of Mexico marine mammal stock assessments–2008. NOAA Technical Memorandum NMFS-NE-210. Woods Hole, Massachusetts: Northeast Fishery Science Center, National Marine Fisheries Service. 440 pages.

Waring, G., E. Josephson, K. Maze-Foley, P.E. Rosel, eds. 2010. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments–2010. NOAA Technical Memorandum NMFS-NE-219. Woods Hole, Massachusetts: Northeast Fisheries Science Center, National Marine Fisheries Service. 606 pages.

Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal 37:6-15.

Watkins, W.A. 1967. The harmonic interval: Fact or artifact in spectral analysis of pulse trains. In W.M. Tavolga, ed. Marine bio-acoustics, Volume 2. Oxford, United Kingdom: Pergamon Press.

Watkins, W.A. 1981. Activities and underwater sounds of fin whales. Scientific Report of the Whales Research Institute 33:83-117.

Watkins, W.A., and G.C. Ray. 1977. Underwater sounds from ribbon seal, *Phoca (Histriophoca) fasciata*. Fishery Bulletin 75:450-453.

Watkins, W.A., and W.E. Schevill. 1977. Sperm whale codas. The Journal of the Acoustical Society of America 62(6):1485-1490.

Watkins, W.A., and D. Wartzok. 1985. Sensory biophysics of marine mammals. Marine Mammal Science 1(3):219–260.

Watkins, W.A., W.E. Schevill, and P.B. Best. 1977. Underwater sounds of *Cephalorhynchus heavisidii* (Mammalia: Cetacea). Journal of Mammalogy 58(3):316-320.

Watkins, W.A., K.E. Moore, and P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Watkins, W.A., P. Tyack, K.E. Moore, and J.E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). The Journal of the Acoustical Society of America 82(6):1901-1912.

Watkins, W.A., P. Tyack, K.E. Moore, and G. Notarbartolo-Di-Sciara. 1987a. *Steno bredanensis* in the Mediterranean Sea. Marine Mammal Science 3(1):78-82.

Watkins, W.A., M.A. Daher, K.M. Fristrup, and G. Notarbartolo-Di-Sciara. 1994. Fishing and acoustic behavior of Fraser's dolphin (*Lagenodelphis hosei*) near Dominica, Southeast Caribbean. Caribbean Journal of Science 30(1):76–82.

Watkins, W.A., M.A. Daher, A. Samuels, and D.P. Gannon. 1997. Observations of *Peponocephala electra*, the melon-headed whale, in the southeastern Caribbean. Caribbean Journal of Science 33(1-2):34-40.

Watkins, W.A., M.A. Daher, N.A. Dimarzio, A. Samuels, D. Wartzok, K.M. Fristrup, P.W. Howey, and R.R. Maiefski. 2002. Sperm whale dives tracked by radio tag telemetry. Marine Mammal Science 18(1):55-68.

Watson, C.S. 2005. Some comments on informational masking. Acta Acustica united with Acustica 91(3):502-512.

WDPA (World Database on Protected Areas). 2009. 2009 World database on protected areas annual release. Accessed October 2009. <http://www.wdpa.org/AnnualRelease.aspx>.

Webb, J.F., J.C. Montgomery, and J. Mogdans. 2008. Bioacoustics and the lateral line system of fishes. Chapter 5. Pages 145-182 in J.F. Webb, A.N. Popper, and R.R. Fay, eds. Fish bioacoustics. Springer Handbook of Auditory Research, Volume 32, R.R. Fay and A.N. Popper, series eds. New York, New York: Springer Science+Business Media, LLC.

Weilgart, L.S. and H. Whitehead. 1990. Vocalization of the North Atlantic pilot whale (*Globicephala melaena*) as related to behavioral contexts. Behavioral Ecology and Sociobiology 26(6):399-402.

Weilgart, L., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galapagos Islands. Canadian Journal of Zoology 71(4):744-752.

Weilgart, L., and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40(5):277-285.

Weir, C.W. 2007. Observations of marine turtles in relation to seismic airgun sound off Angola. Marine Turtle Newsletter 116:17-20.

Weller, D.W., B. Würsig, S.K. Lynn, and A.J. Schiro. 2000. Preliminary findings on the occurrence and site fidelity of photo-identified sperm whales (*Physeter macrocephalus*) in the northern Gulf of Mexico. Gulf of Mexico Science 18(1):35-39.

Wells, R.S., and M.D. Scott. 2009. Common bottlenose dolphin (*Tursiops truncatus*). Pages 249-255 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition San Diego, California: Academic Press.

Weng, K.C., A.M. Boustany, P. Pyle, S.D. Anderson, A. Brown, and B.A. Block. 2007. Migration and habitat of white sharks (*Carcharodon carcharias*) in the eastern Pacific Ocean. Marine Biology 152(4): 877-894.

Werner, R., and C. Campagna. 1995. Diving behaviour of lactating southern sea lions (*Otaria flavescens*) in Patagonia. Canadian Journal of Zoology 73(11):1975-1982.

Westgate, A.J., A.J. Read, P. Berggren, H.N. Koopman, and D.E. Gaskin. 1995. Diving behaviour of harbour porpoises, *Phocoena phocoena*. Canadian Journal of Fisheries and Aquatic Sciences 52(5):1064–1073.

Whales Bermuda. 2008. Humpback whales in Bermuda. Accessed <http://whalesbermuda.com/>.

Whitehead, H. 2009. Sperm whale. Pages 1091-1097 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego: Academic Press.

Whitehead, H., and L. Weilgart. 1991. Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. Behaviour 118(3):275-296.

Whitehead, H., A. Faucher, S. Gowans, and S. McCarrey. 1997. Status of the northern bottlenose whale, *Hyperoodon ampullatus*, in the Gully, Nova Scotia. Canadian Field-Naturalist 111(2):287-292.

Whiting, A.U., A. Thomson, M. Chaloupka, and C.J. Limpus. 2009. Seasonality, abundance, and breeding biology of one of the largest populations of nesting flatback turtles, Natator depressus: Cape Domett, Western Australia. Australian Journal of Zoology 56(5):297-303.

Whitman, E.C. 2001. Air-independent propulsion—AIP technology creates a new undersea threat. Undersea Warfare Fall 2001. Accessed: <http://www.navy.mil/navydata/cno/n87/usw/issue_13/propulsion.htm>.

WHOI (Woods Hole Oceanographic Institute). 2008. Ocean acoustic tomography. Woods Hole Oceanographic Institute, Ocean Acoustics Lab. Accessed May 4, 2009. <http://www.oal.whoi.edu/tomo2.html>.

Williams, T.M. 2009. Swimming. Pages 1140-1147 in W.F. Perrin, B. Wursig, and H.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Willis, P.M., and R.W. Baird. 1998. Status of the dwarf sperm whale, *Kogia simus*, with special reference to Canada. Canadian Field-Naturalist 112(1):114-125.

Wilson, M., R.T. Hanlon, P.L. Tyack, and P.T. Madsen. 2007. Intense ultrasonic clicks from echolocating toothed whales do not elicit anti–predator responses or debilitate the squid *Loligo pealeii*. Biology Letters (3):225.

Winn, H.E., and P.J. Perkins. 1976. Distribution and sounds of the minke whale, with a review of mysticete sounds. Cetology 19:1-12.

Wolfe, R.J., J.A. Fall, and M. Riedel. 2009. The subsistence harvest of harbor seals and Steller sea lions by Alaskan natives in 2008. Technical Paper 347. Final report for year sixteen, Harvest Assessment Program. Alaska Department of Fish and Game, Division of Subsistence, Anchorage, Alaska. 252 pages.

Wolski, L.F., R.C. Anderson, A.E. Bowles, and P.K. Yochem. 2003. Measuring hearing in the harbor seal (*Phoca vitulina*): Comparison of behavioral and auditory brainstem response techniques. Journal of the Acoustical Society of America 113(1)**:**629-637.

WPFMC (Western Pacific Fishery Management Council). 2009. Western Pacific fishery management council. Accessed September 2009. <http://www.wpcouncil.org/>.

Würsig, B. 1982. Radio tracking dusky porpoises in the South Atlantic. Pages 145-160 in Mammals in the sea. Volume 4, Small cetaceans, seals, sirenians and otters. Food and Agriculture Organization, Fisheries Series No. 5.

Würsig, B., and W.J. Richardson. 2009. Effects of noise. Pages 765-773 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. San Diego, California: Academic Press.

Würsig, B., and M. Würsig. 1980. Behavior and ecology of the dusky dolphin, *Lagenorhynchus obscurus,* in the south Atlantic. Fishery Bulletin 77(4):871-890.

Wyneken, J. 1997. Sea turtle locomotion: Mechanisms, behavior, and energetics. Pages 165-198 in P.L. Lutz and J.A. Musick. eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Wynne, K., and M. Schwartz. 1999. Guide to marine mammals and turtles of the U.S. Atlantic and Gulf of Mexico. Narragansett, Rhode Island: Rhode Island Sea Grant.

Wysocki, L.E., and F. Ladich. 2005. Effects of noise exposure on click detection and the temporal resolution ability of the goldfish auditory system. Hearing Research 201:27-35.

Wysocki, L.E., J.W. Davidson III, M.E. Smith, A.S. Frankel, W.T. Ellison, P.M. Mazik, A.N. Popper, and J. Bebak. 2007. Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout *Oncorhynchus myki*ss. Aquaculture 272(1):687-697.

Yan, H.Y., and A.N. Popper. 1992. Auditory sensitivity of the cichlid fish *Astronotus ocellatus* (Cuvier). Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 171(1):105-109.

Yang, Z., Z. Wang, C. Tang, and Y. Ying. 1996. Biological effects of weak blast waves and safety limits for internal organ injury in the human body. Journal of Trauma 40:S81-S84.

Yatsu, A., H. Shimada, M. Murata. 1993. Distributions of epipelagic fishes, squids, marine mammals, seabirds, and sea turtles in the central North Pacific. International North Pacific Fisheries Commission Bulletin 53:111-146.

Yelverton, J.T., D.R. Hicks, K. Saunders, and E.R. Fletcher. 1975. The relationship between fish size and rheir response to underwater blast. Washington, D.C.: Defense Nuclear Agency.

Yemelyanenkov, A. 2008. BBC monitoring former Soviet Union. 28 November 2008. Accessed: <http://mutex.gmu.edu:2048/login?url=http://proquest.umi.com/pqdweb?did=1601362391&Fmt=7&clientId=31810&RQT=309&VName=PQD>.

Young, B.A. 2003. Snake bioacoustics: Toward a richer understanding of the behavioral ecology of snakes. The Quarterly Review of Biology 78(3):303.

Yuen, M.M.L., P.E. Nachtigall, M. Breese, and A.Y. Supin. 2005. Behavioral and auditory evoked potential audiograms of a false killer whale (*Pseudorca crassidens*). Journal of the Acoustical Society of America 118(4):2688-2695.

Zelick, R., D. Mann, and A.N. Popper. 1999. Acoustic communication in fishes and frogs. Pages 363-411 in R.R. Fay and A.N. Popper, eds. Comparative hearing: Fish and amphibians. New York, New York: Springer-Verlag.

Zhang, G., T. Hiraishi, K. Motomatsu, K. Yamamoto, and K. Nashimoto. 1998. Auditory threshold of marbled sole (*Pleuronectes yokohamae*). Nippon Suisan Gakkaishi 64(2):211-215.

Zimmer, W.M.X., and P.L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whales. Marine Mammal Science 23(4):888-925.

Zimmer, W.M.X., P.L. Tyack, M.P. Johnson, and P.T. Madsen. 2005. Three-dimensional beam pattern of regular sperm whale clicks confirms bent-horn hypothesis. The Journal of the Acoustical Society of America 117(3), Part I:1473-1485.

Zimmer, W.M.X., M.P. Johnson, P.T. Madsen, and P.L. Tyack. 2005a. Echolocation clicks of free-ranging Cuvier's beaked whales (*Ziphius cavirostris*). The Journal of the Acoustical Society of America 117(6):3919-3927.

Zingareli, R., D. King, L. Gainey & E. Holmes. 1999. Software test description for the Parabolic Equation/Finite Element Parabolic Equation model. Version 5.0. 38 pages.

THIS PAGE IS INTENTIONALLY LEFT BLANK

10.0 LIST OF PREPARERS AND REVIEWERS

Department of the Navy

- Jeffery S. Currer, Captain

  Chief of Naval Operations
  Branch Head, Undersea Capabilities, N2/N6F24
  M.A., Economics

- Neil T. Smith, Commander

  Chief of Naval Operations,
  Undersea Capabilities, N2/N6F24
  Requirements Officer SURTASS LFA Sonar Systems
  M.S., Air Ocean Sciences

- Rachael A. Dempsey, Commander

  Chief of Naval Operations,
  Undersea Capabilities, N2/N6F24
  Requirements Officer SURTASS LFA Sonar Systems
  M.S., Physical Oceanography

National Marine Fisheries Service

- Jolie Harrison

  Office of Protected Resources; Permits, Conservation, and Education Division
  Supervisory Resource Management Specialist
  M.S., Environmental Science

- Jeannine Cody

  Office of Protected Resources; Permits, Conservation, and Education Division
  Fishery Biologist
  M.S., Animal Science

- Kristine Petersen

  Office of Protected Resources; Endangered Species Division
  Fishery Biologist
  M.S., Marine Biology

- Amy Scholik-Schlomer

  Office of Protected Resources; Marine Mammal and Sea Turtle Conservation Division
  Fishery Biologist
  Ph.D., Biology

- Shane Guan

  Office of Protected Resources; Permits, Conservation, and Education Division
  Fishery Biologist
  M.S., Marine Biology

- Jason Gedamke

  Office of Science and Technology
  Ocean Acoustics Program Manager
  Ph.D., Ocean Sciences

Cornell University

- Christopher W. Clark

  I. P. Johnson Director, Bioacoustics Research Program
  Cornell Laboratory of Ornithology
  Senior Scientist, Department of Neurobiology and Behavior
  Ph.D., Biology

University of Maryland

- Arthur N. Popper

  Neuroscience and Cognitive Science Program, Director
  Associate Dean, Graduate School
  Biology, Professor
  Ph.D., Biology

Marine Acoustics, Inc.

- William T. Ellison

  Subject Matter Expert in Acoustics; Reviewer
  Ph.D., Acoustics

- Clayton H. Spikes

  Program Manager; Editor-in-Chief
  M.S., Physical Oceanography

- Adam S. Frankel

  Senior Marine Mammal Bioacoustician
  Ph.D., Biological Oceanography

- Stanley J. Labak

  Acoustician, Ocean Engineer
  M.S., Ocean Engineering

- John F. Mayer

  Project Manager; Regulatory Specialist; Editor
  M.S., Chemical Oceanography

- Cheryl L. Schroeder

  Senior Marine Biologist; Assistant Editor
  M.S., Biological Oceanography

- Kathleen J. Vigness-Raposa

  Senior Marine Biologist
  Ph.D., Environmental Sciences

- David Zeddies
  AIM Modeler; Experimental Biologist
  Ph.D., Neuroscience
- Brian Gunn
  Research Analyst
  M.A., History

TASC, Inc.

- Timothy G. Kline
  Technical Advisor; Reviewer
  B.S., Mathematics

THIS PAGE IS INTENTIONALLY LEFT BLANK

APPENDIX A— CORRESPONDENCE

THIS PAGE IS INTENTIONALLY LEFT BLANK

DEPARTMENT OF THE NAVY

OFFICE OF THE ASSISTANT SECRETARY
(INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON DC 20350-1000

November 14, 2008

MEMORANDUM FOR THE DEPUTY CHIEF OF NAVAL OPERATIONS FOR INTEGRATION OF CAPABILITIES AND RESOURCES (N8)

SUBJECT: SURTASS LFA Sonar Supplemental Eis/Supplemental OEIS

I previously reviewed the Final Supplemental Environmental Impact Statement (Final SEIS) for the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar and the August 15, 2007 Record of Decision (ROD) concerning the continued employment of SURTASS LFA sonar systems. I found that the analysis of the Final SEIS took the requisite "hard look" at the environmental consequences of the decision to employ SURTASS LFA sonar systems and that the ROD adequately addressed issues raised.

Due to recent concerns raised during litigation over employment of the SURTASS LFA Sonar system, and to support issuance of a new Final Rule under the Marine Mammal Protection Act (MMPA) for employment of SURTASS LFA sonar systems, I have determined that the purposes of the National Environmental Policy Act (NEPA) and Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions) would be furthered by the preparation of additional supplemental analysis related to the employment of the system. This analysis should take the form of a new SEIS / supplemental overseas environmental impact statement (SOEIS).

Based on discussions with the Department of Justice, the new SEIS/SOEIS must provide further analysis of potential additional offshore (greater than 12 nm) biologically important areas (OBIAs) in regions of the world where the Navy intends to use the SURTASS LFA sonar systems for routine training, testing, and military operations. The phrase "military operations" does not include use of SURTASS LFA in armed conflict or direct combat support operations nor to use of SURTASS LFA during periods of heightened threat conditions as determined by the National Command Authorities. The new SEIS/SOEIS also must include further analysis of whether using a larger coastal standoff distance is practicable where the continental shelf extends further than the current standoff distance, and further analysis of cumulative impacts involving other active sonar sources. Once completed, information developed from these analyses will be used to assist the Navy in determining how to employ SURTASS LFA sonar, including the selection of operating areas that the Navy requires for routine training, testing, and military operations in requests for MMPA Letters of Authorization (LOAs) submitted to the National Marine Fisheries Service.

Please ensure that the supplemental analysis as discussed above complies with both the NEPA and Executive Order 12114. My point of contact for this supplemental analysis is Captain Dean Leech, JAGC, USN. He can be reached at (703) 614-3137 or dean.leech@navy.mil.

DONALD R. SCHREGARDUS
Deputy Assistant Secretary of the Navy
(Environment)

2

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350

IN REPLY REFER TO
9462
Ser N872A/8U179097
24 November 08

From: Chief of Naval Operations
Head, Undersea Surveillance Branch (N872A)
To: Director, Office of Protected Resources
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, Maryland 20910

Subj: COOPERATING AGENCY REQUEST FOR SURTASS LFA SONAR SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

Ref: (a) Deputy Assistant Secretary of the Navy (Environment) Memorandum for the Deputy Chief of Naval Operations for Integration of Capabilities and Resources (N8) SURTASS LFA Sonar Supplemental EIS/Supplemental OEIS, 14 November 2008

1. In reference (a), the Deputy Assistant Secretary of the Navy for Environment directed the Navy to prepare a supplemental environmental impact statement (SEIS)/supplemental overseas environmental impact statement (SOEIS) for the employment of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar to address concerns raised by the court in recent litigation and to support a new 5-Year Final Rule under the Marine Mammal Protection Act (MMPA) for employment of SURTASS LFA sonar.

2. In preparation for the important work ahead in developing the SEIS/SOEIS, the Navy requests that the National Marine Fisheries Service (NMFS) serve as a cooperating agency in accordance with National Environmental Policy Act (NEPA) regulations (40 CFR 1501.6) and the Council on Environmental Quality Cooperating Agency guidance issued on January 30, 2002.

3. The Navy will be responsible for overseeing preparation of the SEIS/SOEIS, which includes but is not limited to:

- Gathering all necessary background information and preparing the SEIS/SOEIS and all necessary permit applications associated with the employment of the SURTASS LFA sonar.
- Working with NMFS personnel in determining and applying the best available science in the analyses in the SEIS/SOEIS.
- Responding to NMFS requests for information in a timely manner.
- Circulating the NEPA/Executive Order 12114 documentation to the general public and any other interested parties.

Subj: COOPERATING AGENCY REQUEST FOR SURTASS LFA SONAR SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

- Maintaining the SEIS/SOEIS schedule and supervising meetings held in support of the NEPA/Executive Order 12114 process.
- Compiling and drafting responses to comments received on the Draft SEIS/SOEIS.

4. As a cooperating agency, the Navy requests that NMFS provide the following support:

- Provide timely comments on working drafts of the SEIS/SOEIS.
- Coordinate closely with the Navy to identify potential additional offshore (greater than 12 nm) biologically important areas (OBIAs) in regions of the world where the Navy anticipates the potential use of SURTASS LFA sonar for routine training, testing, and military operations.
- Respond to Navy requests for information in a timely manner.
- Coordinate, to the maximum extent practicable, any public comment periods that are necessary in the permitting process under the MMPA for the new 5-Year Final Rule with the NEPA comment period on the SEIS/SOEIS.
- Assist the Navy in responding to public comments.
- Participate in meetings hosted by the Navy for discussions of the SEIS/SOEIS and permitting related issues.
- Adhere, to the maximum extent possible, to the overall project schedule as agreed upon by the Navy and NMFS.

5. The Navy views this agreement as important to the successful completion of the SURTASS LFA Sonar SEIS/SOEIS. It is the Navy's goal to complete the analysis as expeditiously as possible, while using the best scientific information available. NMFS participation as a cooperating agency is greatly desired and will be invaluable in this endeavor. A formal, written response is requested.

6. We look forward to a continuation of the past positive and productive interactions between personnel from my office and the NMFS Office of Protected Resources. This cooperation has been largely responsible for the timely completion of complex NEPA documents and the issuance of required permits that have allowed the Navy to test, train and operate underwater surveillance systems critical to our national security.

7. The CNO point of contact is LCDR Neil Smith (N872A), who can be reached at 703-604-6333, E-mail: neil.t.smith@navy.mil.

J. S. Currer
Captain, U. S. Navy

2

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910
THE DIRECTOR

FEB 0 6 2009

Captain J.S. Currer
Head, Undersea Surveillance Branch (N872A)
Office of the Chief of Naval Operations
2000 Navy Pentagon
Washington, D.C. 20350-2000

Dear Captain Currer:

Thank you for your letter (Ser N872A/8U179097) requesting that NOAA's National Marine Fisheries Service (NMFS) participate as a cooperating agency in the preparation of a Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (Supplemental EIS/OEIS) for the operational deployment of the Surface Towed Array Surveillance System Low Frequency Active (SURTASS LFA) Sonar. The Final EIS/OEIS for SURTASS LFA sonar was completed in 2001 (65 FR 8788) and a Supplemental Final EIS/OEIS was completed and made available to the public on May 4, 2007 (72 FR 25302). NMFS supports the Navy's decision to prepare an additional Supplemental EIS/OEIS to analyze specific aspects of the proposed SURTASS LFA sonar activity, and agrees to be a cooperating agency, due, in part, to our responsibilities under section 101(a)(5)(A) of the Marine Mammal Protection Act and section 7 of the Endangered Species Act.

This cooperating agency role is entered in accordance with the Council on Environmental Quality's National Environmental Policy Act implementing regulations (specifically, 40 CFR 1501.6). We agree with the list of responsibilities for the Navy and NMFS identified in your letter, to ensure successful and timely completion of the subject Supplemental EIS/OEIS.

My staff looks forward to meeting with you soon to develop the cooperating agency responsibilities and schedules in more detail. In the meantime, should you need any additional information, please contact Kenneth Hollingshead or Jeannine Cody (301/713-2289, ext 128 or 113), who will be the NMFS points of contact for this Supplemental EIS/OEIS.

Sincerely,

James W. Balsiger, Ph.D.
Acting Assistant Administrator
for Fisheries

Printed on Recycled Paper

THE ASSISTANT ADMINISTRATOR
FOR FISHERIES

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350

IN REPLY REFER TO
5090
Ser N2N6F2/11U152124
August 25,2011

Alaskan Command
Attn: Jerome Montague
Native Affairs and Natural
Resources Advisor
Building 10471
Suite 301 A
Elmendorf, AFB, AK 99506-2100

Subj: DRAFT SURVEILLANCE TOWED ARRAY SENSOR SYSTEM (SURTASS) LOW FREQUENCY ACTIVE (LFA) SONAR SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (SEIS)/SUPPLEMENTAL OVERSEAS EIS (SOEIS)

Dear Mr. Montague:

The U.S. Navy has prepared a Draft Supplemental EIS/Supplemental OEIS (DSEIS/SOEIS) for SURTASS LFA sonar (five CD copies enclosed). The notice of availability of the document was announced in the Federal Register, Vol. 76, No. 161, on 19 August 2011, as EIS No. 20110269.

The Navy currently plans to operate up to four SURTASS LFA sonar systems for routine training, testing and military operations. Based on current U.S. Navy national security and operational requirements, these sonar systems could operate in the Pacific, Atlantic and Indian Oceans, and the Mediterranean Sea. Vessels equipped with, or to be equipped with, SURTASS LFA sonar systems are the USNS IMPECCABLE (T-AGOS 23) and USNS VICTORIOUS (T-AGOS 19) class ocean surveillance vessels. In addition to the No Action Alternative, the DSEIS/SOEIS analyzes two additional alternatives. The analysis of these three alternatives is intended to address concerns of the U.S. District Court for the Northern District of California in its 6 February 2008 Opinion and Order in relation to compliance with the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and the Marine Mammal Protection Act; and to provide additional information related to the proposed action. SURTASS LFA sonar will not be operated within 12 nautical miles of any coastline, including islands, nor within areas designated as biologically significant for marine mammals and/or ESA-listed species.

The Navy is requesting and welcomes comments on the Draft SEIS/SOEIS from pertinent Alaska native groups that participate in subsistence hunting in the Gulf of Alaska. Request that you liaison with those groups you deem appropriate to inform them that the Draft SEIS/SOEIS is available on the SURTASS LFA website www.surtass-lfa-eis.com. CD copies are also available, and if you are able to provide us names and addresses, we can mail a CD to whomever desires one. A limited number of paper copies are also available upon request.

Comments may be submitted by email at eisteam@mindspring.com, or mailed to:

Chief of Naval Operations, Code N2/N6F24
c/o SURTASS LFA sonar SEIS/SOEIS Program Manager
4100 Fairfax Drive, Suite 730
Arlington, VA 22203

All comments must be received by October 17, 2011 to ensure they become a part of the official record. All timely comments will be addressed in the Final SEIS/SOEIS.

If you have any questions or comments, please contact CDR Rachael Dempsey at 703-695-8266, or by email at rachael.dempsey@navy.mil.

J. S. Currer
Captain, U.S. Navy

Encl:
SURTASS LFA Draft SEIS/SOEIS (5 CD copies)

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350

IN REPLY REFER TO

9462
Ser N2N6F2/12U128260
07 MAY 2012

From: Deputy for Undersea Surveillance (N2/N6F24)
To: Director, Office of National Marine Sanctuaries
NOAA National Marine Sanctuary Program
1305 East-West Highway
Silver Spring, Maryland 20910-3282

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

Ref: (a) National Marine Fisheries Service (NMFS [OPR1]) email of 16 Nov 11 (NOAA comments on Navy Draft Supplemental Environmental Impact Statement/ Supplemental Overseas Environmental Impact Statement [DSEIS/SOEIS] for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar)
(b) DSEIS/SOEIS for SURTASS LFA sonar, Department of the Navy, August 2011
(c) Taking and Importing Marine Mammals: Taking Marine Mammals Incidental to U.S. Navy Operations of Surveillance Towed Array Sensor System Low Frequency Active Sonar: Proposed Rule. 2011. Federal Register Vol 77(4): 842-894.

1. Reference (a) provided comments on the Navy's DSEIS/SOEIS for SURTASS LFA sonar (reference [b]) from NOAA's Office of National Marine Sanctuaries (ONMS). This letter responds to those comments.

2. The employment of SURTASS LFA sonar is always subject to the geographic restrictions and the tripartite mitigation procedures (visual observers, passive acoustic monitoring, and active acoustic monitoring using the High Frequency Marine Mammal Monitoring [HF/M3] sonar), which are detailed in reference (b). These constraints on SURTASS LFA sonar

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

operations make the possibility of exposure to marine mammals at or above 180 dB re 1 μPa (rms) extremely remote and result in the overall negligible risk of harm to all sanctuary resources from SURTASS LFA sonar transmissions.

3. Those National Marine Sanctuaries that are located within proposed SURTASS LFA Marine Mammal (LFA MM) Offshore Biologically Important Areas (OBIA), as detailed in reference (b), are protected by the OBIA limitation of no ensonification at or above 180 dB re 1 μPa (rms) at a distance of 1 kilometer (km) (0.54 nautical mile [nmi]) seaward of the OBIA boundary; except for the operational exception, in accordance with NMFS' Proposed Rule for SURTASS LFA sonar (reference [c]).

4. Pursuant to NMSA section 304(d), ONMS may recommend alternatives to agencies whose activities are "likely to injure" any sanctuary resources. ONMS recommends that sound levels in all sanctuaries potentially affected by SURTASS LFA sonar operations should not exceed levels at or above 160 dB re 1 μPa. ONMS also stated that their definition of "injure" is more broadly defined and means to "change adversely, either in the short or long term, a chemical, biological, or physical attribute of, or the viability of" (15 CFR 922.3).

Based on our analysis, the Navy does not believe use of SURTASS LFA sonar, consistent with references (b) and (c), will injure sanctuary resources, as the term "injure" is defined above. We also believe the probability of behavioral disturbance and harassment is already minimized. These conclusions are based on employment of the mitigation measures outlined above, as well as the following reasons:

- Clark et al. (2001), which is Technical Report #1 from the initial 2001 SURTASS LFA sonar FOEIS/EIS, provided the results of the Low Frequency Sound Scientific Research Program (LFS SRP). They stated that some portion of whales exposed to LFA sonar responded behaviorally by changing their vocal activity and moving away from the source vessel, but both responses were short-lived. During the LFS SRP field test on foraging, whale encounter rates and dive behavior appeared to be more strongly linked to prey abundances than LFA sonar transmissions (Croll et al., 2001). Fristrup et al. (2003) concluded, based on the results of the LFS SRP, that exposure to LFA sonar would

2

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

not impose a risk of dramatic changes in humpback whale singing behavior that would have demographic consequences.

- The National Research Council (NRC) defines biologically significant behavior as that which affects an animal's ability to grow, survive, and reproduce; as well as to produce population-level consequences and to affect the viability of the species (NRC, 2005). Reference (b) concluded that the potential effects on any marine mammal from SURTASS LFA sonar transmissions are considered to be minimal, and thus, are not biologically significant.
- As presented in reference (b) Subchapter 4.4.4, Supplemental Risk Assessment, and Tables 4-5 through 4-23, the estimated percent of marine mammal stocks potentially subject to MMPA Level B harassment are below the conditions delineated by NMFS in the LOAs issued under the 2001 and 2007 Rules. For NMFS to grant authorization under the MMPA, NMFS must find that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). In over 9 years of operations, SURTASS LFA sonar operations have remained under, in most cases well under, this limit. Also, SURTASS LFA sonar has never been involved in any marine mammal strandings or mortalities.
- As noted earlier, in the proposed rule NMFS is requiring an additional 1-km (0.54-nmi) buffer zone seaward of OBIA boundaries (which include most NMSs), adding an additional level of conservatism.

The above listed reasons, in addition to the proposed mitigation measures presented in reference (b) and NMFS' Proposed MMPA Rule, are sufficient to minimize the likelihood of significant behavioral disturbance and harassment, as defined by the NRC. Therefore, SURTASS LFA sonar operations, under the current geographical restrictions and mitigation procedures, meet the requirements of the ONMS, since the operation of SURTASS LFA sonar is not likely to injure any sanctuary resources based on the best available science. Any further received level restrictions in the vicinity of NMSs are unwarranted.

5. Here are the Navy's responses to ONMS' additional NMS-specific recommendations:

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

a. Stellwagen Bank: This NMS is located entirely within proposed LFA MM OBIA #3, with the 180 dB re 1 µPa (rms) received level restriction at a distance of 1 km (0.54 nmi) seaward of the OBIA boundary in place from January 1 to November 14. For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 µPa (rms) received level restriction year-round.

b. Monitor: The Navy agrees with ONMS' recommendation that this NMS be treated as a dive site (145 dB re 1 µPa [rms] received level restriction) from March through November. The SEIS/SOEIS document will be modified to include the Monitor NMS as a dive site.

c. Gray's Reef: The Navy agrees with ONMS' recommendation that this NMS be treated as a dive site (145 dB re 1 µPa [rms] received level restriction) year-round. The SEIS/SOEIS document will be modified to include Gray's Reef NMS as a dive site.

d. Florida Keys: The Navy agrees with ONMS' recommendation that this NMS be treated as a dive site (145 dB re 1 µPa [rms] received level restriction) from shore to the 100-foot isobath year-round. The SEIS/SOEIS document will be modified to note these restrictions. For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 µPa (rms) received level restriction between the 100-foot and 300-foot isobaths year-round.

e. Flower Garden Banks: The Navy agrees with ONMS' recommendation that this NMS be treated as a dive site (145 dB re 1 µPa [rms] received level restriction) year-round and the SEIS/SOEIS document will be modified accordingly.

f. Channel Islands: The Navy agrees with ONMS' recommendation that this NMS be treated as a dive site (145 dB re 1 µPa (rms) received level restriction) year-round. The SEIS/SOEIS document will be modified to include the Channel Islands NMS as a dive site.

g. Monterey Bay, Gulf of the Farallones, and Cordell Bank: These sanctuaries are entirely within proposed LFA MM OBIA #10. Based on confirmed marine mammal activity periods June through November within the OBIA boundary, the Navy believes the 180 dB re 1 µPa (rms) received level restriction at a distance of 1 km (0.54 nmi) seaward of the OBIA boundary affords ample protection for sanctuary resources during that time period. We believe the

4

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

tripartite monitoring mitigation procedures that are always in effect for SURTASS LFA sonar operations provide the needed protection for sanctuary resources for the remainder of the year. For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 µPa (rms) received level restriction year-round. ONMS also recommends that the MBNMS near-shore area (0-3 nmi) should not receive sounds above 145 dB re 1 µPa, deemed appropriate for known recreational/scientific diving areas. If SURTASS LFA sonar operations are planned for waters in the vicinity of the MBNMS, known commercial and recreational/scientific dive sites within the sanctuary will be identified and the 145 dB received level restriction will apply to them, year-round. Since 2001, recreational dive sites have generally been defined as coastal areas from the shoreline out to the 40-m (130-ft) depth contour.

h. Olympic Coast: Proposed LFA MM OBIA #21 encompasses the vast majority of this NMS and, in fact, with the addition of the Prairie, Barkley, and Nitnat Canyons, the OBIA is greater in area than the NMS. Based on confirmed marine mammal activity periods in January, March, May and December within the original OBIA boundary; and June through September for the part of the proposed OBIA that has been added (Prairie, Barkley, and Nitnat Canyons), the Navy believes the 180 dB re 1 µPa (rms) received level restriction at a distance of 1 km (0.54 nmi) seaward of the OBIA boundary affords ample protection for sanctuary resources during those time periods. With respect to ONMS' recommendation for a 160 dB re 1 µPa (rms) received level restriction year-round, the Navy cannot agree with this restriction for the reasons stated above.

i. Hawaiian Island Humpback Whale: The portion of this NMS that is outside of 22 km (12 nmi) from shore (i.e., Penguin Bank) has been designated as proposed LFA MM OBIA #16. Thus, the resources of this sanctuary would be protected from LFA sonar transmissions above 180 dB re 1 µPa (rms) received level 1 km (0.54 nmi) seaward of the OBIA boundary from November through April and year-round within 22 km (12 nmi) from shore. For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 µPa (rms) received level restriction.

j. Fagatele Bay: All of this NMS is located within the geographic restricted area (i.e., 22 km [12 nmi] of shore) where SURTASS LFA operations are limited; this NMS is thus

5

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

protected by the 180 dB re 1 μPa(rms) received level restriction year-round. For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 μPa (rms) received level restriction.

6. The following provide the Navy's responses to ONMS' additional Marine National Monument (MNM)-specific recommendations:

   a. Rose Atoll: For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 μPa (rms) received level restriction.

   b. Papahānaumokuākea: For reasons stated above, the Navy cannot agree with ONMS' recommendation for a 160 dB re 1 μPa (rms) received level restriction. Moreover, The Navy and NMFS concur that the Papahanaumokuakea (Northwestern Hawaiian Islands) MNM boundaries extend seaward of the SURTASS LFA sonar 22-km (12-nmi) coastal standoff. Under Presidential Proclamation 8031 of 15 June 2006, Establishment of the Northwestern Hawaiian Islands Marine National Monument, the prohibitions required by this proclamation do not apply to Armed Forces activities and exercises, provided that these activities are carried out in a manner that avoids, to the extent practicable and consistent with operational requirements, adverse impacts on monument resources and qualities. SURTASS LFA sonar operations are carried out in such a manner.

7. As the point of contact on this matter, I can be reached at (703) 695-8266.

R. A. Dempsey

Copy to:
M. Payne, NMFS OPR
J. Harrison, NMFS OPR1
J. Cody, NMFS OPR1
G. Shultz, NMFS OPR5
K. Petersen, NMFS OPR5
CDR J. Landis, CNO(N45)

6

Subj: COMMENTS FROM NOAA'S OFFICE OF NATIONAL MARINE SANCTUARIES TO THE NAVY REGARDING SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR AND THE NATIONAL MARINE SANCTUARY SYSTEM

Cited Literature:

Clark, C.W., P. Tyack, and W.T. Ellison. 2001. Technical Report 1, revised: low frequency sound scientific research program technical report (responses of four species of whales to sounds of SURTASS LFA sonar transmissions). Report for the U.S., DoN rev. 2001. Included in Overseas environmental impact statement and environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar.

Croll, D.A., C.W. Clark, J. Calambokidis, W.T. Ellison, and B.R. Tershy. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4:13-27.

Fristrup, K.M., L.T. Hatch, and C.W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. The Journal of the Acoustical Society of America 113(6):3411-3424.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects. Washington, D.C.: National Academies Press.

NOTHING FOLLOWS

7

APPENDIX B—
REPRESENTATIVE MARINE AND FRESHWATER FISH TAXA (ORDERS) AND THEIR HEARING CAPABILITIES

THIS PAGE IS INTENTIONALLY LEFT BLANK

B.1 HEARING CAPABILITIES OF REPRESENTATIVE MARINE AND FRESHWATER FISH

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

FISH ORDER	COMMON NAME (REPRESENTATIVE SPECIES FOR ORDER)	PELAGIC OR DEMERSAL	HEARING CHARACTERISTICS[1]
Heterodontiformes	Bullhead Sharks	Demersal	The horn shark, *Heterodontus francisci*, reportedly hears from 20 to 160 Hz (Kelly and Nelson, 1975).[2] Casper and Mann (2007) showed detection from 20 to around 400 Hz in this species and provided particle motion data.
Orectolobiformes	Carpet Sharks	Demersal	The nurse shark *Ginglymostoma cirratum* is able to detect sounds to above 1 kHz with best sensitivity below about 400 Hz (Casper and Mann, 2006). Casper and Mann (2007) measured hearing in white-spotted bamboo shark, *Chiloscyllium plagiosum*, and determined particle motion thresholds from about 20 Hz to 400 Hz, with best sensitivity at the lower frequencies.

1 It is suggested that whereas the hearing bandwidth and general sensitivity trends are generally valid, the "details" of the specific bandwidth and hearing sensitivity must be viewed with some caution in all species reported. In particular, the data reported here were obtained using a wide range of methods and so some of the differences among species may reflect the experimental approach more than real differences. For example, while the lowest frequency detectable is given, careful analysis of the original papers will show that the lower frequency is often related to the methods used to produce sounds. Thus, a lower limit of 50 or 100 Hz may reflect that the sound sources used in the experiments could not produce sounds below that frequency, whereas if a different sound system were used the fish may have actually been able to respond to lower frequencies. This is less of a problem with the upper frequency limits for hearing since sound systems used in most studies often could produce much higher frequencies than tested. The other caveat in these data is the actual threshold (lowest detectable sound). The "threshold" is defined as the signal that is detectable only a certain percent of the time (e.g., often 50 percent). Moreover, thresholds may vary within an individual based upon motivation and other factors. Finally, and significantly, many of the earlier studies were done with less than ideal acoustics and whereas the thresholds reported may have been based upon pressure signals, the fish themselves may have been responding to the particle displacement component of the sound field.

2 Data for sharks and rays and for a number of bony fish have only been obtained for a few specimens. Future research is needed to replicate these results on both threshold and bandwidth.

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

FISH ORDER	COMMON NAME (REPRESENTATIVE SPECIES FOR ORDER)	PELAGIC OR DEMERSAL	HEARING CHARACTERISTICS[1]
Lamniformes	Pelagic Sharks	Pelagic	Hearing range for the bull shark, *Carcharhinus leucas*, reportedly is 100 to 1400 Hz (Kritzler and Wood, 1961), the lemon, *Negaprion brevirostris,* hears from 10 to 640 Hz (Banner, 1967; Nelson, 1967; Banner, 1972), and the hammerhead shark, *Sphyrna lewini*, from 250 to 750 Hz (Olla, 1962). Data from shark attraction experiments suggest hearing up to 1500 Hz in a number of species, although these data are not quantified and should be repeated.2
Rajiformes	Skates and Rays	Demersal	The little skate, *Raja erinacea*, hears from 100 to 800 Hz, with best hearing at 200 Hz at approximately 122 dB re 1 µPa @ 1 m threshold (Casper et al., 2003). The yellow stingray, *Urobatis jamaicensis*, detects sounds to about 1 kHz with best sensitivity below 400 Hz (Casper and Mann, 2006).
Anguilliformes	Eels	Demersal	The upper audible limit of *Anguilla anguilla* hearing is reported to be about 600 Hz with best hearing at about 100 Hz at 95 dB re 1 µPa @ 1 m threshold (Jerkø et al., 1989). There is some evidence that *Anguilla* can detect infrasound (signals below about 30 Hz) but only when the source is within a few body lengths of the fish (Sand et al., 2000).
Albuleiformes	Bonefish	Pelagic and Demersal	The bonefish (*Albula vulpes*) detects sounds from 50 to 700 Hz (Tavolga, 1974).

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

Fish Order	Common Name (Representative Species for Order)	Pelagic or Demersal	Hearing Characteristics[1]
Clupeiformes	Herrings/Shads/Sardines/Anchovies	Pelagic	Maximum hearing sensitivity for Pacific herring (*Clupea harengus pallasi*) is reportedly 125 to 500 Hz (reviewed in Croll et al., 1999), Pacific sardine (*Sardinops sagax*) best sensitivity is reported to be from 63 to 500 Hz (Sonalysts, 1995–unpublished "gray" literature). Spotlined sardines (*Sardinops melanostictus*) are reported to hear from 256 to 2048 Hz, with maximum sensitivity near 1 kHz (Akamatsu et al., 2003). Maximum sensitivity for spotted shad (*Clupanodon punctatus*) is 125 to 500 Hz (Sorokin et al., 1988). All of these data are highly suspect, and most clupeiforms appear to detect sounds to over 3 kHz (Mann et al., 2001 and 2005) and some species in the genus *Alosa* can detect sounds to over 180 kHz (Mann et al., 1998 and 2001). There is a report that the twaite shad (*Alosa fallax*) avoided 200 kHz sound pulses (Gregory and Clabburn, 2003).
Salmoniformes	Salmons/Trout/Chars	Pelagic	Some species (e.g. *Salmo salar*) are able to detect sounds from 30 Hz to about 600 Hz (Hawkins and Johnstone, 1978; Knudsen et al., 1992). Recent studies show that rainbow trout (*Oncorhynchus mykiss*) appear to be able to detect sounds to over 800 Hz (Popper et al., 2007; Wysocki et al., 2007). A similar hearing range is detectable by the broad whitefish (*Coregonus nasus*) (Popper et al., 2005b).

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

FISH ORDER	COMMON NAME (REPRESENTATIVE SPECIES FOR ORDER)	PELAGIC OR DEMERSAL	HEARING CHARACTERISTICS[1]
Gadiformes	Cods/Hakes/Haddock/Pollock	Pelagic and demersal	Hearing range of the cod (*Gadus morhua)* is 10 to 500 Hz (Chapman and Hawkins, 1973), while that of the haddock (*Melanogrammus aeglefinus*) range from 30 to 470 Hz (Chapman, 1973). Pollack (*Pollachius polachius*) hear about the same range of sounds (Chapman, 1973). Walleye pollock (*Theragra chalcogramma*) are reported to be able to detect sounds from 60 to 1000 Hz, with best hearing at 120 to 200 Hz (Park et al., 1995), although Mann et al., (2009) more recently demonstrated that upper hearing was more likely limited to 450 Hz. The ling (*Molva molva*) reportedly detects sounds from 40 to 550 Hz (Chapman, 1973). There is evidence that the burbot, *Lota lota*, can detect sounds to over 1,500 Hz (Mann et al., 2007).
Pleuronectiformes	Flounders/Sole/Halibut	Demersal	*Pleuronectes platessa* and *Limanda limanda* reportedly detect sounds up to 200 Hz (Chapman and Sand, 1974), while *Pleuronectes* is able to detect sounds as low as 30 or 40 Hz (Karlsen, 1992a). *Paralichthys olivaceous* detects sounds from 70 to 500 Hz, with best hearing at 100 Hz (Fujieda et al., 1996). *Pleuronectes yokohamae* is able to detect sounds from 60 to 1000 Hz, with best hearing at 100 Hz (Zhang et al., 1998).
Beryciformes	Squirrelfish (Holocentridae)	Pelagic and demersal	One species of squirrelfish (*Myripriste kuntee*) can detect sounds between 100 to 3,000 Hz with best sensitivity between 300 to 2,000 Hz, while another species (*Adioryx xantherythrus*) can only detect from about 100 to 1000 Hz (Coombs and Popper, 1979). The squirrelfishes (*Holocentrus vexillaris* and *Holocentrus ascensionis*) can detect sounds from 100 to 1200 Hz (Tavolga and Wodinsky, 1963; Wodinsky and Tavolga, 1964). Large variability in hearing capabilities exists within this group of fish.

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

Fish Order	Common Name (Representative Species for Order)	Pelagic or Demersal	Hearing Characteristics[1]
Batrachoidiformes	Toadfish (Batrachoididae)	Demersal	Oyster toadfish (*Opsanus tau*) reportedly detect sounds from 40 to 700 Hz, with best sensitivity between 40 to 200 Hz (Fish and Offutt, 1972), which has been confirmed from neurophysiological studies (Fay and Edds-Walton, 1997). Measures of hearing using auditory brainstem response show a similar hearing range in the Lusitanian toadfish, *Halobatrachus didactylus* (Vasconcelos et al., 2007).
Scorpaeniformes	Searobins (Triglidae)	Demersal	Slender searobin (*Prionotus scitulus*) detects sounds from 100 to 600 Hz, with best sensitivity from 200 to 400 Hz (Tavolga and Wodinsky, 1963).
Perciformes (This is such a diverse group of fish that they are broken down by taxonomic family)	Tunas (Scombridae)	Pelagic and Demersal	Yellowfin tuna (*Thunnus albacares*) hearing ranges from 50 to 1,100 Hz, with most sensitive hearing between 300 and 500 Hz (Iverson, 1967). This species has much better sensitivity than another tuna, the kawakawa (*Euthynnus affinis*), which has the same hearing range (Iverson, 1967).
	Damselfish (Pomacentridae)	Demersal	Various species in this family (genus *Eupomacentrus*) can detect sounds from 100 to 1200 Hz, with best hearing from 300 to 600 Hz (Myrberg and Spires, 1980).
	Wrasses (Labridae)	Pelagic and Demersal	Very diverse group and not likely that data for limited number of species represent variation in hearing likely to be found. However, blue-head wrasse (*Thalassoma bifasciatum*) can detect sounds from 100 to 1200 Hz, with best sensitivity from 200 to 600 Hz (Tavolga and Wodinsky, 1963).
	Sea basses (Serranidae)	Pelagic and Demersal	Only data are for the red hind (*Epinephelus guttatus*) report hearing from 100 to 1,000 Hz, with best sensitivity from 200 to 400 Hz (Tavolga and Wodinsky, 1963).

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

FISH ORDER	COMMON NAME (REPRESENTATIVE SPECIES FOR ORDER)	PELAGIC OR DEMERSAL	HEARING CHARACTERISTICS[1]
Perciformes (Continued)	Snappers (Lutjanidae)	Pelagic and Demersal	Schoolmaster (*Lutjanus apodus*) hears from 100 to 1000 Hz, with best sensitivity from 200 to 600 Hz. (Tavolga and Wodinsky, 1963).
	Drums (croakers) (Sciaenidae)	Pelagic and Demersal	There is broad diversity in ear structure and in hearing in this group (Ramcharitar et al., 2001 and 2004; Ramcharitar and Popper, 2004). Several species can detect sounds to over 2,000 Hz, while others can only detect sounds to 800 Hz. Many sciaenids use sound for communication as well.
	Grunts (Haemulidae)	Demersal	Blue-striped grunt (*Haemulon sciurus*) hears from 50 to 1,000 Hz, with best hearing from 50 to 500 Hz (Tavolga and Wodinsky 1963 and 1965).
	Breams and Porgies (Sparidae)	Pelagic	Ringed sea-bream (*Sargus annularis*) reportedly hears from 400 to 1,200 Hz, with best hearing from 400 to 800 Hz (Dijkgraaf, 1952). Red sea-bream (*Pagrus major*) hears from 50 to 1500 Hz, with best hearing at 200 Hz (Ishioka et al., 1988; Iwashita et al., 1999). Pinfish (*Lagodon rhomboides*) hears from 100 to 1000 Hz, with best sensitivity at 300 Hz (Tavolga, 1974).
	Jacks and mackerels (Carangidae)	Pelagic	Horse mackerel (*Trachurus japonicus*) hears 70 to 3,000 Hz, with best hearing at 1,000 to 1,500 Hz (Chung et al., 1995).
	Sleeper gobies (Eleotridae)	Demersal	Sleeper goby (*Dormitator latifrons*) detects frequencies from 50 to 400 Hz (Lu and Xu, 2002).
	Goatfish (Mullidae)	Dermersal	Hearing ability in *Mullus* has greatest sensitivity occurring at 450 to 900 Hz (Maliukina, 1960).

Table B-1. Representative marine and freshwater fish taxa (by Order) and their hearing capabilities.

FISH ORDER	COMMON NAME (REPRESENTATIVE SPECIES FOR ORDER)	PELAGIC OR DEMERSAL	HEARING CHARACTERISTICS[1]
Perciformes (Continued)	Mullet (Mugilidae)	Pelagic	Hearing ability in *Mugil* has an upper frequency limit of 1,600 to 2,500 Hz, with greatest sensitivity occurring at 640 Hz (Maliukina, 1960).
	Gobies (Gobiidae)	Demersal	Hearing ability in *Gobius* has an upper frequency limit of 800 Hz, (Dijkgraaf, 1952).
Siluriformes	Catfish	Demersal	Marine catfish (*Arius felis*) hears from 50 to 1,000 Hz, with best hearing from 100 to 400 Hz (Popper and Tavolga, 1981). *Amiurus nebulosus* hears from 60 to 10,000 Hz with best hearing at 400 to 1,500 Hz (Poggendorf, 1952).

B.2 LITERATURE CITED

Akamatsu, T., A. Nanami, and H.Y. Yan. 2003. Spotlined sardine *Sardinops melanostictus* listens to 1-kHz sound by using its gas bladder. Fisheries Science 69(2):348-354.

Banner, A. 1967. Evidence of sensitivity to acoustic displacements in the lemon shark, *Negaprion brevirostris* (Poey). Pages 265-273 in P.H. Cahn, ed. Lateral line detectors. Bloomington, Indiana: Indiana University Press.

Banner, A. 1972. Use of sound in predation by young lemon sharks, *Negaprion brevirostris* (Poey). Bulletin of Marine Science 22(2):251-283.

Casper, B.M., and D.A. Mann. 2006. Evoked potential audiograms of the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*). Environmental Biology of Fishes 76(1):101-108.

Casper, B.M., and D.A. Mann. 2007. Dipole hearing measurements in elasmobranch fishes. Journal of Experimental Biology 210(1):75-81.

Casper, B.M., P.S. Lobel, and H.Y. Yan. 2003. The hearing sensitivity of the little skate, *Raja erinacea*: A comparison of two methods. Environmental Biology of Fishes 68(4):371-379.

Chapman, C.J. 1973. Field studies of hearing in teleost fish. Helgoland Marine Research 24(1):371-390.

Chapman, C.J., and A.D. Hawkins. 1973. A field study of hearing in the cod, *Gadus morhua* L. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 85(2):147-167.

Chapman, C.J., and O. Sand. 1974. Field studies of hearing in two species of flatfish *Pleuronectes platessa* (L.) and *Limanda limanda* (L.) (Family Pleuronectidae). Comparative Biochemistry and Physiology 47A:371-385.

Chung, Y.J., Y. Matsuno, S. Fujeida, and Y. Yamanaka. 1995. Auditory threshold of Japanese horse mackerel (*Trachurus japonicus*). Nippon Suisan Gakkaishi 61(5):695-699.

Coombs, S., and A.N. Popper. 1979. Hearing differences among Hawaiian squirrelfish (family Holocentridae) related to differences in the peripheral auditory system. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 132(3):203-207.

Croll, D.A., B.R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical Report for SURTASS LFA EIS. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California, Santa Cruz. 473 pages.

Dijkgraaf, S. 1952. Uber die schallwahrnehmung bei meeresfischen. Zeitschrift für Vergleichende Physiologie 34:104-122.

Fay, R.R., and P.L. Edds-Walton. 1997. Diversity in frequency response properties of saccular afferents of the toadfish, *Opsanus tau*. Hearing Research 113(1):235-246.

Fish, J.F., and G.C. Offutt. 1972. Hearing thresholds from toadfish, *Opsanus tau*, measured in the laboratory and field. Journal of the Acoustical Society of America 51(4):1318-1321.

Fujieda, S., Y. Matsuno, and Y. Yamanaka. 1996. The auditory threshold of the bastard halibut (*Paralichthys olivaceus*). Nippon Suisan Gakkaishi 62(2):201-204.

Gregory, Jim, and Peter Clabburn. 2003. Avoidance behaviour of *Alosa fallax fallax* to pulsed ultrasound and its potential as a technique for monitoring clupeid spawning migration in a shallow river. Aquatic Living Resources 16(3):313-316.

Hawkins, A.D., and A.D.F. Johnstone. 1978. The hearing of the Atlantic salmon (*Salmo salar*). Journal of Fish Biology 13(6):655-673.

Ishioka, H., Y. Hatakeyama, and S. Sakaguchi. 1988. The hearing ability of the red sea bream (*Pagrus major*). Nippon Suisan Gakkaishi 54(6):947-951.

Iverson, R.T.B. 1967. Response to yellow fin tuna to underwater sound. Pages 105-121 in W.N. Tavolga, ed. Marine bioacoustics. Oxford, England: Pergamon Press.

Iwashita, A., M. Sakamoto, T. Kojima, Y. Watanabe, and H. Soeda. 1999. Growth effects on the auditory threshold of red sea bream. Nippon Suisan Gakkaishi 65(5):833-838.

Jerkø, H., I. Turunen-Rise, P. S. Enger, and O. Sand. 1989. Hearing in the eel (*Anguilla anguilla*). Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 165(4):455-459.

Karlsen, H.E. 1992a. Infrasound sensitivity in the plaice (*Pleuronectes platessa*). Journal of Experimental Biology 171(1):173-187.

Kelly, J.C., and D.R. Nelson. 1975. Hearing thresholds of the horn shark, *Heterodontus francisci*. Journal of the Acoustical Society of America 58(4):905-909.

Knudsen, F.R., P.S. Enger, and O. Sand. 1992. Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo salar* L. Journal of Fish Biology 40(4):523-534.

Kritzler, H., and L. Wood. 1961. Provisional audiogram for the shark, *Carcharhinus leucas*. Science 133:1480-1482.

Lu, Z., and Z. Xu. 2002. Effects of saccular otolith removal on hearing sensitivity of the sleeper goby (*Dormitator latifrons*). Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 188(8):595-602.

Maliukina, G.A. 1960. Hearing in certain Black Sea fishes in connection with ecology and particulars in the structure of their hearing apparatus. Zhurnal Obshchei Biologii (Journal of General Biology) 21:198-205.

Mann, D.A., Z. Lu, M.C. Hastings, and A.N. Popper. 1998. Detection of ultrasonic tones and simulated dolphin echolocation clicks by a teleost fish, the American shad (*Alosa sapidissima*). Journal of the Acoustical Society of America 104:562-568.

Mann, D.A., D.M. Higgs, W.N. Tavolga, M.J. Souza, and A.N. Popper. 2001. Ultrasound detection by clupeiform fishes. Journal of the Acoustical Society of America 109(6):3048-3054.

Mann, D.A, A.N Popper, and B. Wilson. 2005. Pacific herring hearing does not include ultrasound. Biology Letters 1(2):158-161.

Mann, D.A., P.A. Cott, B.W. Hanna, and A.N. Popper. 2007. Hearing in eight species of northern Canadian freshwater fishes. Journal of Fish Biology 70(1):109-120.

Mann, D.A., C.D. Wilson, J. Song, and A.N. Popper. 2009. Hearing sensitivity of the walleye pollock, *Theragra chalcogramma*. Transactions of the American Fisheries Society 138(5):1000-1008.

Myrberg, A.A., and J.Y. Spires. 1980. Hearing in damselfishes: An analysis of signal detection among closely related species. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 140(2):135-144.

Nelson, D.R. 1967. Hearing thresholds, frequency discrimination, and acoustic orientation in the lemon shark, *Negaprion brevirostris* (Poey). Bulletin of Marine Science 17:741-768.

Olla, B. 1962. The perception of sound in small hammerhead sharks *Sphyrna lewini*. M.S. thesis, University of Hawaii.

Park, Y.S., K. Iida, T. Mukai, and Y.K. Sakura. 1995. Auditory characteristics of walleye pollock *Theragra chalcogramma* (Pallas). Nippon Suisan Gakkaishi 61(2):159-163.

Poggendorf, D. 1952. Die aboluten horschwellwn des zwergwelses (*Amiurus nebulosus*) und beitrage zur physik des weberschen apparatus der ostariophysen. Zeitschrift für Vergleichende Physiologie 34:222-257.

Popper, A.N., and W.N. Tavolga. 1981. Structure and function of the ear in the marine catfish, *Arius felis*. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 144(1):27-34.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGillivray, M.E. Austin, and D.A. Mann. 2005b. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6)**:**3958-3971.

Popper, A.N., M.B. Halvorsen, A. Kane, D.L. Miller, M.E. Smith, J. Song, P. Stein, and L.E. Wysocki. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustical Society of America 122(1):623-635.

Ramcharitar, J., and A.N. Popper. 2004. Masked auditory thresholds in sciaenid fishes: A comparative study. Journal of the Acoustical Society of America 116(3):1687-1691.

Ramcharitar, J., D.M. Higgs, and A.N. Popper. 2001. Sciaenid inner ears: A study in diversity. Brain, Behavior and Evolution 58(3):152-162.

Ramcharitar, J.U, X. Deng, D. Ketten, and A.N. Popper. 2004. Form and function in the unique inner ear of a teleost: The silver perch (*Bairdiella chrysoura*). Journal of Comparative Neurology 475(4):531-539.

Sand, O., P.S. Enger, H.E. Karlsen, F. Knudsen, and T. Kvernstuen. 2000. Avoidance responses to Infrasound in downstream migrating European silver eels, *Anguilla anguilla*. Environmental Biology of Fishes 57(3):327-336.

Sonalysts, Inc. 1995. Testing responses of fishes to acoustic signals at the Redondo Marine Laboratory. Report prepared by Southern California Edison Co.

Sorokin, M.A., S.V. Donskoi, and A.N. Lebedva. 1988. Sound reception in Clupeidae. Russian Journal of Marine Biology (Biologiya Morya) 2:24-40.

Tavolga, W.N. 1974. Signal/noise ratio and the critical band in fishes. Journal of the Acoustical Society of America 55(6):1323-1333.

Tavolga, W.N., and J. Wodinsky. 1963. Auditory capacities in fishes: Pure tone thresholds in nine species of marine teleosts. Bulletin of the American Museum of Natural History 126:177-244.

Tavolga, W.N., and J. Wodinsky. 1965. Auditory capacities in fishes: threshold variability in the blue-striped grunt, *Haemulon sciurus*. Animal Behaviour 13(2):301-11.

Vasconcelos, R.O., M.C.P. Amorim, and F. Ladich. 2007. Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish. Journal of Experimental Biology 210(12):2104-2112.

Wodinsky, J., and W.N. Tavolga. 1964. Sound detection in teleost fishes. Pages 269-280 in W.N. Tavolga, ed. Marine bioacoustics. Oxford, England: Pergamon Press.

Wysocki, L.E., J.W. Davidson III, M.E. Smith, A.S. Frankel, W.T. Ellison, P.M. Mazik, A.N. Popper, and J. Bebak. 2007. Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout *Oncorhynchus myki*ss. Aquaculture 272(1):687-697.

Zhang, G., T. Hiraishi, K. Motomatsu, K. Yamamoto, and K. Nashimoto. 1998. Auditory threshold of marbled sole (*Pleuronectes yokohamae*). Nippon Suisan Gakkaishi 64(2):211-215.

APPENDIX C—
MARINE MAMMAL IMPACT ANALYSIS AND HARASSMENT LEVEL CALCULATION

THIS PAGE IS INTENTIONALLY LEFT BLANK

C-1 INTRODUCTION

As previously discussed in Chapter 4 of this SEIS/SOEIS, the types of potential effects on marine mammals from SURTASS LFA sonar operations include: 1) non-auditory injury; 2) permanent loss of hearing; 3) temporary loss of hearing; 4) behavioral change; and 5) masking. Richardson et al. (1995b) provided the most comprehensive review of contemporary knowledge on the sources and effects of anthropogenic noise on marine mammals, and Nowacek et al. (2007) provide a more recent review of the effects of anthropogenic noise on cetaceans. Nowacek et al. (2007) included an update on the documented behavioral, acoustic, and some physiological responses of cetaceans to man-made noise, and focused on literature that reported quantitatively on the sound field and some indicator of response. Southall et al. (2007) reported on the results from a panel of acoustic research experts in the behavioral, physiological, and physical disciplines. The panel's purpose was to review the expanding literature on marine mammal hearing, as well as physiological and behavioral responses to anthropogenic sound with the objective of proposing exposure criteria for certain effects.

References to Underwater Sound Levels
• **References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa @ 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).**   • **In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time and expressed as an equivalent one-second in duration signal, unless otherwise stated; the appropriate units for SEL are dB re 1 µPa²-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).**   • **The term "Single Ping Equivalent" (SPE) (as defined in Chapter 4 and Appendix C of this SEIS/SOEIS) is an intermediate calculation for input to the risk continuum used in this document. SPE accounts for the energy of all the LFA acoustic transmissions that a modeled animal receives during an entire LFA mission (modeled for operations from 7 to 20 days). Calculating the potential risk from SURTASS LFA is a complex process and the reader is referred to Appendix C for details. As discussed in Appendix C, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been in the SURTASS LFA sonar FOEIS/FEIS and FSEIS documents (DoN, 2001 and 2007a).**

The first two potential effects from SURTASS LFA sonar listed above (i.e., non-auditory physical effects and permanent loss of hearing) are typically grouped together and constitute "injury effects" or Level A harassments as defined under the MMPA. As previously discussed, Southall et al. (2007) proposed a dual injury criteria for individual low frequency (LF)/mid-frequency (MF)/high frequency (HF) marine mammal groups exposed to non-pulsed sound type, which included discrete acoustic exposures from SURTASS LFA sonar, and consists of an SPL and an SEL criteria. Due to the long duration of the LFA signal (i.e., nominally 60 sec), the SEL criterion from Southall et al. (2007) is always the dominant of the dual criteria identified there. Thus, the proposed injury criteria, which are based on onset of PTS, for LF/MF/HF cetaceans are a sound exposure level (SEL) of 215 dB re 1 µPa²-sec and for pinnipeds in water an SEL of 203 dB re 1 µPa²-sec. The current and historic SURTASS LFA sonar acoustic analyses have established and maintained a threshold of injury, or Level A harassment, to occur for an SPE received level (RL) ≥180 dB SPE. A comparison of the Southall et al. (2007) PTS SEL criterion and the 180 dB SPE can be made by adjusting the Southall et al. (2007) criterion for the longer LFA signal (nominally 60 sec), using 10 Log (T/Ti) where T is 60 sec and Ti is 1 sec. Thus, an 18-dB adjustment is made to the Southall et al. (2007) criterion, resulting in an SEL injury criterion for SURTASS LFA sonar of

197 dB re 1 µPa²-sec RL for cetaceans. For pinnipeds in water, this adjusted value would be an SEL of 185 dB re 1 µPa²-sec RL. The SURTASS LFA sonar injury criterion for all marine mammals of 180 dB SPE is conservative when compared to the adjusted Southall et al. (2007) SEL values above and it would be even more conservative if compared to the Southall et al. (2007) SPL criteria of 230 and 218 dB SPL for cetaceans and pinnipeds, respectively. An additional potential effect, masking, has been addressed in Chapter 4.

Additionally, based on simple spherical spreading (i.e., a transmission loss [TL] based on 20×Log10 [range in meters]) and assuming that the LFA array is a point source, a cetacean would need to approach and remain within approximately 33 m (108 ft) of the LFA source array (while a pinniped would need to be within 130 m [427 ft] of the array, which is approximately 76 m [250 ft] deep) for the complete 60 sec of the transmission, without detection, in order to exceed the Southall et al. (2007) injury thresholds. Based on the mitigation enacted during LFA transmission operations, the chances of this occurring are negligible and therefore will not be further discussed in this appendix. In addition, since the array is not a point source, these very short ranges (i.e., 33 and 130 m) are actually conservative values because at these ranges, the animal would still be in the near-field of the array (i.e., where the individual source elements are still affecting each others' signal and the theoretical source level calculated for a point source with a beam pattern over-predicts the actual source levels observed).

The next two potential effects listed above (i.e., temporary loss of hearing and behavioral change) are also typically grouped together and constitute "non-injury or harassment effects" or Level B harassments as defined in the MMPA. In the 2002 and 2007 SURTASS LFA Sonar Final Rules (NOAA, 2002a and 2007c), NMFS stated that TTS is not an injury. The underlying scientific studies and reports that have been detailed in Chapter 4 of this document show the potential impacts to marine mammal hearing varies not only from species to species but also from animal to animal within a species. Thus the utilization of a risk continuum to attempt to capture the variability of acoustic impacts to a species, as was first done for U.S. Navy environmental compliance documents in the SURTASS LFA sonar FOEIS/EIS (DoN, 2001), has become the standard approach for the U.S. Navy. This appendix is designed to document the details of that analysis effort for this SEIS/SOEIS.

A description and application of the risk continuum used in the analysis for this document is included in this appendix. The original application of a risk continuum in Navy documents occurred with the first SURTASS LFA FOEIS/EIS (DoN, 2001), which has been incorporated into this document by reference. The Navy, however, has since expanded the use of risk continuums to other documents. The current Navy standards as specified by CNO (N45) for assessing acoustic impacts requires the use of a risk continuum function (as was done in the SURTASS LFA Sonar FOEIS/EIS, Hawaii Range Complex (HRC) FEIS/OEIS, the Southern California Range Complex (SOCAL) FEIS/OEIS, and Atlantic Fleet Active Sonar Training (AFAST) FEIS/OEIS [(DoN, 2001, 2008a, b, c)] to calculate the potential impacts from acoustic sources. However, the Navy standard risk continuum and its implementation as used for the Mid-Frequency Active (MFA) systems in these three FOEIS/OEISs differs from the LFA risk continuum and subsequent take calculations in several ways including: a) the use of an SPL (MFA) vice an SPE (LFA) as a starting argument into the risk function; b) the period of time integrated for each entry into the risk continuum; and c) the details of the criteria for the categories of potential impact. In general, the LFA risk continuum function is a means of predicting the potential behavioral impacts associated with underwater acoustic operations on marine mammal species near the operational area of sonar systems. The inputs to the LFA risk continuum are typically the amount of acoustic exposure an animal is likely to receive during the proposed operation (energy is integrated over all exposures received during a 7 to 20 day mission). To determine the likely acoustic exposure, the movement of animals in the area is modeled along with the acoustic field generated by the sonar system(s). This appendix addresses the acoustic modeling performed for the additional 19 potential LFA operating areas documented in the SEIS/SOEIS.

C-2 ACOUSTIC IMPACT MODELING

For convenience, the details of the modeling conducted for this SEIS/SOEIS are provided in Subsections C-2.1 through C-2.4. Subsections C-2.5 through C-2.8 provide the historical and scientific data supporting the general use and development of the LFA risk continuum. These later subsections primarily consist of an updated and expanded version of the technical analysis methodology, which can be found in Chapter 4 of the original LFA FOEIS/EIS (DoN, 2001). Finally, this appendix presents a summary of the analysis in Section C-3.0.

For this SEIS/SOEIS, the Acoustic Integration Model© (AIM) was used to simulate the sound field produced by the SURTASS LFA sonar source operations and the correct marine mammal disposition and movement for all of the species present in the 19 different modeled oceanic areas (in addition to the 31 areas that were modeled in the original LFA FOEIS/EIS [DoN, 2001]). AIM integrates these results to ascertain the potential acoustic impacts to each of the marine mammal species present at each site. The sound fields produced by the LFA source in the different areas were modeled based on the system's specifications provided in Chapter 2 of this SEIS/SOEIS (i.e., source level, frequency, source depths, beam pattern, and location of the sonar system). Details of the physical acoustic environment as well as details of marine species' presence and their movement come from numerous sources (described below). The AIM modeling process includes both AIM modeling operations and post-AIM calculations. During the internal AIM modeling, AIM convolves sound field data generated by an embedded acoustic model with animal movement data generated from AIM's animal movement engine. The result data are stored in files and consist of an exposure history for each simulated animal ("animat"). These data are a sequential history as if each animat was fitted with an "acoustic dosimeter" and the resulting received levels from the LFA source were recorded. These exposure data for individual modeled animats are then scaled and summed to predict the risk of harassment for each animal species.

C-2.1 INTRODUCTION TO AIM

AIM is a Monte Carlo-method statistical model. AIM grew out of two earlier models; a whale movement and tracking model developed for the census of the bowhead whale, *Balaena mysticetus* (Ellison et al., 1987), and an underwater acoustic back-scattering model for a moving sound source in an under-ice Arctic environment (Bishop et al., 1987). Since its initial use in a National Environmental Policy Act (NEPA) document in 2001 (DoN, 2001), AIM has had several expansions of underlying databases and models, and the programming code has been improved to allow more detailed and larger simulations. In 2007 the Center for Regulatory Effectiveness (CRE) requested and the National Marine Fisheries Service (NMFS) sponsored a review of AIM by the Center for Independent Experts (CIE). The CIE report found that AIM was fully capable of assessing potential impacts on marine animals.

The exact positions of animals relative to sound sources cannot be known. Multiple runs of realistic predictions are therefore used to provide statistical power for the estimated effects. The movement of sources and receivers (animals) are modeled based on measured or defined data. Each source and receiver is modeled via the animat concept. Animats are computationally simulated animals or objects. When an animat represents an object, such as an acoustic source, the speed, direction, and depth is usually specified. When an animat represents an animal, movement is defined by specifying behavioral variables, such as dive parameters, swimming speed, and course changes (see below). The results are realistic representations of animal movements such as diving patterns that mimic the real-world diving patterns of that species. The movement of an animat can also be programmed to respond to environmental factors (e.g., water depth at the position of the animat). In this way, marine species that normally inhabit a particular environment can be constrained to stay within a specified habitat.

Once the behavior of the animats has been programmed, the simulation is "seeded" with an appropriate number of animats and the model is run. A model run consists of a user-specified number of steps forward in time. During each time step, each animat is moved according to the programmed rules describing its behavior. For each time step, the received sound level at each receiver animat is calculated. At the end of each time step, each animat evaluates its environment including its three-dimensional (3D) location. If an environmental variable has exceeded the user-specified boundary value (e.g., the animat has moved into water that is too shallow), then the animat will alter its course to react to the environment. These responses to the environment are called “aversions.” There are many aversion variables that can be used to specify an animat’s reactions and to obtain realistic behavior (e.g., bathymetry, geographic boundaries, water temperature, density of prey species, and level of pollution).

C-2.2 MARINE MAMMAL OCCURRENCE IN NINETEEN POTENTIAL OPERATION AREAS

To estimate the risk to marine mammals in each of the additional 19 potential SURTASS LFA sonar operation areas, a list of marine mammals likely to be encountered in each region must be developed and abundance and density estimates calculated for each species at each model site. The primary resource for generating a list of marine mammals potentially occurring at each model site was AquaMaps (Kaschner et al,. 2008; http://www.aquamaps.org/search.php). This list was verified with additional published literature specific to each model site. Once the species at a site were determined, they were modeled in AIM at densities higher than those found in the real world in order to sufficiently capture the statistical distribution of potential exposure conditions. Post-processing of the AIM results scaled the modeled densities to the real-world density estimates and divided by the abundance of the population to determine the overall percentage of potential risk to the population.

C-2.2.1 Marine Mammal Density

The distribution of many marine mammal species is irregular and highly dependent upon geography, oceanography, and seasonality. Density and abundance estimates are critical components needed to analytically estimate risk to marine mammal populations from activities occurring in the marine environment. The process for developing density and abundance estimates for every species at the 19 potential operation areas was a multi-step procedure that utilized data with the highest degree of fidelity first. Direct estimates from line-transect surveys that occurred in or near each of the 19 model sites were utilized first (e.g., Barlow, 2006). For the majority of species, abundance estimates were available for each of the 19 model sites (Table C-1). However, density estimates require more sophisticated sampling and analysis and were not always available for each species at all sites. When density estimates were not available from a survey in the operation area, then density estimates from a region with similar oceanographic characteristics were extrapolated to the operation area. For example, the eastern tropical Pacific has been extensively surveyed and provides a comprehensive understanding of marine mammals in temperate oceanic waters (Ferguson and Barlow, 2001, 2003). Further, density estimates are sometimes pooled for species of the same genus if sufficient data are not available to compute a density for individual species or the species are difficult to distinguish at sea. This is often the case for pilot whales and beaked whales, as well as the pygmy and dwarf sperm whales. Density estimates are available for these species groups rather than the individual species (Table C-1). References for density and abundance estimates for each species at each modeled site are provided at the end of Table C-1.

C-2.3 AIM MODELING FOR SURTASS LFA SEIS/SOEIS

The simulation areas for acoustic impact analysis were the potentially ensonified areas of the 19 proposed SURTASS LFA sonar operating areas (Table C-2). Each marine mammal species potentially found in these areas was simulated by creating animats programmed with behavioral values describing their dive behavior; including dive depth, surfacing time, dive duration, swimming speed, and course change.

After the animats were created, they were randomly distributed over the simulation area. The simulation area was determined by first finding the range at which the transmission loss was at least 100 dB (more details follow). The time step used for modeling was 30 sec and the modeling animat density was 0.1 or 0.05 animats/km^2, which is higher than that expected in the actual environment. This “over-population”

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Site 1: East of Japan					
Blue whale	NP	9,250	1, 2, 3	0.0002	1, 2, 3
Fin whale	NP	9,250	1, 2, 3	0.0002	1, 2, 3
Sei whale	NP	8,600	1	0.0006	1, 2
Bryde's whale	WNP	20,501	4	0.0006	3
Minke whale	WNP "O" Stock	25,049	5	0.0022	5
North Pacific right whale (spring, fall)	WNP	922	6	<0.00001	
Sperm whale	NP	102,112	7	0.0010	8
Kogia spp.	NP	350,553	9, 10	0.0031	9, 10
Baird's beaked whale	WNP	8,000	11	0.0029	11
Cuvier's beaked whale	NP	90,725	10	0.0054	10
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
Hubbs' beaked whale	NP	22,799	9, 10	0.0005	9, 10
False killer whale	WNP	16,668	12	0.0036	12
Pygmy killer whale	WNP	30,214	10	0.0021	10
Short-finned pilot whale	WNP	53,608	12	0.0128	12
Risso's dolphin	WNP	83,289	12	0.0097	12
Common dolphin	WNP	3,286,163	9, 10	0.0761	9, 10
Fraser's dolphin	WNP	220,789	9, 10	0.0040	9, 10
Bottlenose dolphin	WNP	168,791	12	0.0171	12

1 NP=North Pacific; WNP=Western North Pacific; ENP=Eastern North Pacific; CNP=Central North Pacific; IA=Inshore Archipelago; SOJ=Sea of Japan; ECS=East China Sea; CA/OR/WA=California, Oregon, and Washington; WNA=Western North Atlantic; ENA=Eastern North Atlantic; MED=Mediterranean; WMED=Western Mediterranean; IND=Indian Ocean; XAR=Stock X/Arabian Sea; ETP=Eastern Tropical Pacific; NEOP=Northeastern Offshore Pacific; WSP=Western South Pacific; GVEA=Group V East Australia

2 See end of this appendix table for literature references associated with the numerical values listed in table.

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (animals)	Stock / Abundance Reference(s)[2]	Density (animals per km^2)	Density Reference(s)[2]
Pantropical spotted dolphin	WNP	438,064	12	0.0259	12
Striped dolphin	WNP	570,038	12	0.0111	12
Spinner dolphin	WNP	1,015,059	9, 10	0.0005	9, 10
Pacific white-sided dolphin	WNP	931,000	9, 10	0.0082	9, 10
Rough-toothed dolphin	WNP	145,729	9, 10	0.0059	9, 10
Site 2: North Philippine Sea					
Bryde's whale	WNP	20,501	4	0.0006	3
Minke whale	WNP “O” Stock	25,049	5	0.0044	5
North Pacific right whale (fall to spring)	WNP	922	6	<0.00001	
Sperm whale	NP	102,112	14	0.0028	15
Kogia spp.	NP	350,553	9, 10	0.0031	9, 10
Cuvier's beaked whale	NP	90,725	10	0.0054	10
Blainville's beaked whale	NP	8,032	9, 10	0.0005	9, 10
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
Killer whale	NP	12,256	9, 10	0.0004	9, 10
False killer whale	WNP	16,668	12	0.0029	12
Pygmy killer whale	WNP	30,214	10	0.0021	10
Melon-headed whale	WNP	36,770	9, 10	0.0012	15
Short-finned pilot whale	WNP	53,608	12	0.0153	12
Risso's dolphin	WNP	83,289	12	0.0106	12
Common dolphin	WNP	3,286,163	9, 10	0.0562	9, 10
Fraser’s dolphin	WNP	220,789	9, 10	0.0040	9, 10
Bottlenose dolphin	WNP	168,791	12	0.0146	12
Pantropical spotted dolphin	WNP	438,064	12	0.0137	12
Striped dolphin	WNP	570,038	12	0.0329	12

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Spinner dolphin	WNP	1,015,059	9, 10	0.0005	9, 10
Pacific white-sided dolphin	WNP	931,000	9, 10	0.0119	9, 10
Rough-toothed dolphin	WNP	145,729	9, 10	0.0059	9, 10
Site 3: West Philippine Sea					
Fin whale	NP	9,250	2, 3, 4	0.0002	2, 3, 4
Bryde's whale	WNP	20,501	4	0.0006	3
Minke whale	WNP “O” Stock	25,049	5	0.0033	5
Humpback whale (winter only)	WNP	1,107	16	0.0008	17
Sperm whale	NP	102,112	7	0.0010	8
Kogia spp.	NP	350,553	9	0.0017	10
Cuvier's beaked whale	NP	90,725	10	0.0003	10
Blainville's beaked whale	NP	8,032	9, 10	0.0005	9, 10
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
False killer whale	WNP	16,668	12	0.0029	12
Pygmy killer whale	WNP	30,214	10	0.0021	10
Melon-headed whale	WNP	36,770	9, 10	0.0012	15
Short-finned pilot whale	WNP	53,608	12	0.0076	12
Risso's dolphin	WNP	83,289	12	0.0106	12
Common dolphin	WNP	3,286,163	9, 10	0.0562	9, 10
Fraser's dolphin	WNP	220,789	9, 10	0.0040	9, 10
Bottlenose dolphin	WNP	168,791	12	0.0146	12
Pantropical spotted dolphin	WNP	438,064	12	0.0137	12
Striped dolphin	WNP	570,038	12	0.0164	12
Spinner dolphin	WNP	1,015,059	9, 10	0.0005	9, 10
Pacific white-sided dolphin	WNP	931,000	9, 10	0.0245	9, 10

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

MARINE MAMMAL SPECIES NAME	STOCK NAME[1]	STOCK / ABUNDANCE (ANIMALS)	STOCK / ABUNDANCE REFERENCE(S)[2]	DENSITY (ANIMALS PER KM^2)	DENSITY REFERENCE(S)[2]
Rough-toothed dolphin	WNP	145,729	9, 10	0.0059	9, 10
SITE 4: OFFSHORE GUAM					
Blue whale	ENP	2,842	18	0.0001	9, 10
Fin whale	ENP	9,250	10	0.0003	10
Sei whale	NP	8,600	1	0.0003	19
Bryde's whale	WNP	20,501	4	0.0004	19
Minke whale	WNP “O” Stock	25,049	5	0.0003	9, 10
Humpback whale (October to May only)	CNP	10,103	16	0.0069	9, 10
Sperm whale	NP	102,112	7	0.0012	19
Kogia spp.	NP	350,553	10	0.0101	15
Cuvier's beaked whale	NP	90,725	10	0.0062	15
Blainville's beaked whale	NP	8,032	10	0.0012	15
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
Longman’s beaked whale	CNP	1,007	15	0.0004	15
Killer whale	CNP	349	15	0.0001	15
False killer whale	WNP	16,668	12	0.0011	19
Pygmy killer whale	WNP	30,214	10	0.0001	19
Melon-headed whale	WNP	36,770	10	0.0043	19
Short-finned pilot whale	WNP	53,608	12	0.0016	19
Risso's dolphin	WNP	83289	12	0.0010	15
Common dolphin	WNP	3,286,163	9, 10	0.0021	9, 10
Fraser’s dolphin	CNP	10,226	15	0.0042	15
Bottlenose dolphin	WNP	168,791	12	0.0002	19
Pantropical spotted dolphin	WNP	438,064	12	0.0226	19

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (animals)	Stock / Abundance Reference(s)[2]	Density (animals per km^2)	Density Reference(s)[2]
Striped dolphin	WNP	570,038	12	0.0062	19
Spinner dolphin	WNP	1,015,059	10	0.0031	19
Rough-toothed dolphin	WNP	145,729	10	0.0003	19
Site 5: Sea of Japan					
Fin whale	NP	9,250	1, 2, 3	0.0009	9, 10
Bryde's whale	WNP	20,501	4	0.0001	10
Minke whale	WNP “O” Stock	25,049	5	0.0004	10
Minke whale	WNP “J” Stock	893	20	0.0002	20
North Pacific right whale (fall to spring)	WNP	922	6	<0.00001	
Gray whale	WNP	121	4	<0.00001	
Sperm whale	NP	102,112	7	0.0008	10
Stejneger's beaked whale	NP	8,000	11	0.0014	10
Baird's beaked whale	WNP	8,000	11	0.0003	9, 10
Cuvier's beaked whale	NP	90,725	10	0.0043	10
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
False killer whale	IA	9,777	12	0.0027	10
Melon-headed whale	WNP	36,770	10	0.00001	10
Short-finned pilot whale	WNP	53,608	12	0.0014	12
Risso's dolphin	WNP	83,289	12	0.0073	12
Common dolphin	WNP	3,286,163	9, 10	0.0860	9, 10
Bottlenose dolphin	IA	105,138	21	0.0009	10
Pantropical spotted dolphin	WNP	219,032	12	0.0137	12
Spinner dolphin	WNP	1,015,059	9, 10	0.00001	9, 10
Pacific white-sided dolphin	WNP	931,000	9, 10	0.0030	9, 10

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Dall's porpoise	SOJ	76,720	10	0.0520	10
Site 6: East China Sea					
Fin whale	ECS	500	1, 2, 3	0.0002	1, 2, 3
Bryde's whale	WNP	20,501	4	0.0006	3
Minke whale	WNP “O” Stock	25,049	5	0.0044	5
Minke whale	WNP “J” Stock	893	20	0.0018	20
North Pacific right whale (winter only)	WNP	922	6	<0.00001	
Gray whale (winter only)	WNP	121	4	<0.00001	
Sperm whale	NP	102,112	7	0.0012	19
Kogia spp.	NP	350,553	9	0.0031	10
Cuvier's beaked whale	NP	90,725	10	0.0062	15
Blainville's beaked whale	NP	8,032	9, 10	0.0012	9, 10
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
False killer whale	IA	9,777	21	0.0011	19
Pygmy killer whale	WNP	30,214	10	0.0001	19
Melon-headed whale	WNP	36,770	10	0.0043	19
Short-finned pilot whale	WNP	53,608	12	0.0016	19
Risso's dolphin	WNP	83,289	12	0.0106	12
Common dolphin	WNP	3,286,163	9, 10	0.0461	9, 10
Fraser’s dolphin	WNP	220,789	9, 10	0.0040	9, 10
Bottlenose dolphin	IA	105,138	21	0.0146	12
Pantropical spotted dolphin	WNP	219,032	12	0.0137	12
Striped dolphin	WNP	570,038	12	0.0164	12
Spinner dolphin	WNP	1,015,059	10	0.0031	19
Pacific white-sided dolphin	WNP	931,000	9, 10	0.0028	9, 10

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Rough-toothed dolphin	WNP	145,729	10	0.0059	9, 10
Site 7: South China Sea					
Fin whale	WNP	9,250	1, 2, 3	0.0002	1, 2, 3
Bryde's whale	WNP	20,501	4	0.0006	3
Minke whale	WNP “O” Stock	25,049	5	0.0033	5
North Pacific right whale (winter only)	WNP	922	6	<0.00001	
Gray whale (winter only)	WNP	121	4	<0.0001	
Sperm whale	NP	102,112	7	0.0012	19
Kogia spp.	NP	350,553	9	0.0017	10
Cuvier's beaked whale	NP	90,725	10	0.0003	10
Blainville's beaked whale	NP	8,032	9, 10	0.0005	9, 10
Ginkgo-toothed beaked whale	NP	22,799	9, 10	0.0005	9, 10
False killer whale	IA	9,777	21	0.0011	19
Pygmy killer whale	WNP	30,214	10	0.0001	19
Melon-headed whale	WNP	36,770	10	0.0043	19
Short-finned pilot whale	WNP	53,608	12	0.0016	19
Risso's dolphin	WNP	83,289	12	0.0106	12
Common dolphin	WNP	3,286,163	9, 10	0.0461	9, 10
Fraser's dolphin	WNP	220,789	9, 10	0.0040	9, 10
Bottlenose dolphin	IA	105,138	21	0.0146	12
Pantropical spotted dolphin	WNP	219,032	12	0.0137	12
Striped dolphin	WNP	570,038	12	0.0164	12
Spinner dolphin	WNP	1,015,059	10	0.3140	19
Rough-toothed dolphin	WNP	145,729	9, 10	0.0040	9, 10

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (animals)	Stock / Abundance Reference(s)[2]	Density (animals per km^2)	Density Reference(s)[2]
Site 8: Offshore Japan (25º to 40ºN)					
Blue whale	NP	9,250	1	0.0003	1
Fin whale	NP	9,250	1, 2, 3	0.0001	1, 2, 3
Sei whale	NP	37,000	3	0.0003	19
Bryde's whale	WNP	20,501	4	0.0004	19
Minke whale	WNP "O" Stock	25,049	5	0.0003	5
Sperm whale	NP	102,112	7	0.0003	9, 10
Kogia spp.	NP	350,553	9	0.0049	10
Baird's beaked whale	WNP	8,000	11	0.0001	11
Cuvier's beaked whale	NP	90,725	10	0.0017	10
Mesoplodon spp.	NP	22,799	9, 10	0.0005	9, 10
False killer whale	WNP	16,668	12	0.0036	12
Pygmy killer whale	WNP	30,214	10	0.0001	19
Melon-headed whale	WNP	36,770	10	0.0012	15
Short-finned pilot whale	WNP	53,608	12	0.0001	10
Risso's dolphin	WNP	83,289	12	0.0010	10
Common dolphin	WNP	3,286,163	9, 10	0.0863	9, 10
Bottlenose dolphin	WNP	168,791	12	0.0005	10
Pantropical spotted dolphin	WNP	438,064	12	0.0181	9, 10
Striped dolphin	WNP	570,038	12	0.0500	9, 10
Spinner dolphin	WNP	1,015,059	9, 10	0.00001	9, 10
Pacific white-sided dolphin	WNP	67,769	9, 10	0.0048	9, 10
Rough-toothed dolphin	WNP	145,729	9, 10	0.0003	19
Hawaiian monk seal	Hawaii	1,129	18	<0.00001	

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

MARINE MAMMAL SPECIES NAME	STOCK NAME[1]	STOCK / ABUNDANCE (ANIMALS)	STOCK / ABUNDANCE REFERENCE(S)[2]	DENSITY (ANIMALS PER KM^2)	DENSITY REFERENCE(S)[2]
SITE 9: OFFSHORE JAPAN (10° TO 25°N)					
Bryde's whale	WNP	20,501	4	0.0004	19
Sperm whale	NP	102,112	22	0.0004	9, 10
Kogia spp.	NP	350,553	9	0.0009	10
Cuvier's beaked whale	NP	90,725	10	0.0017	10
False killer whale	WNP	16,668	12	0.0021	12
Melon-headed whale	WNP	36,770	10	0.0012	15
Short-finned pilot whale	WNP	53,608	12	0.0009	10
Risso's dolphin	WNP	83,289	12	0.0026	10
Common dolphin	WNP	3,286,163	9, 10	0.0863	9, 10
Bottlenose dolphin	WNP	168,791	12	0.0007	10
Pantropical spotted dolphin	WNP	438,064	12	0.0226	19
Striped dolphin	WNP	570,038	12	0.0110	12
Spinner dolphin	WNP	1,015,059	10	0.0031	19
Rough-toothed dolphin	WNP	145,729	9, 10	0.0003	19
SITE 10: HAWAII NORTH					
Blue whale	WNP	1,548	17	0.0002	9, 10
Fin whale	Hawaii	2,099	17	0.0007	9, 10
Bryde’s whale	Hawaii	469	15	0.0002	15
Minke whale	WNP	25,000	5	0.0002	9, 10
Humpback whale (summer)	Hawaii	10,103	16	<0.0001	15
Sperm whale	CNP	6,919	15	0.0028	15
Kogia spp	Hawaii	24,657	15	0.0101	15
Cuvier’s beaked whale	Hawaii	15,242	15	0.0062	15
Blainville’s beaked whale	Hawaii	2,872	15	0.0012	15

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (animals)	Stock / Abundance Reference(s)[2]	Density (animals per km²)	Density Reference(s)[2]
Longman's beaked whale	Hawaii	1,007	15	0.0004	15
Killer whale	Hawaii	349	15	0.0001	15
False killer whale	Hawaii Pelagic	484	61	0.0002	61
	Hawaii Insular	123	18	0.0002	61
Pygmy killer whale	Hawaii	956	15	0.0004	15
Melon-headed whale	Hawaii	2,950	15	0.0012	15
Short-finned pilot whale	Hawaii	8,870	15	0.0036	15
Risso's dolphin	Hawaii	2,372	15	0.0010	15
Fraser's dolphin	Hawaii	10,226	15	0.0042	15
Bottlenose dolphin	Hawaii	3,215	15	0.0013	15
Pantropical spotted dolphin	Hawaii	8,978	15	0.0037	15
Striped dolphin	Hawaii	13,143	15	0.0054	15
Spinner dolphin	Hawaii	3,351	15	0.0014	15
Rough-toothed dolphin	Hawaii	8,709	15	0.0036	15
Hawaiian monk seal	Hawaii	1,129	18	<0.0001	
Site 11: Hawaii South					
Blue whale	WNP	1,548	17	0.0002	9, 10
Fin whale	Hawaii	2,099	17	0.0007	9, 10
Bryde's whale	Hawaii	469	15	0.0002	15
Minke whale	Hawaii	25,000	5	0.0002	9, 10
Humpback whale (fall through spring)	Hawaii	10,103	16	0.0008	17
Sperm whale	CNP	6,919	15	0.0028	15
Kogia spp.	Hawaii	24,657	15	0.0101	15
Cuvier's beaked whale	Hawaii	15,242	15	0.0062	15
Blainville's beaked whale	Hawaii	2,872	15	0.0012	15

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

MARINE MAMMAL SPECIES NAME	STOCK NAME[1]	STOCK / ABUNDANCE (ANIMALS)	STOCK / ABUNDANCE REFERENCE(S)[2]	DENSITY (ANIMALS PER KM^2)	DENSITY REFERENCE(S)[2]
Longman's beaked whale	Hawaii	1,007	15	0.0004	15
Killer whale	Hawaii	349	15	0.0001	15
False killer whale	Hawaii Pelagic	484	61	0.0002	61
	Hawaii Insular	123	18	0.0002	61
Pygmy killer whale	Hawaii	956	15	0.0004	15
Melon-headed whale	Hawaii	2,950	15	0.0012	15
Short-finned pilot whale	Hawaii	8,870	15	0.0036	15
Risso's dolphin	Hawaii	2,372	15	0.0010	15
Fraser's dolphin	Hawaii	10,226	15	0.0042	15
Bottlenose dolphin	Hawaii	3,215	15	0.0013	15
Pantropical spotted dolphin	Hawaii	8,978	15	0.0037	15
Striped dolphin	Hawaii	13,143	15	0.0054	15
Spinner dolphin	Hawaii	3,351	15	0.0014	15
Rough-toothed dolphin	Hawaii	8,709	15	0.0036	15
Hawaiian monk seal	Hawaii	1,129	18	<0.0001	
SITE 12: OFFSHORE SOUTHERN CALIFORNIA (IN SOCAL OPAREA)					
Blue whale	ENP	2,842	18	0.0014	17
Fin whale	CA/OR/WA	2,099	17	0.0018	17
Sei whale	ENP	98	17	0.0001	17
Bryde's whale	ENP	13,000	24	0.00001	24
Northern minke whale	CA/OR/WA	823	17	0.0007	17
Humpback whale	CA/OR/WA	942	17	0.0008	17
Gray whale	ENP	18,813	14	0.051	25
Sperm whale	CA/OR/WA	1,934	17	0.0017	17
Pygmy sperm whale	CA/OR/WA	1,237	17	0.0011	17

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (animals)	Stock / Abundance Reference(s)[2]	Density (animals per km^2)	Density Reference(s)[2]
Stejneger's beaked whale	CA/OR/WA	1,177	17	0.0010	17
Baird's beaked whale	CA/OR/WA	1,005	17	0.0009	17
Cuvier's beaked whale	CA/OR/WA	4,342	17	0.0038	17
Blainville's beaked whale	CA/OR/WA	1,177	17	0.0010	17
Ginkgo-toothed beaked whale	CA/OR/WA	1,177	17	0.0010	17
Hubb's beaked whale	CA/OR/WA	1,177	17	0.0010	17
Longman's beaked whale	Hawaii	1,177	17	0.0010	17
Perrin's beaked whale	CA/OR/WA	1,177	17	0.0010	17
Pygmy beaked whale	CA/OR/WA	1,177	17	0.0010	17
Killer whale	ENP Offshore	810	17	0.0007	17
Short-finned pilot whale	CA/OR/WA	350	17	0.0003	17
Risso's dolphin	CA/OR/WA	11,910	17	0.0105	17
Long-beaked common dolphin	CA/OR/WA	21,902	17	0.0192	17
Short-beaked common dolphin	CA/OR/WA	352,069	17	0.3094	17
Bottlenose dolphin	CA/OR/WA offshore	2,026	17	0.0018	17
Striped dolphin	CA/OR/WA	18,976	17	0.0167	17
Pacific white-sided dolphin	CA/OR/WA	23,817	17	0.0209	17
Northern right whale dolphin	CA/OR/WA	11,097	17	0.0098	17
Dall's porpoise	CA/OR/WA	85,955	17	0.0753	17
Guadalupe fur seal	Mexico	7,408	18	0.007	25
Northern fur seal	San Miguel Island	9,424	18	0	25
California sea lion (on shelf)	California	238,000	18	0.54	25
California sea lion (offshore)	California	238,000	18	0	25
Harbor seal	California	34,233	18	0.0095	25

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

MARINE MAMMAL SPECIES NAME	STOCK NAME[1]	STOCK / ABUNDANCE (ANIMALS)	STOCK / ABUNDANCE REFERENCE(S)[2]	DENSITY (ANIMALS PER KM^2)	DENSITY REFERENCE(S)[2]
Northern elephant seal (on shelf)	California Breeding	124,000	18	0.0045	25
Northern elephant seal (offshore)	California Breeding	124,000	18	0	25
SITE 13: NORTHWESTERN ATLANTIC OFF FLORIDA (IN JAX OPAREA)					
Humpback whale	WNA	11,570	27	0.0006	26
North Atlantic right whale (on shelf; winter to spring only)	WNA	438	28	0.0012	26
Sperm whale (on shelf)	WNA	4,804	29	0	26
Sperm whale (off shelf)	WNA	4,804	29	0.0005	26
Kogia spp.	WNA	580	30	0.0010	26
Beaked whales (on shelf)	WNA	3,513	29	0	26
Beaked whales (off shelf)	WNA	3,513	29	0.0006	26
Cuvier's beaked whale	WNA	3,513	29	0.0006	26
Blainville's beaked whale	WNA	3,513	29	0.0006	26
Gervais' beaked whale	WNA	3,513	29	0.0006	26
Sowerby's beaked whale	WNA	3,513	29	0.0006	26
True's beaked whale	WNA	3,513	29	0.0006	26
Short-finned pilot whale (on shelf)	WNA	31,139	29	0.00004	26
Short-finned pilot whale (off shelf)	WNA	31,139	29	0.0271	26
Risso's dolphin (on shelf)	WNA	20,479	29	0.0009	26
Risso's dolphin (off shelf)	WNA	20,479	29	0.0181	26
Common dolphin	WNA	120,743	29	0.00002	26
Bottlenose dolphin (off shelf)	WNA	81,588	29	0.1163	26

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Coastal bottlenose dolphin (on shelf)	Southern Migratory Coast	12,482	62	0.2132	26
	Northern Florida Coast	3,064	62	0.2132	26
	Central Florida Coast	6,318	62	0.2132	26
Pantropical spotted dolphin	WNA	12,747	30	0.0223	26
Striped dolphin	WNA	94,462	29	0.00003	26
Atlantic spotted dolphin (on shelf)	WNA	50,978	29	0.4435	26
Atlantic spotted dolphin (off shelf)	WNA	50,978	29	0.0041	26
Clymene dolphin	WNA	6,086	29	0.0106	26
Rough-toothed dolphin	WNA	274	30	0.0005	26
Site 14: Northeastern Atlantic off United Kingdom					
Blue whale	ENA	100	31, 32	0.00001	32
Fin whale	ENA	10,369	32	0.0031	32
Sei whale	ENA	14,152	33, 34	0.0113	33
Northern minke whale	ENA	107,205	35	0.0068	36
Humpback whale	ENA	4,695	32	0.0019	32
Sperm whale	ENA	6,375	32	0.0049	32
Kogia spp.	ENA	580	30	0.0001	30
Cuvier's beaked whale	ENA	3,513	29	0.0013	26
Blainville's beaked whale	ENA	3,513	29	0.0013	26
Sowerby's beaked whale	ENA	3,513	29	0.0013	26
Northern bottlenose whale	ENA	5,827	38	0.0003	37
Killer whale	ENA	6,618	38	0.0001	37

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
False killer whale	ENA	484	18	0.0001	37
Long-finned pilot whale	ENA	778,000	39	0.0121	26
Risso's dolphin	ENA	20,479	29	0.0063	26
Common dolphin	ENA	273,150	40	0.238	31
Bottlenose dolphin	ENA	81,588	29	0.0094	26
Striped dolphin	ENA	94,462	29	0.0765	26
Atlantic white-sided dolphin	ENA	11,760	36	0.0027	36
White-beaked dolphin	ENA	11,760	36	0.0027	36
Harbor porpoise	ENA	341,366	36	0.2299	36
Harbor seal	Ireland / Scotland	23,500	41	0.0230	26
Gray seal	ENA	113,300	42	0.027	26
Site 15: Western Mediterranean Sea—Ligurian Sea					
Fin whale	MED	3,583	44	0.004	43, 44, 45
Sperm whale	WMED	6,375	32	0.0049	32
Cuvier's beaked whale	ENA	3,513	29	0.0013	26
Long-finned pilot whale	ENA	778,000	39	0.0121	26
Risso's dolphin	WMED	5,320	46, 47	0.0075	46
Common dolphin	WMED	19,428	48	0.0144	48
Bottlenose dolphin	WMED	23,304	46, 49, 50	0.041	46
Striped dolphin	WMED	117,880	51	0.24	51
Site 16: Northern Arabian Sea					
Bryde's whale	IND	9,176	24	0.0001	52, 53
Humpback whale	XAR	200	54, 55, 56	0.0004	9, 10
Sperm whale	IND	24,446	24	0.0125	52, 53
Dwarf sperm whale	IND	10,541	24	0.0145	52, 53

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Cuvier's beaked whale	IND	27,272	24	0.0001	52, 53
Blainville's beaked whale	IND	16,867	24	0.0016	52, 53
Gingko-toothed beaked whale	IND	16,867	24	0.0016	52, 53
Longman's beaked whale	IND	16,867	24	0.0016	52, 53
False killer whale	IND	144,188	24	0.0003	52, 53
Pygmy killer whale	IND	22,029	24	0.0026	52, 53
Melon-headed whale	IND	64,600	24	0.0661	52, 53
Short-finned pilot whale	IND	268,751	24	0.0034	52, 53
Risso's dolphin	IND	452,125	24	0.0125	52, 53
Common dolphin	IND	1,819,882	24	0.0265	52, 53
Bottlenose dolphin	IND	785,585	24	0.0164	52, 53
Pantropical spotted dolphin	IND	736,575	24	0.0127	52, 53
Striped dolphin	IND	674,578	24	0.0706	52, 53
Spinner dolphin	IND	634,108	24	0.01	52, 53
Rough-toothed dolphin	IND	156,690	24	0.0081	52, 53
Site 17: Andaman Sea (off Myanmar)					
Bryde's whale	IND	9,176	24	0.0001	52, 53
Sperm whale	IND	24,446	24	0.0125	52, 53
Dwarf sperm whale	IND	10,541	24	0.0145	52, 53
Cuvier's beaked whale	IND	27,272	24	0.0001	52, 53
Blainville's beaked whale	IND	16,867	24	0.0016	52, 53
Gingko-toothed beaked whale	IND	16,867	24	0.0016	52, 53
Longman's beaked whale	IND	16,867	24	0.0016	52, 53
Killer whale	IND	12,593	24	0.0001	52, 53
False killer whale	IND	144,188	24	0.0003	52, 53

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Pygmy killer whale	IND	22,029	24	0.0026	52, 53
Melon-headed whale	IND	64,600	24	0.0661	52, 53
Short-finned pilot whale	IND	268,751	24	0.0034	52, 53
Risso’s dolphin	IND	452,125	24	0.0125	52, 53
Common dolphin	IND	1,819,882	24	0.0265	52, 53
Bottlenose dolphin	IND	785,585	24	0.0164	52, 53
Pantropical spotted dolphin	IND	736,575	24	0.0127	52, 53
Striped dolphin	IND	674,578	24	0.0706	52, 53
Spinner dolphin	IND	634,108	24	0.01	52, 53
Rough-toothed dolphin	IND	156,690	24	0.0081	52, 53
Site 18: Panama Canal—West Approach					
Blue whale	ENP	2,842	18	0.0001	9, 10
Bryde’s whale	ETP	13,000	24	0.0003	9, 10
Humpback whale	ENP	1,391	18	0.0004	9, 10
Sperm whale	ETP	22,700	24	0.0047	9, 10
Dwarf sperm whale	ETP	11,200	24	0.0145	9, 10
Cuvier’s beaked whale	ETP	20,000	24	0.0025	9, 10
Blainville’s beaked whale	ETP	25,300	24	0.0013	9, 10
Gingko-toothed beaked whale	ETP	25,300	24	0.0016	9, 10
Longman’s beaked whale	ETP	25,300	24	0.0003	9, 10
Pygmy beaked whale	ETP	25,300	24	0.0016	9, 10
Killer whale	ETP	8,500	24	0.0002	9, 10
False killer whale	ETP	39,800	24	0.0004	9, 10
Pygmy killer whale	ETP	38,900	24	0.0014	9, 10
Melon-headed whale	ETP	45,400	24	0.0174	9, 10

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (animals)	Stock / Abundance Reference(s)[2]	Density (animals per km^2)	Density Reference(s)[2]
Short-finned pilot whale	ETP	160,200	24	0.0058	9, 10
Risso's dolphin	ETP	110,457	57	0.0161	9, 10
Common dolphin	ETP	3,127,203	57	0.049	9, 10
Fraser's dolphin	ETP	289,300	24	0.001	9, 10
Bottlenose dolphin	ETP	335,834	57	0.0157	9, 10
Pantropical spotted dolphin	NEOP	640,000	58	0.0669	9, 10
Striped dolphin	ETP	964,362	57	0.1199	9, 10
Spinner dolphin	Eastern	450,000	58	0.007	9, 10
Rough-toothed dolphin	ETP	107,633	57	0.0146	9, 10
Site 19: Northeastern Australia Coast					
Blue whale	WSP	9,250	1, 2, 3	0.0002	1, 2, 3
Fin whale	WSP	9,250	1, 2, 3	0.0002	1, 2, 3
Bryde's whale	WSP	22,000	4	0.0006	3
Northern minke whale	WSP	25,000	5	0.0044	5
Humpback whale	GVEA	3,500	59	0.0143	59
Sperm whale	WSP	102,112	14	0.0029	14
Kogia spp.	WSP	350,553	9, 10	0.0031	9, 10
Cuvier's beaked whale	WSP	90,725	10	0.0054	10
Blainville's beaked whale	WSP	8,032	9, 10	0.0005	9, 10
Amoux's beaked whale	WSP	22,799	9, 10	0.0005	9, 10
Gingko-toothed beaked whale	WSP	22,799	9, 10	0.0005	9, 10
Longman's beaked whale	WSP	22,799	9, 10	0.0005	9, 10
Southern bottlenose whale	WSP	22,799	9, 10	0.0005	9, 10
Killer whale	WSP	12,256	9, 10	0.0004	9, 10
False killer whale	WSP	16,668	12	0.0029	12

Table C-1. Marine mammal species and stocks, abundance estimates, density estimates, as well as associated references for each SURTASS LFA sonar operating area.

Marine Mammal Species Name	Stock Name[1]	Stock / Abundance (Animals)	Stock / Abundance Reference(s)[2]	Density (Animals per km^2)	Density Reference(s)[2]
Pygmy killer whale	WSP	30,214	10	0.0021	10
Melon-headed whale	WSP	36,770	9, 10	0.0012	15
Globicephala spp.	WSP	53,608	12	0.0153	12
Risso's dolphin	WSP	83,289	12	0.0106	12
Common dolphin	WSP	3,286,163	9, 10	0.0562	9, 10
Fraser's dolphin	WSP	220,789	9, 10	0.004	9, 10
Bottlenose dolphin	WSP	168,791	12	0.0146	12
Pantropical spotted dolphin	WSP	438,064	12	0.0137	12
Striped dolphin	WSP	570,038	12	0.0329	12
Spinner dolphin	WSP	1,015,059	9, 10	0.0005	9, 10
Dusky dolphin	WSP	12,626	60	0.0002	9, 10
Rough-toothed dolphin	WSP	145,729	9, 10	0.0059	9, 10

APPENDIX TABLE C-1 LITERATURE CITED[3]

1. Tillman, 1977
2. Masaki, 1977
3. Ohsumi, 1977
4. IWC, 2009
5. Buckland et al., 1992
6. Best et al., 2001
7. Kato and Miyashita, 1998
8. Mobley et al., 2000
9. Ferguson and Barlow, 2001
10. Ferguson and Barlow, 2003
11. Kasuya, 1986
12. Miyashita, 1993
13. Buckland et al., 1993
14. Allen and Angliss, 2010
15. Barlow, 2006
16. Calamboikidis et al., 2008
17. Barlow and Forney, 2007
18. Carretta et al., 2010
19. Fulling et al., 2011
20. Pastene and Goto, 1998
21. Miyashita, 1986
22. Kasuya and Miyashita, 1988
24. Wade and Gerrodette, 1993
25. DoN, 2008
26. DoN, 2007b
27. Stevick et al., 2003
28. NARWC, 2009
29. Waring et al., 2009
30. Mullin and Fulling, 2003
31. Waring et al., 2008
32. Øien, 2008
33. Macleod et al., 2006
34. Heide-Jørgensen et al., 2007
35. Skaug et al., 2004
36. Hammond et al., 2002
37. Barlow et al., 2006
38. Gunnlaugsson and Sigurjónsson, 1990
39. Buckland et al., 1993b
40. Cañadas et al., 2004
41. NAMMCO, 2006
42. Gerondeau et al., 2007
43. Forcada et al., 1995
44. Forcada et al., 1996
45. Gannier, 1997
46. Gómez de Segura et al., 2006
47. Airoldi et al., 2005
48. Cañadas, 2006
49. Forcada et al., 2004
50. Cañadas and Hammond, 2006
51. Forcada and Hammon, 1998
52. Ballance and Pitman, 1998
53. Dolar et al., 2006
54. Rosenbaum et al., 2009
55. Minton et al., 2008
56. Minton et al., In Press
57. Gerrodette et al., 2008
58. Gerrodette and Forcada, 2005
59. Department of the Environment and Heritage, 2005
60. Markowitz, 2004
61. Barlow and Rankin, 2007
62. Waring et al., 2010

3 Full citations for the literature listed here may be found at the end of Appendix C in the Literature Cited section.

Table C-2. Locations of the 19 potential SURTASS LFA sonar operating areas (OPAREAs).

OPAREA	SITE NAME	SEASON	LOCATION	REMARKS
1	East of Japan	Summer	38°N/148°E	
2	North Philippine Sea	Fall	29°N/136°E	
3	West Philippine Sea	Fall	22°N/124°E	
4	Guam	Sum/Fall	11°N/145°E	Mariana Islands Range Complex (outside Mariana Trench)
5	Sea of Japan	Fall	39°N/132°E	
6	East China Sea	Summer	26°N/125°E	
7	South China Sea	Fall	21°N/119°E	
8	NW Pacific 25° to 40°N	Summer	30°N/165°E	
9	NW Pacific 10° to 25°N	Winter	15°N/165°E	
10	Hawaii North	Summer	25°N/158°W	Hawaii Range Complex
11	Hawaii South	Spring/Fall	19.5°N/158.5°W	Hawaii Range Complex
12	Offshore Southern California	Spring	32°N/120°W	SOCAL Range Complex
13	Western Atlantic (off Florida)	Winter	30°N/78°W	AFAST Study Area (Jacksonville OPAREA)
14	Eastern North Atlantic	Summer	56.5N/10W	NW Approaches
15	Mediterranean Sea–Ligurian Sea	Summer	43°N/8°E	
16	Arabian Sea	Summer	20°N/65°E	
17	Andaman Sea	Summer	7.5°N/96°E	Approaches to Strait of Malacca
18	Panama Canal	Winter	5°N/81°W	Western Approach
19	NE Australian Coast	Spring	23°S/155°E	

ensures that the result of the simulation is not unduly influenced by the chance placement of a few animals. To obtain final harassment estimates, the results are normalized by the ratio of the modeled animat density to the real-world animal population density estimate. This allows for greater statistical power without overestimating risk.

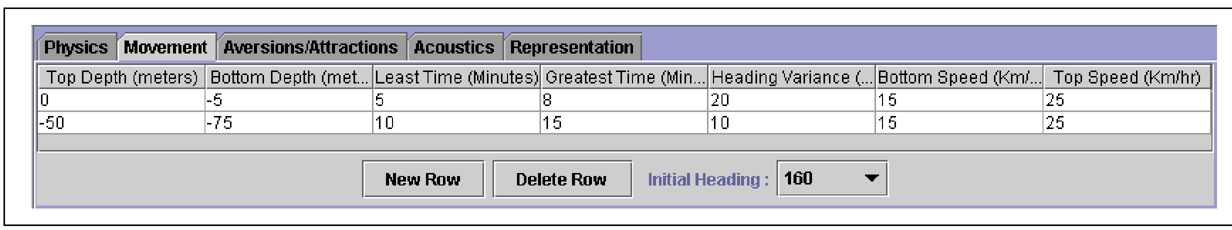
During the AIM modeling, the animats were programmed to remain within the analysis area, and they “reflected” off the boundaries of the AIM analysis area. This reflection represented one animat entering the analysis area for each animat leaving the area—hence, a net change in the number of animats in the analysis area was zero and no animats diffused out of the analysis area. For a nominal AIM model run of approximately seven (7) days, it has been the Navy’s experience that only about 2 to 10% of the modeled animats encounter the analysis area boundary. Additionally, due to the distance from the model area boundary to the source at the box’s center (0 to 150 nmi), it is only a very small percentage (typically less than 0.1% of all modeled animats) that ever approach within 10 nmi of the source while it is transmitting, within the seven modeled days.

C-2.3.1 Animat Movement in AIM

Animals move through four dimensions: three spatial dimensions and time. One of the outputs of AIM is a report of the four-dimensional movement of an animat. Several parameters are used in AIM to produce simulated movement that accurately represents expected real animal movement patterns. The following sections are short discussions of the various parameters and their implementation.

Diving Patterns

A typical dive pattern for a marine mammal consists of at least two phases; a shallow respiratory sequence that is followed by a deeper, longer dive. Diving parameters, such as time limits, depth limits, heading variance, and speed, are specified for each animat in the AIM model (Figure C-1). The first row shows the parameter values for shallow, respiratory dives. In this case, the parameters specify that an animal dives from the surface to a maximum depth of 5 m for at least 5 min and up to 8 min. The second row describes the second phase of the dive; in this phase the animal dives to a depth between 50 and 75 m for at least 10 min and up to 15 min. The horizontal component of the dive is handled with the “heading variance” term; it allows the animal to change course up to a certain number of degrees at each movement step. In this case, the animal can change course 20° during the shallow dive, but only 10° during the deep dive. This example is for a narrowly constrained set of variables, appropriate for a migratory animal. Using these diving parameters, AIM generates realistic dive patterns (Figure C-2). The dive parameters listed in Figure C-3, produced the sample dive pattern shown here. The animat dives from the surface to a maximum depth of 5 m for approximately 6 min before resurfacing. The animat then performs a deep dive to 60 m for about 5 min, changes depth to 50 m for another 5 min, and then surfaces.



Top Depth (meters)	Bottom Depth (met...	Least Time (Minutes)	Greatest Time (Min...	Heading Variance (...	Bottom Speed (Km/...	Top Speed (Km/hr)
0	-5	5	8	20	15	25
-50	-75	10	15	10	15	25

Figure C-1. Example of marine mammal dive parameters.

Aversions

In addition to movement patterns, the animats can be programmed to avoid certain environmental characteristics. For example, aversions can be used to constrain an animal to a particular depth regime (e.g., an animat can be constrained to waters between 2,000 and 5,000 m deep). The second row specifies that the animat reacts by making a series of 20° turns if it is in waters that are shallower than 2,000 m or deeper than 5,000 m. The animat will continue to turn until the aversion is satisfied.

C-2.3.2 Animal Behavior Parameters Used in AIM Modeling

MAI maintains a database of animal behavior parameters to be used in AIM modeling. Dive parameters that were used in the modeling are discussed and listed for available species (Table C-3). Little or no data are available to specify movement and aversion values for some marine mammal species. For this reason, some species are grouped with their closest taxonomic relatives for modeling purposes. When

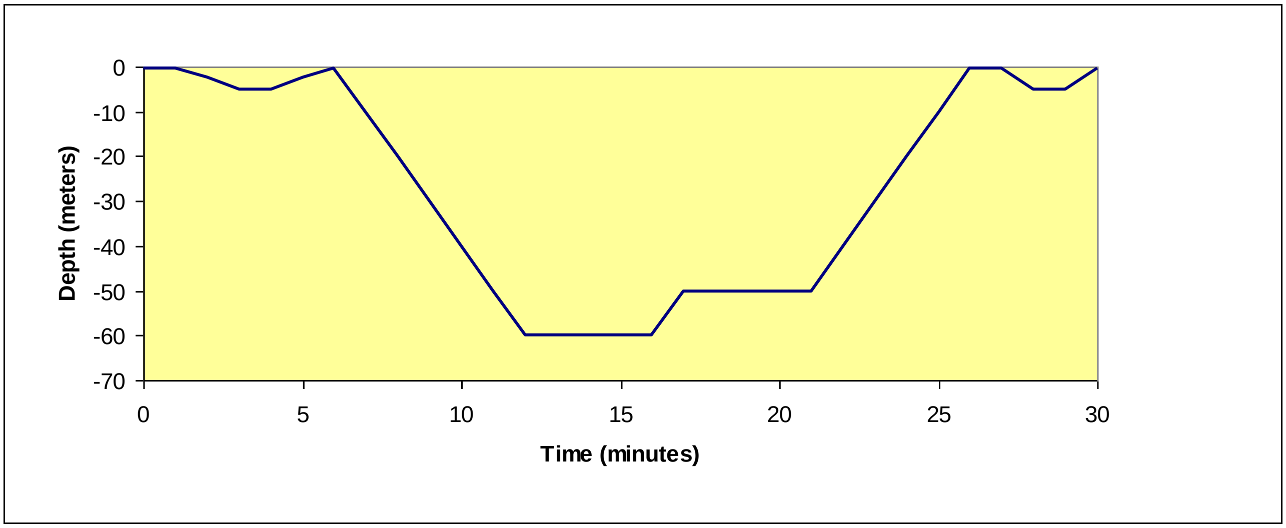


Figure C-2. Example of marine mammal dive pattern.

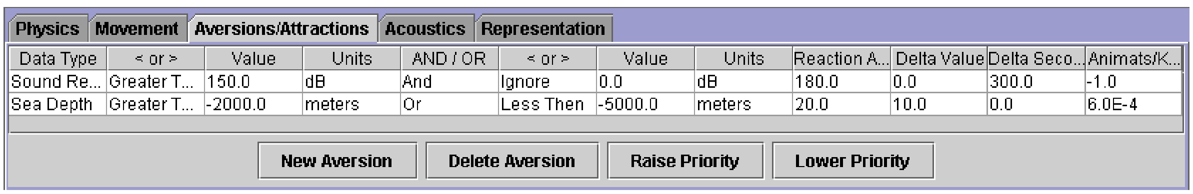


Figure C-3. Example of depth aversion parameters for marine mammal movement modeling.

species are grouped, the rationale is given in the introduction to that group. Dive details for individual species are provided, including the reference information and logic used to select each of the parameters.

Blue Whale (Balaenoptera musculus)

Surface Time

Of four satellite-tagged blue whales, data reported for one whale's surface intervals was 7 to 90 sec, with a mean of 48 sec. No surface intervals >60 sec were reported for the other three whales, indicating that the surface time was short (Lagerquist et al., 2000).

Dive Depth

Croll et al. (2001a) reported a mean dive depth of 140 m (± 46.01) for non-foraging animals, while foraging whales had a mean dive depth of 67.6 m (± 51.46). Satellite-tagged whales off California had a maximum dive depth of 192 m (Lagerquist et al., 2000). The distribution of dive depths was bimodal (Figure C-4) (note that this is from one animal). Therefore, the blue whale will be programmed with most of its dives to shallow water depth, with a lower percentage of deep dives.

Dive Time

Mean dive times of 4.3, 7.8, 4.9 5.7, 10.0, and 7.0 min have been reported for blue whales (Laurie, 1933; Doi 1974; Lockyer, 1976; Croll et al., 1998; Croll et al., 2001a). The best estimate of the maximum dive time is 14.7 min (Croll et al., 2001a), although a maximum time of 30 min was reported by Laurie (1933) The longest dive reported for satellite-tagged whales was 18 min, although the mean dive times for all whales was 5.8 (±1.5) min (Lagerquist et al., 2000).

Table C-3. Dive parameters of the marine mammal species modeled for risk assessment to acoustic exposure.

Modeled Species	Min/Max Surface Time (min)	Surface / Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/ Max Dive Time (min)	Heading Variance (Angle / Time)	Min /Max Speed (km/hr)	Speed Distribution	Depth Limit (m) / Reaction Angle
Blue Whale (non-foraging)	1/2		40/192	2/18	30	3/14	Normal	100/ reflect
Blue Whale (foraging)	1/2		10/20 (70) 20/160 (30)	2/18 4/18	30	3/14	Normal	100/ reflect
Fin Whale	1/1		20/250 (90) 250/470 (10)	5/8 1/20	20	1/16	Normal	30/ reflect
Sei/Bryde's Whale	1/1	90/75	20/150	2/11	30	0/20	5/1	50/ reflect
Minke Whale	1/3		20/100	2/6	Surf 45, Dive 20	1/18	Gamma (3.25,2)	10 / reflect
Humpback Whale (migrating)	1/2		10/40 (100)	5/10	10	2/10	Normal	(Min =100) / reflect
Humpback Whale (feeding)	1/2		10/40 (75) 40/100 (20) 100/150 (5)	5/10	45/30	2/10	Normal	(Min =100) / reflect
Humpback Whale (winter grounds, singing)	1/1		10/25 (100)	5/25	20	0/1	Normal	>1000/ reflect
Humpback Whale (calf)	1/2		5/30 (100)	2/5	45	1/3	Normal	>200/ reflect
Humpback Whale (winter grounds and migrating adults)	1/1		10/50	5/20	20	1/6	Gamma	1000/ reflect
Right Whale	4/5		113/130	11/13	30	3/6	Normal	
Gray Whale (migrating)	1/2		10/40	3/12	10	2/9	Normal	10/ reflect
Gray Whale (summering)	1/2		10 / bottom	1/7	45	1/5	Normal	
Sperm Whale	8/11	90/75	600/1400 (90), 200/600 (10)	18/65	20	0.1 / 10	Normal	200/ reflect
Kogia species.	1/2		200/1000	5/12	30	0/11	Normal	117/ reflect
Beaked Whales	1/7		1000/1453 (90), 50/200 (10)	12/70	30	3/6	Normal	253/ reflect

Table C-3. Dive parameters of the marine mammal species modeled for risk assessment to acoustic exposure.

Modeled Species	Min/Max Surface Time (min)	Surface / Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/ Max Dive Time (min)	Heading Variance (Angle / Time)	Min /Max Speed (km/hr)	Speed Distribution	Depth Limit (m) / Reaction Angle
Killer Whale	1/1		10/180	1/10	30	3/12	Normal	25/ reflect
False/Pygmy Killer whales	1/1		5/50 (80) 50/100 (20)	2/12	30	2/22.4	Gamma.	200/ reflect
Pilot Whales	1/1		5/50 (80) 50/1000 (20)	2/12	30	2/12	Gamma.	200/ reflect
Risso's Dolphin	1/3		150/1000	2/12	30	2/12	Normal	150/ reflect
Common Dolphin	1/1		50/200	1/5	30	2/9	Normal	100-1000/ reflect
Fraser's Dolphin	1/1		10/700	1/6	30	2/9	Normal	100/ reflect
Bottlenose Dolphin (Coastal)	1/1		15/98	1/3	30	2/16	Normal	10/ reflect
Bottlenose Dolphin (Pelagic)	1/1		15/200	1/3	30	2/16	Normal	101/ 1226 reflect
Stenella species	1/1		Day: 5/25 (50) Night: 10/400 (10) Night: 10/100 (40)	1/4	30	2/9	Normal	10/ reflect
Lagenorhynchus species	1/1		25/125	1/3	30	2/9	Normal	
Rough-toothed Dolphin	1/3		50/600	3/5	30	5/16	Normal	194/ reflect
Right Whale Dolphin	1/1			1/6	30	0/5 and 20/35	Normal	
Harbor Porpoise	1/1	17/31	1/10 (35%) 10/40 (45%) 40/100 (15) 100/230 (5)	1/4	30	2/7	Normal	100-1000/ reflect
Dall's Porpoise	1/1		5/94	1/2	30	6/16	Normal	deeper than 100 m

Table C-3. Dive parameters of the marine mammal species modeled for risk assessment to acoustic exposure.

Modeled Species	Min/Max Surface Time (min)	Surface / Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/ Max Dive Time (min)	Heading Variance (Angle / Time)	Min /Max Speed (km/hr)	Speed Distribution	Depth limit (m) / reaction angle
Guadalupe Fur Seal	0.5/2 0.5/1 1/2 1/2		0/5 (73) 5/50 (22) 60/100 (2) -1/5 (3)	1/4 2.4/4.2 4.2/7.7 1/4		5/9 5/9 5/9 0/1		
Northern Fur Seal (on shelf)	0.5/2 1/2 1/2		0/5 (57) 100/150 (26) -1/5 (17)	1/4 3/7 1/4		4.0/6.5 4.0/6.5 0/1		>200 /reflect
Northern Fur Seal (off shelf)	0.5/2 1/2 1/2		0/5 (57) 30/75 (26) -1/5 (17)	1/4 1/4 1/4		4.0/6.5 4.0/6.5 0/1		<1000 /reflect
Steller Sea Lion (winter)	3/8		4/10 (54) 10/50 (37) 50/250 (10)	0/2 2/4 4/8		3/10		
Steller Sea Lion (summer)	3/8		4/10 (35) 10/50 (61) 50/250 (3)	0/1 1/4 4/8		3/10		
California Sea Lion	2/3		8/75 (96) 75/224 (4)	1/3 4/8		6/12	0/0	
Hawaiian Monk Seal	1/2		50/500	4/12	30	2/9	Normal	
Northern Elephant Seal (male)	1.8/3.6	45	328/404	21.5/26.1		2.1/5.4		
Northern Elephant Seal (female)	1.5/2.7	45	437/535	22.1/26.9		2.1/5.4		
Harbor Seal	0.33/1 0.33/1 0.33/1 1/4	30/70	0/5 (40) 5/20(15) 50/150(5) -1/5(40)	0.5/2 0.5/2 4/7 1/4		1/4		

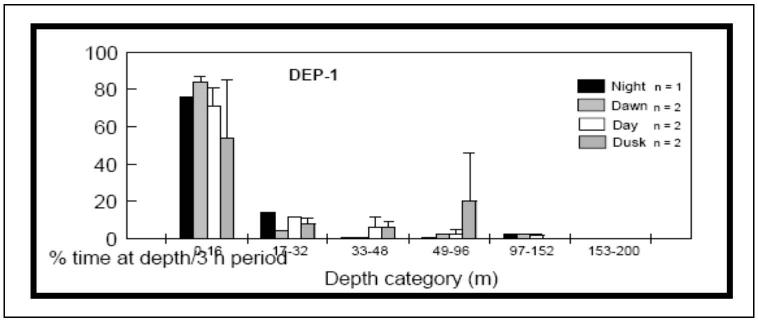


Figure C-4. Blue whale dive depth distribution (for one whale) showing bimodal distribution.

Speed

Dive descent rates of 1.26 m/sec have been recorded (Williams et al., 2000). A mean surface speed of 1.25 m/sec with a maximum speed of 2.0 m/sec was reported from satellite tags (Mate et al., 1999), although satellite data tend to smooth the track and therefore underestimate speed. A second satellite tag study found straight-line speed under estimates from 1.3 to 14.2 km/hr.

Group Size

Blue whales in the Eastern Tropical Pacific had a modal group size of one, although pods of two were somewhat common (Reilly and Thayer, 1990). The mean group size of blue whales off Australia (*B. m. brevicauda*) was 1.55 animals (Gill, 2002).

Fin Whale (Balaenoptera physalus)

Surface Time

Remarkably good data for surface times exist for fin whales. A log survivorship analysis of all inter-blow intervals was used to determine an inflection point of 28 and 31 sec between surface and dive activity for feeding and non-feeding animals, respectively (Kopelman and Sadove, 1995). The mean surface duration for fin whales, without boats present, off Maine was 54.63 sec (SD = 59.61) while dive times were 200.84 sec (SD = 192.91) (Stone et al., 1992).

Dive Depth

Foraging fin whales had mean dive depths of 97.9 +/- 32.59 m, while traveling fin whales had mean dive depths of 59.3 +/- 29.67 m (Croll et al., 2001a). Migrating fin whales were determined to have a maximal dive depth of 364 m (Charif et al., 2002). Fin whales in the Mediterranean Sea typically dove to about 100 m, and occasionally dove to 470 m, or more (Panigada et al., 1999), however these are unusually deep dives. The animats here model the more typical dive pattern 90% of the time. Foraging fin whales off California had a mean maximum dive depth of 248 m (Goldbogen et al., 2006). Based on this study, the most frequent AIM dive depth is extended to 250 m.

Dive Time

Foraging fin whales had mean dive times of 6.3 +/- 1.53 min, while traveling fin whales had mean dive time of 4.2 +/- 1.67 min (Croll et al., 2001a). The maximum dive time observed was 16.9 min. Fin whales off the east coast of the U.S. were observed to have mean dive times of 2.9 min. Ranges for the dive times of feeding animals ranged from 29 to 1001 sec, while non-feeding animals had longer dives between 32 and 1212 sec (Kopelman and Sadove, 1995). (Panigada et al., 1999) found that shallow (<100m) dives had a mean dive time of 7.1 min, while deeper dives had dive times of 11.7 and 12.6 min.

Fin whales foraging on Jeffrey's Ledge in the Gulf of Maine had mean dive times of 5.83 to 5.89 min (Ramirez et al., 2006).

Speed

(Watkins, 1981) reported a mean speed of 10 km/hr, ranging from 1 to 16 km/hr, with bursts of 20 km/hr reported. Mean descent speeds of 3.2 m/sec (SD = 1.82) and ascent speeds of 2.1 m/sec (SD=0.82) have been reported from fin whales in the Mediterranean (Panigada et al., 1999).

Habitat

Fin whales are found feeding on shallow banks and in bays (Woodley and Gaskin, 1996) as well as in the abyssal plains of the ocean (Watkins, 1981). Thus fin whales are allowed to move into shallow water in AIM, with a 30 meter inshore limit to keep them out of the very shallow waters.

Group Size

In the Gulf of Mexico fin whales had a mean group size of 5.7, with a range in group sizes from 1 to 50 (Silber et al., 1994). In the Mediterranean sea the mean group size over a number of years was 1.75 animals (Panigada et al., 2005).

Sei/Bryde's Whale (Balaenoptera borealis and B. edeni)

There are a paucity of data for these species. Since they are similar in size, data for both species have been pooled to derive model parameters for these species.

Surface Time

No direct data were available so fin whale values were used.

Dive Depth

No direct data were available, fin whale values were used.

Dive Time

Dive times ranged between 0.75 and 11 min, with a mean duration of 1.5 min (Schilling et al., 1992). Most of the dives were short in duration, presumably because they were associated with surface or near-surface foraging. The same paper reported surface times that ranged between 2 sec and 15 min.

Heading Variance

Observations of foraging sei whales found that they had a very high reorientation rate, frequently resulting in minimal net movement (Schilling et al., 1992).

Speed

Brown (1977) reported an overall speed of advance from tagged sei whales as 4.6 km/hr. The highest speed reported for a Bryde's whale was 20 km/hr (Cummings, 1985). A Bryde's whale being attacked by killer whales traveled approximately 9 km in 94 min, with most of the travel occurring in the first 50 min, producing an estimated speed of 10.8 km/hr (Silber et al., 1990). The maximum speed of sei whales reported from a satellite tracking study was 7.6 m/sec, although the distribution of speeds was highly skewed toward lower values (Olsen et al., 2009). The speed parameters used in AIM are 0 to 20 km/hr, using a gamma distribution with alpha and beta parameters of 5 and 1 (Figure C-5), which covers the reported range of speed reported by Olsen et al. (2009) and approximated the mean value reported by Brown (1977).

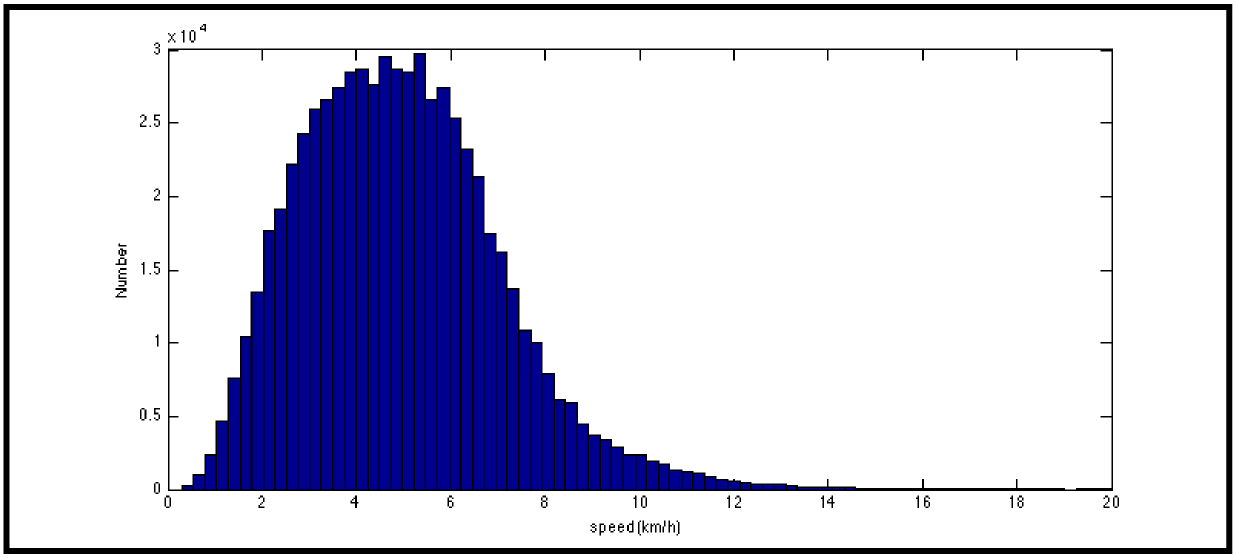


Figure C-5. Bryde's whale speed distribution.

Habitat

Sei whales are known to feed on shallow banks, such as Stellwagen Bank (Kenney and Winn, 1986). Therefore, Sei and Bryde's whales are allowed to move into shallow water.

Group Size

Sei whales in the Gulf of Maine were seen in groups of 1 to 6 animals with a mean group size of 1.8 whales (Schilling et al., 1992). Bryde's whales in the Gulf of California were seen in groups of 1 to 2 animals, with a mean size of 1.2 whales (Silber et al., 1994).

Minke Whale (Balaenoptera acutorostrata)

Surface Time

A mean surface time of 1.72 min, with a range of 0.63 to 2.35 min was reported by Stern (1992).

Dive Depth

Inferred from other species; however, reduced in depth, since minke whales are likely to be pelagic feeders, feeding on species found near the surface (Olsen and Holst, 2001).

Dive Time

The mean dive time of 4.43 +/- 2.7 min was reported by Stern (1992). Dive times measured off Norway range from approximately 1 to 6 min (Joyce et al., 1989). Dive times also show small diel and seasonal variability (Stockin et al., 2001), but the variability is small enough to be considered not significant for AIM modeling. Dive times were non-normal (Figure C-6) (Øien et al., 1990).

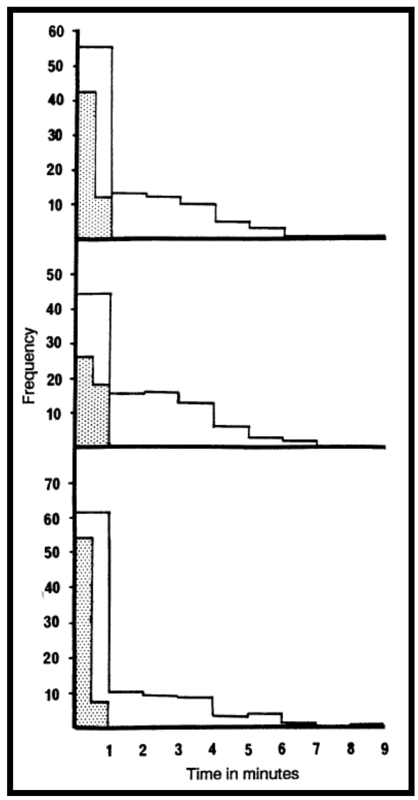


Figure C-6. Minke whale dive durations (Øien et al., 1990).

Speed

The mean speed value for minke whales in Monterey Bay was 8.3 +/- 6.4 km/hr (4.5 +/- 3.45 knots) (Stern, 1992). Satellite tagging studies have shown movement of up to 79 km/day (3.3 km/hr). Minke whales being pursued by killer whales were able to swim at 15 to 30 km/hr (Ford et al., 2005). A gamma function was fit to the available speed data (Figure C-7). The modal speed of this function is 4.5 km/hr, matching the Stern (1992) data, and has a maximum of 18 km/hr, somewhat less than the maximum speed achievable (30 km/hr), observed during predation.

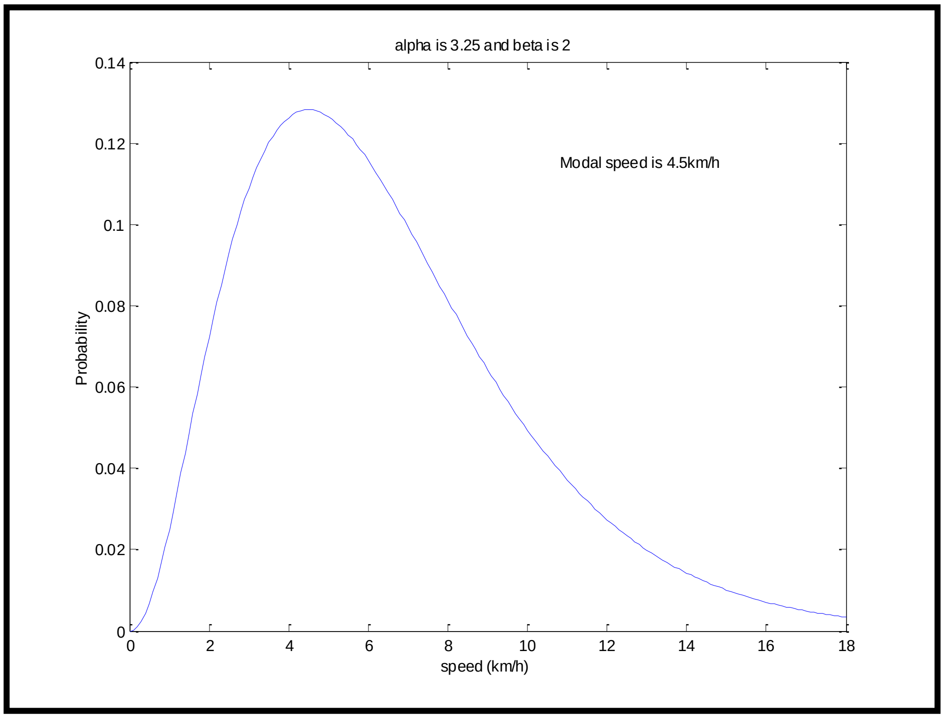


Figure C-7. Speed distribution for the minke whale.

Habitat

Minke whales in Monterey Bay were reported to be at a median depth of 48.6 m (Stern, 1992). They are known to move into very shallow water as well as deep oceanic basins. The 10 meter limit and reflection aversion are intended to let minke whales roam freely, but to stay off the beach.

Group Size

Minke whales in the Gulf of California were seen in group sizes of 1 to 50, with a mean size of 5.7 (Silber et al., 1994).

Residency

Foraging minke whales have been shown to exhibit small-scale site fidelity (Morris and Tscherter, 2006). Therefore, foraging minke whales should have their course change parameters set to be variable to allow for small net movements.

Humpback Whale (Megaptera novaeangliae) (Migrating)

Surface Time

Approximately 65% of all surfacings observed in Alaska were 2 min in length or less (Dolphin, 1987b). Surface times in Hawai'i are similar, with the exception of surface-active groups (SAGs) (Bauer et al., 1995).

Dive Depth

Humpback whale dive depths have been measured on the feeding grounds, with 75% of dives ranging to 40 m or less (Dolphin, 1988). It is likely that migrating animals would also predominantly dive to these shallow depths.

Dive Time

Surface times range between 1 and 2 min, while dive times range between 5 and 10 min (Gabriele et al., 1996).

Heading Variance

Set very low for migrating animals. Most non-competitive group breeding animals also have linear travel. Migrating humpbacks swam very close to magnetic north from Hawai'i with very little deviation (Mate et al., 1998).

Speed

The mean speed for humpback whales is about 4.5 km/hr. The measured range is 2 to 11.4 km/hr (excluding stationary pods) (Gabriele et al., 1996). Satellite-tracked migrating humpback whales moved at a minimum of 150 km/day (6.25 km/hr) for a mother and calf pod, while another two whales moved 110 km/day (4.5 km/hr). Humpbacks off Australia were estimated to migrate at a mean speed of 8 km/hr, with a range between 4.8 to 14.2 km/hr (Chittleborough, 1953). More recent studies of Australian humpbacks found a mean northern migration speed of 5.47 km/hr, while the southern migration speed had a mean of 5.02 km/hr for non-calf pods, while calf pods had mean speeds of 5.03 and 4.25 km/hr (Chaudry, 2006).

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the oceanic abyssal plains. Humpbacks that swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for this species has been set at 100 m. Non-calf pods migrating off Australia had a mean offshore distance of 3.2 km during the northern migration and 2.6 km during the southern migration. Calf pods migrated "significantly" closer inshore (Chaudry, 2006).

Humpback Whale (Megaptera novaeangliae) (Feeding)

Surface Time

Approximately 65% of all surfacings were 2 min in length or less (Dolphin, 1987b).

Dive Depth

Humpback whale dive depths have been measured on the feeding grounds, where 75% of their dives were to 40 m or less with a maximum depth of 150 m (Dolphin, 1988). Dive depth appears to be determined by prey distribution. Whales in this study were primarily foraging on euphasids. There is also a strong correlation of dive depth and dive time and is described by the following equation (Dolphin, 1987b).

Feeding humpbacks off Kodiak Alaska had a mean maximum dive depth of 106.2 m, with 62% of the dives occurring between 92 and 120 m, with a maximum of about 160 m (Witteveen et al., 2008) (Figure C-8). The humpbacks appeared to be feeding largely on capelin and pollock. There are strong differences

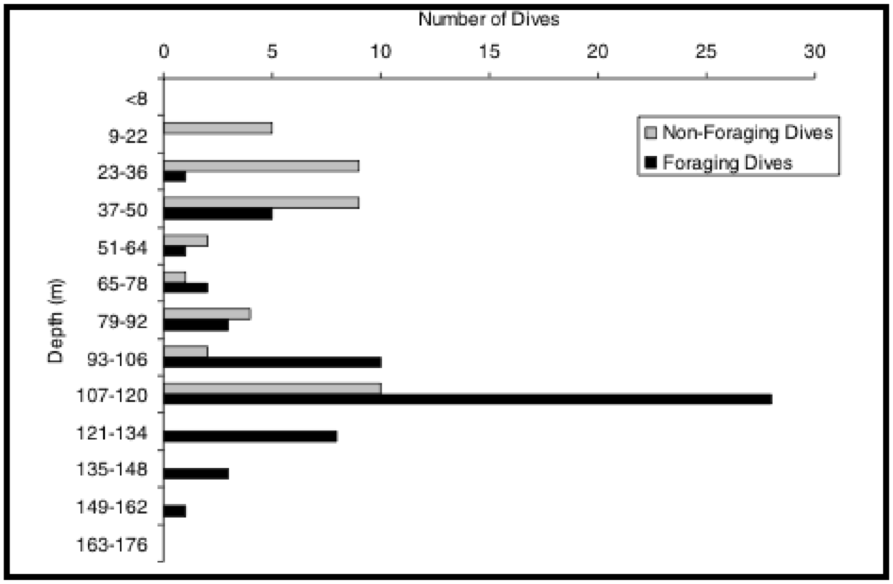


Figure C-8. Frequency distribution of feeding humpback whale mean maximum dive depths in 14 m (1 SD of mean maximum dive depth) depth bins for dives recorded from tagged humpback whales (Witteveen et al., 2008).

in the data between these two studies. These differences may reflect the distribution of prey rather than behavioral abilities of the whales.

Dive Time

The maximum of the continuous portion of the distribution of dive times was 15 min (Dolphin, 1987b). The distribution was skewed toward shorter dives. Several dive steps can be programmed in AIM to capture this variability.

Heading Variance

Set very low for migrating animals. Most non-competitive group breeding animals also have linear travel. Migrating humpbacks swam very close to magnetic north from Hawai'i with very little deviation (Mate et al., 1998).

Speed

Mean speeds for humpbacks are near 4.5 km/hr. The measured range is 2 to 11.4 km/hr (excluding stationary pods) (Gabriele et al., 1996). Ascent rates during dives range from 1.5 to 2.5 m/sec, while descent rates range between 1.25 and 2 m/sec (Dolphin, 1987a). The mean speed for all pod types in Glacier Bay was 3.31 km/hr (Baker and Herman, 1989).

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the oceanic abyssal plains. Humpbacks that swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for this species has been set at 100 m.

Group Size

Ninety-six percent of 27,252 pods in the Gulf of Maine were composed of 1 to 3 animals, with a modal size of one adult (Clapham, 1993).

Humpback Whale (Megaptera novaeangliae) (Winter Grounds: Singer)

Surface Time

Singing humpback whales typically surface for <1 min. Singing humpback whales in the Caribbean blew between 2 and 8 times per surfacing (Chu, 1988).

Dive Depth

Humpback singers inhabit relatively shallow depths.

Dive Time

Dive times typically range from 10 to 25 min. Observations of 20 singing humpback whales in the Caribbean found dive times between 5 and 20 min in duration (Chu, 1988).

Heading Variance

Set very low for singers. While traveling very slowly, even up to becoming nearly stationary, they tend to swim along the coast.

Speed

Most singers are stationary, although a very few move at high speeds.

Habitat

On the wintering grounds, most singers are found within the 100 fathom isobath, but a few are found in deeper waters. The density for these animals would be less.

Group Size

The vast majority of singers are found alone. The largest pod containing a singer that has been reported was four animals (Frankel et al., 1995).

Humpback Whale (Megaptera novaeangliae) (Calf)

Surface Time

Calves can be on the surface for an extended time, compared to adults.

Dive Depth

Dive depths have not been measured for calves, but are likely to be less than 30 m on the wintering grounds.

Dive Time

Dive times for calves range between 2 and 5 min.

Heading Variance

Heading variances can be relatively high.

Speed

Calf pods tend to be relatively slow moving.

Habitat

Humpbacks on the wintering grounds are most common within the 100 fathom isobath, although they are found in deeper waters in lower densities.

Group Size

Calves are almost always found with their mother. Weaning typically occurs when the calf is one year old, after which calves are considered independent.

Humpback Whale (Megaptera novaeangliae) (Winter Ground and Migrating Adult)

Surface Time

Approximately 65% of all surfacings observed in Alaska were 2 minute in length or less (Dolphin, 1987b). Surface times in Hawaiʻi are similar, with the exception of surface active groups (SAGs) (Bauer et al., 1995)

Dive Depth

The maximum dive depth reported for a humpback on the Hawaiian winter grounds was 176 m (Baird et al., 2000). The distribution of dive depths was strongly skewed toward shallower dives (Table C-4).

Table C-4. Humpback whale dive distributions.

DEPTH CATEGORY (M)	MEAN % TIME IN DEPTH CATEGORY	SD	CUMULATIVE % TIME
1-10	39.55	20.57	39.55
11-20	26.51	13.29	66.06
21-30	11.65	11.84	77.71
31-40	4.25	2.77	81.96
41-50	3.04	2.28	85.00
51-60	2.47	2.28	87.47
61-70	2.14	1.73	89.61
71-80	1.66	1.54	91.27
81-90	1.97	1.91	93.24
91-100	1.55	2.36	94.79
101-110	1.39	2.17	96.18
111-120	1.31	2.33	97.49
121-130	0.92	1.75	98.41
131-140	0.72	1.73	99.13
141-150	0.30	0.56	99.43
151-160	0.23	0.40	99.66
161-170	0.15	0.26	99.81
171-180	0.09	0.22	99.90

Dive Time

Surface times range between 1 and 2 min, while dive times range between 5 and 10 min (Gabriele et al., 1996).

Heading Variance

Most non-competitive group breeding animals also have largely linear travel.

Speed

Mean speeds for humpbacks are near 4.5 km/hr while the measured range is 2 to 11.4 km/hr (excluding stationary pods) (Gabriele et al., 1996). Fitted Gamma curve parameters (Table C-5) and the humpback whale speed distribution (Figure C-9) are shown below.

Table C-5. Gamma curve parameters for Figure C-8.

TYPE	PARAMETER	ESTIMATE	LOWER 95%	UPPER 95%
Shape	Alpha	2.326775	2.255537	2.398012
Scale	Sigma	1.617174	1.561936	1.672412
Threshold	Theta	0.000000	1.570127	

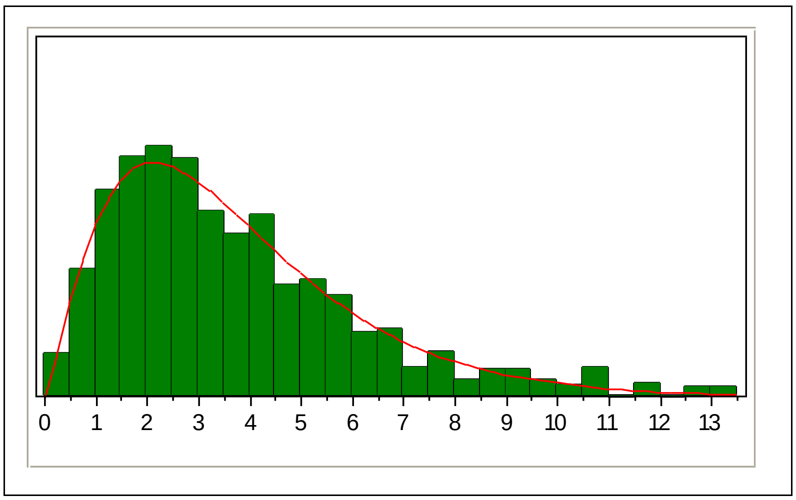


Figure C-9. Humpback whale speed histogram for pods in Hawai'i (km/hr).

Group Size

The modal group size in Hawai'i was 2 adults (Mobley and Herman, 1985)

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the oceanic abyssal plains. Humpbacks that swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for migrating animals has been set at 100 m.

North Atlantic Right Whale (Eubalaena glacialis)

Surface Time

Mean surface time for northern right whales was less than 60 sec (Winn et al., 1995). Therefore, a one minute surface time was used for AIM.

Dive Depth

Northern right whale feeding dives in the northwest Atlantic were characterized by rapid descent to depths between 80 and 175 m. The median depth was 119 m with a 90% confidence interval between 113 and 130 m (Baumgartner and Mate, 2003). This 95% confidence range was used for the dive depth range. In a nearby area, right whales dove to depths between approximately 120 and 180 m (Nowacek et al., 2004).

Dive Time

The median dive time for foraging northern right whales was 12.65 min, with a 95% confidence interval of 11.4 to 12.9 min (Baumgartner and Mate, 2003).

Speed

Descent speed of diving northern right whales had a 95% confidence interval of 1.3 to 1.5 m/sec, while the ascent speed was 1.4 to 1.7 m/sec (Baumgartner and Mate, 2003). Radio-tagged whales that remained in the Bay of Fundy had a mean speed of 1.1 km/hr, while those that left the bay had a mean speed of 3.5 km/hr (Mate et al., 1997). Note that radio-tagging tends to underestimate whale speed, since the data greatly smooth the recorded course of the animal

Habitat

Northern right whales are currently found in the northwest Atlantic Ocean and the North Pacific Ocean. In the North Atlantic, they range from the Bay of Fundy area during the summer foraging season. They migrate along the coast and their breeding area is in the shallow waters offshore of Florida and Georgia. It is believed that a portion of the population migrates to an undiscovered location.

Group Size

The group size of surface active groups (SAGs) in the Bay of Fundy ranged from 2 to 15 animals (Parks and Tyack, 2005).

Gray Whale (Eschrichtius robustus)

Surface Time

Most of the surface times for summering gray whales fell in the range of 0 to 2 min (Würsig et al., 1986).

Dive Depth

No dive depth data for migrating grays were available. However, the near shore habitat of migrating gray whales makes the estimated ranges of 10 to 40 m a reasonable estimate. Summering (foraging) gray whales are presumed to dive to depths between 10 m and the local bottom depth, since they are bottom feeders (Nerini, 1984).

Dive Time

Gray whales migrating past Unimak Island in Alaska were recorded to have dive times between 3 and 700 sec (Rugh, 1984). However, numerous other papers cite a minimum dive time of 3 min or longer (Wyrick, 1954; Rice and Wolman, 1971). Therefore, the values of 3 to 12 min were used in the modeling. Summering gray whales appear to have shorter dive times, ranging up to approximately 7 min, with a mean near four min (Würsig et al., 1986).

Speed

Tagged migrating gray whales have been documented to cover between 31.4 and 125 km/day (Mate and Harvey, 1984). A maximum speed of 9 km/hr was calculated by Rice and Wolman (1971). Summering (foraging) gray whales were measured at 2.3 +/-2.18, 2.3 +/- 1.75 and 2.8 +/- 2.23 km/hr (Würsig et al., 1986). Therefore, summering gray whales are programmed to swim between 1 and 5 km/hr

Habitat

Gray whales are famous for migrating very close to shore. They will occasionally cross the mouths of bays (e.g., San Diego) which may take them further offshore. Therefore, their inshore depth limit is set at 10 m, a depth from which they will 'reflect' or move seaward in the model. All gray whales are currently set to avoid waters deeper than 100 m.

Group Size

Migrating gray whales off California had slightly different pod sizes during the day and the night (mean day = 1.75 ± 0.280, mean night = 1.63 ± 0.232) (Perryman et al., 1999). Foraging western gray whales off Sakhalin Island, Russia had pod sizes ranging from 1 to 3, with a mean size of 1.2 animals (Weller et al., 2002).

Sperm Whale (Physeter macrocephalus)

Surface Time

Male sperm whales in New Zealand had a mean duration on the surface of 9.1 min, with a range of 2 to 19 min (Jaquet et al., 2000). The distribution of surface times was non-normal, with 68% of the surface times falling in between 8 and 11 min. These values were used for AIM modeling.

Surfacing and Dive Angles

Surfacing angles of 90° and diving angles between 60° and 90° have been reported (Miller et al., 2004).

Dive Depth

The maximum, accurately measured, sperm whale dive depth was 1,330 m (Watkins et al., 2002). Foraging dives typically begin at depths of 300 m (Papastavrou et al., 1989). Sperm whale diving is not uniform. As an example of this, data from a paper on sperm whale diving reported different dive types for the sperm whales in their study (Amano and Yoshioka, 2003). AIM can now accommodate these different dive types, at different frequencies of use (Table C-6).

Dive depths have also been shown to have diel variation in some areas, while others do not show this variation (Aoki et al., 2007). These differences have been attributed to the behavior of the prey species. Off California, tagged whales changed their dive patterns in response to changes in the depth of tagged squid (Davis et al., 2007). Male sperm whales foraging in high-latitude waters dove to a maximum depth of 1,860 m, but the median dive depth was only 175 m (Teloni et al., 2008).

Dive Time

Sperm whale dive times average 44.4 min in duration and range from 18.2 to 65.3 min (Watkins et al., 2002).

Speed

Sperm whales are typically slow or motionless on the surface. Mean surface speeds of 1.25 km/hr were reported by Jaquet et al.(2000) and 3.42 km/hr Whitehead et al.(1989). Their mean dive rate ranges from 5.22 km/hr to 10.08 km/hr with a mean of 7.32 km/hr (Lockyer, 1997). In Norway, horizontal swimming speeds varied between 0.2 and 2.6 m/sec (0.72 and 9.36 km/hr) (Wahlberg, 2002). Sperm whales in the

Table C-6. Sperm whale diving parameters (Amano and Yoshioka, 2003).

Type of Dive	N	Depth (m)		Time (min)	
		Min	Max	Min	Max
Dives w/ active bottom period	65	606	1082	33.17	41.63
Dives w/o active bottom period	4	417	567	31.29	33.71
V shaped dives	3	213	353	12.77	20.83
Total	74				

Note: The dive data in this table are for only the sperm whales in the Amano and Yoshioka study. These data do not equate to the values used in AIM. For example, the table shows minimum and maximum dive times as 12.77 and 41.63 min respectively, while the AIM values are 18.2 and 65.3 min respectively, as stated below under dive time.

Atlantic Ocean swam at speeds between 2.6 and 3.5 km/hr (Watkins et al., 1999; Jaquet and Whitehead, 1999). Based on these data, a minimum speed of 1 km/hr, and a maximum speed of 8 km/hr was set for sperm whales, specified with a normal distribution, so that mean speeds will be about 4 km/hr.

Habitat

Sperm whales are found almost everywhere, but they are usually in water deeper than 480 m (Davis et al., 1998). However, there have been sightings of animals in shallow water (40 to 100 m) (Scott and Sadove, 1997, Whitehead et al., 1992). In the Gulf of California, there was no relationship between depth or bathymetric slope and abundance, and animals were seen in water as shallow as 100 m (Jaquet and Gendron, 2002). Based on these reports, a compromise value of 200 m is used as the shallow water limit for sperm whales.

Group Size

Social, female-centered groups of sperm whales in the Pacific have ‘typical’ group sizes of 25 to 30 animals, based on the more precise measurements in Coakes and Whitehead (2004); although, less precise estimates are as high as 53 whales in a group.

Dwarf and Pygmy Sperm Whales (Kogia spp.)

Data on dwarf and pygmy sperm whales are rare, and these species are very similar, so data for these two species have been combined.

Surface Time

Observations of *Kogia* off Hawaii found that they logged at the surface for up to a “few” minutes then dove (Baird, 2005).

Dive Depth

In the Gulf of Mexico, *Kogia* were found in waters less than 1000 m, along the upper continental slope (Baumgartner et al., 2001). Therefore, the dive limits of 200 to 1000 m were chosen based on similar species diving deeply to feed, and within the physical constraints of the environment. It should be noted that *Kogia* have been seen in water almost 2000 m deep (Davis et al., 1998), but they may not be diving to the bottom.

Dive Time

Maximum dive time reported for *Kogia* is 12 min (Hohn et al., 1995). A rehabilitated pygmy sperm whale made long dives from 2 to 11 min in length at night, and shorter dives during the day (Scott et al., 2001).

Speed

Tracking of a rehabilitated pygmy sperm whale found that speeds range from 0 to 6 knots (11 km/hr) with a mean value of 5.6 km/hr (3 knots) (Scott et al., 2001).

Habitat

The minimum depth that *Kogia* were found in the Gulf of Mexico was 176 m (Davis et al., 1998). Off Hawai‘i, they were found in waters between 450 and 3200 m depth, with a mean depth of 1425 m (Baird, 2005). *Kogia* in the Philippines were found in waters from 117 to 3744 m in depth (Dolar and Perrin, 2003).

Group Size

Group sizes off Hawai‘i ranged between 1 and 6 animals (Baird, 2005) and group sizes in the Gulf of Mexico range between 1 and 3 (Mullin et al., 2004).

Beaked Whales (Family Ziphiidae)

Data on the behavior of beaked whales is sparse. Therefore, beaked whale species have been pooled into a single animat that is used to model all beaked whale species.

Surface Time

Surface times in Arnoux's beaked whales ranged from 1.2 to 6.8 min (Hobson and Martin, 1996). Sowerby's beaked whales had surface times of 1 to 2 min, during which they would blow 6 to 8 times (Hooker and Baird, 1999b)

Dive Depth

The minimum and maximum dive depth measured for a beaked whale was 120 and 1453 m, respectively (Hooker and Baird, 1999a). *Ziphius* tagged off the Canary Islands had foraging dives between 824 m and 1267 m, while Blainsville's beaked whales dove to depths between 655 m and 975 m (Johnson et al., 2004).

Northern bottlenose whales performed shallow dives with a range of 41 to 332 m (n=33), while deep dives ranged from 493 to 1453 m (n=23). Dive depth and dive duration were strongly correlated (Hooker and Baird, 1999a).

Dive Time

The minimum and maximum dive time measured was 16 and 70.5 min, respectively (Hooker and Baird, 1999a). Sowerby's beaked whales had dives between 12 and (at least) 28 min in the Gully in Canada (Hooker and Baird, 1999b). Arnoux's beaked whale had modal dive times between 35 to 65 min (mean = 46.4 min, SD = 13.1), with a maximum dive time of at least 70 min (Hobson and Martin, 1996). Tagging results with *Ziphius* had one animal diving for 50 min (Johnson et al., 2004). *Mesoplodon stejnegeri* were observed to dive for “10 to 15 min” in Alaska (Loughlin, 1982)

Heading Variance

Sowerby's beaked whales surfacing in the Gully were reported to have no apparent orientation, and would change orientation up to 180° between surfacing (Hooker and Baird, 1999b).

Speed

Dive rates averaged 1 m/sec or 3.6 km/hr (Hooker and Baird, 1999a). A mean surface speed of 5 km/hr was reported by (Kastelein and Gerrits, 1991).

Habitat

The minimum sea depth in which beaked whales were found in the Gulf of Mexico was 253 m (Davis et al., 1998). In the Gully in Canada, Sowerby's beaked whales were found in water ranging from 550 to 1500 m in depth (Hooker and Baird, 1999b). Blainsville's beaked whales (*M. densirostris*) were found in water depths of 136 to 1319 m in the Bahamas, and were found most often in areas with a high bathymetric slope (MacLeod and Zuur, 2005). *Mesoplodons* were found in waters from 700 m to > 1800 m off Scotland and the Faroe Islands (Weir, 2000) and between 680 and 1933 m in the Gulf of Mexico (Davis et al., 1998).

Group Size

Mesoplodon stejnegeri in Alaska had pod sizes between 5 and 15 animals (Loughlin, 1982). Sowerby's beaked whales in the Gully in Canada had group sizes between 3 and 10 (Hooker and Baird, 1999b). Dense-beaked whales off the Canary Islands had group sizes ranging between 2 and 9 with a mean size of 3.44 whales (Ritter and Brederlau, 1999). Sightings of Longman's beaked whale in the western Indian ocean found group sizes between 1 and 40, with a mean size of 7.2 whales (Anderson et al., 2006).

Killer Whale (Orcinus orca)

There is a remarkable paucity of quantitative data available for killer whales, considering their coastal habitat and popular appeal. Nevertheless, most data from "blackfish" were used to model orca, with the exception of dive depth. The different feeding ecology of these species makes very deep dives apparently unnecessary. When additional data allow, separate animats will be developed for "resident" and "transient" killer whales.

Dive Depth

Killer whales feeding on herring were observed to dive to 180 m (Nøttestad et al., 2002). Killer whales are found in at least two "races", transients and residents. Transients feed primarily on marine mammals, whereas residents feed primarily on fish. Residents were reported to dive to the bottom (173 m) (Baird, 1994). Baird (1994) also reported that while residents dive deeper than transients, the transients spent a far greater amount of time in deeper water. Individual resident killer whales in the Pacific northwest had maximum dive depths ranging between 24 and 264 m, with a group mean maximum depth of 140.8 m (SD=61.8, n=34) (Baird et al., 2005). The distribution of dive depths in Baird et al (2005) was strongly skewed toward shallow values.

Dive Time

Daytime dive times for males were 2.79 min, significantly longer than the 2.09 minute dive times for females (Baird et al., 2005).

Speed

Uncalibrated swim speed data were presented by Baird et al.(2005). Killer whales chasing minke whales had prolonged speeds of 15 to 30 km/hr (Ford et al., 2005), although these speeds are probably obtained only during predation. A shore-based study of southern resident killer whales in Washington State had a mean speed of 9.5 km/hr, with a mean range of 4.7 to 16.1 km/hr (Kriete, 2002). The mean speed of control animals was approximately 5.3 km/hr, measured during a study of the response of killer whales to vessels (Williams et al., 2002). A similar study reported a mean speed of 6.64 km/hr without vessels and 6.478 km/hr in the presence of vessels (Bain et al., 2005). Taken together, these three studies produced a speed range of 3 to 12 km/hr for use in AIM.

Habitat

Killer whales are known to occur in very shallow water (e.g., rubbing beaches) as well as across open ocean basins. However, they are usually coastal and most often found in temperate waters.

Group Size

Killer whales in the Gulf of California were seen in groups of 2 to 15 whales, with a mean of 8.5 and a SD of 9.19 (N=2) (Silber et al., 1994). Off the Pacific coast of Costa Rica, the mean group size was 3.51 (SD = 2.99, n=7) (May-Collado et al., 2005).

Blackfish: False Killer Whale, Pygmy Killer Whale, Melon-Headed Whale (Feresa, Pseudorca, and Peponocephala spp.)

Studies describing the movements and diving patterns of these animals are rare and sparse. Therefore, they have been combined into a single “blackfish” category. As more data become available, these species will be split into separate animats.

Surface Time

No direct measurements of surface time are available, so the default value of one minute was used.

Dive Depth

The maximum dive depth of a single false killer whale off the Madeira Islands was 72 m. Most of the time was spent at depths deeper than 20 m, and the dives were V-shaped (Alves et al., 2006). Three false killer whales in Hawai‘i had shallow dives as well, with maximum depths of 22, 52 and 53 m (Ligon and Baird, 2001). It should be noted that these animals were feeding on fish.

Dive Time

No direct measurements were available, so data from pilot whales were used here (Figure C-10).

Speed

Maximum speed recorded for false killer whales was 8.0 m/sec (28.8 km/hr) (Rohr et al., 2002), although the typical cruising speed is 20 to 24% less than the maximum speed (Fish and Rohr, 1999). This “typical” maximum of 6.24 m/sec (22 km/hr) was used as the maximum speed for AIM. Off the Madeira Islands false killer whales were found in water depths from 900 to 2000 m (Alves et al., 2006).

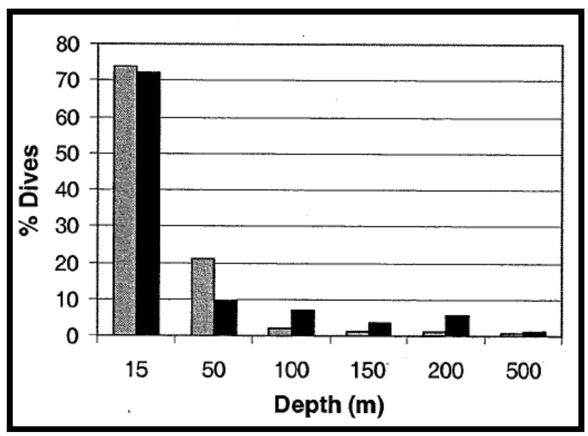


Figure C-10. Distribution of pilot whale dive depths.

Group Size

False Killer whales in the Gulf of Mexico had group sizes between 20 and 35 (mean = 27.5, SE = 7.5, n=2) (Mullin et al. 2004). False killer whales off Costa Rica had a mean group size of 36.16 +/- 52.38 (May-Collado et al., 2005).

Short-finned and Long-finned Pilot Whales (Globicephala spp.)

There are insufficient data available to have separate animats for the two pilot whale species. Therefore they are combined into a single pilot whale animat.

Surface Time

A rehabilitated long-finned pilot whale in the North Atlantic was equipped with a satellite tag and a time-depth recorder (TDR). The log survivorship plot of dive time from this animal had an inflection point at about 40 sec (Mate et al., 2005). The authors did not feel that this qualified as a breakpoint to separate surface and dive behavior. However, it does suggest that most surface intervals are less than one minute.

Dive Depth

Long-finned pilot whales in the Mediterranean were observed to display considerable diurnal variation in their dive depths. During the day they never dove to more than 16 m. However, at night, they dove to a maximum depths of 360 and 648 m with mean depth of 308 and 416 m (Baird et al., 2002). Rehabilitated long-finned pilot whales dove to 312 m on Georges Bank, which has a depth of 360 m; so, these values should not be taken as the maximum. The distribution of dive depths was also skewed toward lower values (Nawojchik et al., 2003).

Dive Time

Baird et al. (2002) reported on dives of two individual long-finned pilot whales, which varied between 2.14 and 12.7 min during the night. Animals spent all of their time in the top 16 m during the day.

A rehabilitated long-finned pilot whale in the North Atlantic had dive times between 1 and 6 min (Mate et al., 2005). Other rehabilitated long-finned pilot whales were reported to dive for at least 25 min, although the distribution is skewed toward shorter dives, with most lasting about 2 min (Nawojchik et al., 2003). Long-finned pilot whales off the Faroe Islands never dove longer than 18 min (Heide-Jørgensen et al., 2002).

Speed

(Shane, 1995) reported a minimum speed of 2 km/hr and a maximum of 12 km/hr for pilot whales. During the day in the Mediterranean, animals slowly swam, with mean values for two animals of 0.762 and 0.885 m/sec (2.85 and 3.18 km/hr), while at night, they swam faster at 1.898 m/sec (6.83 km/hr) and 1.523 m/sec (5.48 km/hr) (Baird et al., 2002). A single satellite-tracked long-finned pilot whale had a minimum speed of 1.4 km/hr (Mate et al., 2005). The speeds of traveling pilot whales (G. *scammoni*) was estimated at 4 to 5 kts (7.4 to 9.3 km/hr) (Norris and Prescott, 1961) (cited in Mate et al., 2005). Vertical dive speeds of three TDR-tagged long-finned pilot whales ranged from 0.79 to 3.38 m/sec, with a mean of 1.99 m/sec (Heide-Jørgensen et al., 2002).

Habitat

The minimum water depth that pilot whales were seen in the Gulf of Mexico was 246 m (Davis et al., 1998) while off of Spain they preferred water deeper than 600 m (Cañadas et al., 2002).

Group Size

Short-finned pilot whales in the Gulf of Mexico ranged in group size between 5 and 50 (mean = 20.4, SE=3.6, n=11) (Mullin et al., 2004). Off the Pacific coast of Costa Rica the mean group size of pilot whales was 14.22 (SD=12.06) (May-Collado et al., 2005).

Risso's Dolphin (Grampus griseus)

Dive Depth

Dive depths of 150 to 1,000 m were inferred from its squid-eating habits, and from similar species.

Dive Time

No data on dive times could be found. The values for blackfish, which have a similar ecological niche, were used.

Speed

Risso's dolphins off Santa Catalina Island were reported to have speeds that range between 2 and 12 km/hr (Shane, 1995).

Habitat

Risso's dolphins were seen in water deeper than 150 m in the Gulf of Mexico (Davis et al., 1998). In the Gulf of Mexico, they were most often observed between 300 and 750 m. Off Chile they were seen in waters deeper than 1000 m (Olavarria et al., 2001). Off Spain, they were found to be deep water species, preferring water deeper than 600 m (Cañadas et al., 2002). In all cases this association seems to be driven by the local oceanographic upwelling conditions that increase primary prey productivity.

Group Size

In the Pacific, group sizes were measured between 1 and 220 animals, with a geometric mean of 10.7. An estimated 76.4% of the groups contained fewer than 20 animals (Leatherwood et al., 1980). Group sizes in the Gulf of Mexico ranged between 2 and 78 animals, with a mean of 12.7 (SE = 2.0, n=39) (Mullin et al., 2004). Off the Pacific coast of Costa Rica, the mean group size was 11.57 (SD=9.64) (May-Collado et al., 2005).

Common dolphin (Delphinus delphis)

Dive Depth

Dive depths are reported to be between 50 and 200 m (Evans, 1994).

Dive Time

The maximum dive time was reported to be 5 min (Heyning and Perrin, 1994).

Speed

The maximum sustainable speed for common dolphins was measured at 2.5 m/sec (9 km/hr) (Hui, 1987).

Habitat

Off the northeastern United States, common dolphins were concentrated along the shelf edge, between 100 and 200 m (Selzer and Payne, 1988). In the Mediterranean common dolphins were found in waters between 25 and 1300 m deep, with 95% of the animals in water between 247 and 326 m (Cañadas et al., 2002).

Group Size

Common dolphins in the Gulf of California were found in groups of 4 to 1,100 animals, with a mean size of 254.3 dolphins (Silber et al., 1994). Off the Pacific Coast of Costa Rica, the mean group size was 220.67 (SD=220.6) (May-Collado et al., 2005).

Frasier's Dolphin (Lagenodelphis hosei)

Dive Depth

Fraser's dolphins dive to about 600 to 700 m to feed, much deeper than spinner dolphins (Dolar et al., 2003). Numerous records indicated that the primary prey of Fraser's dolphins is found at great depth (Caldwell et al., 1976, Miyazaki and Wada, 1978, Robison and Craddock, 1983), although there has been at least one report of near-surface feeding (Watkins et al., 1994). All other behavioral parameters are taken from *Stenella* species, since there are no direct data for Fraser's dolphin. The dive time has been increased to 6 min, to account for the deeper dives.

Group Size

A single group of Fraser's dolphins was seen off the Pacific coast of Costa Rica and had a group size of 158 (May-Collado et al., 2005).

Bottlenose dolphin (Tursiops truncatus)

In many environments there can be coastal and pelagic stocks of bottlenose dolphins. This is certainly the case off the east coast of the United States. However, defining the range of offshore form is difficult (Wells et al., 1999). Regardless of the genetic differences that may exist between these two forms, they frequently occur in different densities, and so they are split into two animat categories.

Dive Depth

The maximum recorded dive depth for wild bottlenose dolphins is 200 m (Kooyman and Andersen, 1969). A satellite-tagged dolphin in Tampa Bay had a maximum dive depth of 98 m (Mate et al., 1995). This value was used as the maximum dive depth for the coastal form of bottlenose.

Dive Time

Measured surface times ranged from 38 sec to 1.2 min (Mate et al., 1995; Lockyer and Morris, 1987; Lockyer and Morris, 1986). Dive times for a juvenile bottlenose had a mean value of 55.3 sec, although the distribution was skewed toward shorter dives (Lockyer and Morris, 1987) (Figure C-11).

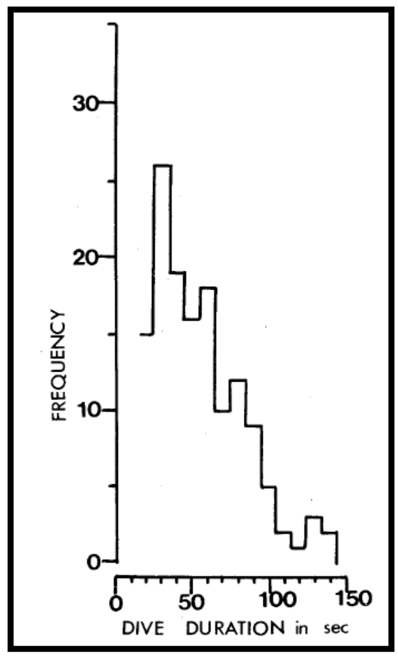


Figure C-11. Bottlenose dolphin dive durations.

Speed

Bottlenose dolphins were observed to swim, for extended periods, at speeds of 4 to 20 km/hr, although they could burst (for about 20 sec) at up to 54 km/hr (Lockyer and Morris, 1987). Dolphins in the Sado Estuary, Portugal had a mean speed of 1.2 m/sec (4.3 km/hr) and maximum speed of 3.2 m/sec (11.2 km/hr) (Harzen, 2002). A more recent analysis found that maximum speed of wild dolphins was 5.7 m/sec (20.5 km/hr), although trained animals could double this speed when preparing to leap (Rohr et al., 2002). Maximum speeds of wild dolphins in France was 4.8 m/sec, with an average speed (relative to water) of 2.2 m/sec (7.9 km/hr) (Ridoux et al., 1997). Bottlenose dolphins off Argentina swam much faster (3.9 m/sec, or 14 km/hr) when in water >10 m than while in shallow water (1.6 m/sec, or 5.8 km/hr) (Würsig and Würsig, 1979).

Habitat

In the Gulf of Mexico, bottlenose where observed in water depths between 101 and 1226 m (Davis et al., 1998). However, tagged animals have been observed to swim into water 5000 m deep (Wells et al., 1999).

Group Size

Bottlenose dolphins in the Gulf of California were seen in groups of 1 to 60 dolphins with a mean group size of 10.1 (Silber et al., 1994). In the Gulf of Mexico, they were seen in groups of 1 to 68 individuals (mean = 14.5, SE = 1.5, n=83) (Mullin et al., 2004). Off the Pacific coast of Costa Rica, the mean group size was 21.5 (SD=33.73, n=176) (May-Collado et al., 2005).

Stenella spp.: Pantropical Spotted, Atlantic Spotted, Spinner, Spotted, Striped, and Clymene Dolphins

Data for species of the genus *Stenella* are surprisingly sparse. Therefore, a single *Stenella* animat is used to represent all of the species of that genus.

Dive Depth

Spinner dolphins feed during the night, and rest inshore during the daytime. At night they dive to about 400 m to feed (Dolar et al., 2003). Pantropical spotted dolphins off Hawai'i also dive deeper at night than during the day. The daytime depth had a mean of 12.8 m, with a maximum of 122 m, whereas the nighttime mean was 57 m, with a maximum of 213 m (Baird et al., 2001).

Spinner dolphins off Hawaii typically track and forage on the mesopelagic boundary layer as it migrates both vertically and horizontally at night. It appears that dolphins have to dive deeply only at the very beginning and end of the migration (Benoit-Bird and Au, 2003). Most of the time spinner dolphins forage at moderate water depths. Therefore, 10% of the dives will be set to be deep, 40% of the dives will be 'typical' foraging depths, with a maximum of 150 m, and 50% of the dives will represent the daytime resting behavior, ranging between 5 and 25 m.

Dive Time

A single spotted dolphin had dive times ranging between 1 and 204 sec (Leatherwood and Ljungblad, 1979). Pantropical spotted dolphins off Hawai'i had a mean dive duration of 1.95 min (SD=0.92) (Baird et al., 2001). An Atlantic spotted dolphin tagged with a satellite linked TDR had a maximum dive time of 3.5 min (Davis et al., 1996). A 4-min dive time maximum was used for modeling purposes in AIM.

Speed

The mean speed of striped dolphins in the Mediterranean was estimated at 6.1 knots (11 km/hr) with bursts to 32 kts (59.3 km/hr) (Archer and Perrin, 1999). A maximum speed of 20 km/hr was chosen as a typical (non-burst) maximum speed. A tagged spotted dolphin was tracked at estimated average speeds of 2.3 to 10.7 knots, with bursts exceeding 12 knots (22.2 km/hr) (Leatherwood and Ljungblad, 1979). The estimated burst speed of spotted dolphins in the Eastern Tropical Pacific was 6 m/sec (21.6 km/hr) for adults and 3 m/sec (10.8 km/hr) for neonates. The estimated long-term top speed is 2.5 m/sec (9 km/hr) for adults and 1 m/sec (3.6 km/hr) for neonates (Edwards, 2006). The Edwards (2006) paper also summarized speed estimates and duration for a number of species. Therefore, their estimate of 9 km/hr will be used for long-term movements, as modeled in AIM.

Habitat

In the Gulf of Mexico, spinner dolphins were seen in water deeper than 526 m, striped dolphins were seen in water deeper than 570 m and spotted dolphins were seen in water deeper than 102 m (Davis et al., 1998). Spinner dolphins in Hawaii are known to move into shallow bays during the day (Norris and Dohl, 1980).

Group Size

Group size estimates were summarized, and the majority of striped dolphin groups were less than 500 animals. The mean of the smaller groups was 101 animals (Archer and Perrin, 1999). Spotted dolphins off Costa Rica had group sizes between 1 and 50 (mean = 10.16 SD = 9.61; Table C-7) (May-Collado and Ramirez, 2005). Group size of *Stenella* dolphins in the Gulf of Mexico ranges from a maximum 210 for pantropical spotted dolphins to 48 for Atlantic spotted dolphins (Mullin et al., 2004) (Table C-8). Clymene dolphins off Costa Rica had a mean group size of 76.1 (SE = 11, n=109) (Fertl et al., 2003).

Table C-7. Group size characteristics of *Stenella* dolphins off Costa Rica (May-Collado et al., 2005).

Species	Mean	SD
Pantropical Spotted Dolphin	29.38	58.28
Striped Dolphin	48.9	43.05
Spinner Dolphin	100.59	107.7

Table C-8. Group size characteristics of *Stenella* dolphins in the Gulf of Mexico (Mullin et al., 2004).

SPECIES	MIN GROUP SIZE	MAX GROUP SIZE	MEAN	SE	N
Pantropical Spotted Dolphin	5	210	49.0	4.5	47
Atlantic Spotted Dolphin	5	48	22.4	3.9	12
Striped dolphin	7	150	46.3	16.0	8
Spinner Dolphin	48	200	91.3	36.4	4
Clymene Dolphin	9	168	59	19.5	7

Lagenorhynchus Species: Atlantic and Pacific White-Sided Dolphins, Peale's, Dusky, White-Beaked and Hourglass Dolphins

Data for species of the genus *Lagenorhynchus* are sparse. Therefore, a single animat was created based on data from species of that genus.

Surface Time

Surface times for tagged white-sided dolphins were less than one minute (Mate et al., 1994a).

Dive Depth

No direct data on dive depth are available for any of the *Lagenorhynchus* species. However, in the Atlantic, they feed on herring and in the Pacific they can feed on squid and mesopelagic fishes. For Atlantic white-sided dolphin, a maximum dive depth of 125 m is used, since this covers the depth range of herring. It is slightly shallower than the other dolphin species, due to the Lags' short dive time.

Dive Time

Maximum dive time for a tagged white-sided dolphin was 4 min, although the mean time was <1 minute (Mate et al., 1994a). Peale's dolphin (*L. australis*) dove from 1 to 130 sec (de Haro and Iniguez, 1997).

Speed

The mean minimum speed of 5.7 km/hr was estimated by the straight-line distance between satellite tag locations, which is almost certainly an underestimate of real world swimming speeds (Mate et al., 1994a). The maximum "minimum speed" was 14.22 km/hr. Theodolite tracking of dusky dolphins (*L. obscurus*) produced mean speeds between 3.68 and 6.08 km/hr, with 10th and 90th percentiles of ~2 and ~9 km/hr (Yin, 1999).

Group Size

The mean group size of Atlantic white-sided dolphins was 52 (Weinrich et al., 2001). The mean group size of Pacific white-sided dolphins was 30.8 (Barlow, 1995). In waters off southeast Alaska the group size was extremely variable, ranging from 1 to 500 animals, with an overall mean of 35.6 animals (Dahlheim and Towell, 1994).

Rough Toothed Dolphin (Steno bredanensis)

Dive Depth

No dive depth data are available. Depths are based upon other species. Since rough-toothed dolphins primarily forage on squid, a deep dive depth is chosen.

Dive Time

The maximum dive time reported for rough-toothed dolphins was 15 min (Miyazaki and Perrin, 1994). A more typical range was 0.5 to 3.5 min (Ritter, 2002).

Speed

Bow-riding Steno were observed at 16 km/hr (Watkins et al., 1987). Porpoising *Steno* off the Canary Islands were tracked at >3 knots (Ritter, 2002).

Habitat

Rough-toothed dolphins were seen in water deeper than 194 m (Davis et al., 1998). Dolphins off the Canary Islands were most often seen in water 100 to 1000 m deep, with occasional shallow water sightings, and one group was seen in water 2,500 m deep (Ritter, 2002). Off French Polynesia, animals were found between 1.8 and 5.5 km offshore, in water between 1,000 and 2,000 m (Gannier and West, 2005).

Group Size

Rough-toothed dolphins off French Polynesia had a mean group size of 10.8 individuals, with a range of 1 to 35 animals (Gannier and West, 2005). Off the Pacific coast of Costa Rica the mean size was 19.31 (SD=21.8) (May-Collado et al., 2005).

Right Whale Dolphin (Lissodelphis spp).

Dive Depth

Right whale dolphins are known to feed on myctophids and *Loglio* squids (Leatherwood and Walker, 1979). This information is used to estimate foraging depths.

Dive Time

Dive times of up to 6.25 min have been recorded (Leatherwood and Walker, 1979).

Speed

Observations of southern right whale dolphins were tracked bow-riding at speeds up to 12.5 km/hr (Rose and Payne, 1991). Other observations have reported them moving at 32 to 35 km/hr or >18 kts (Leatherwood and Walker, 1979). Other observations also report slow swimming and ‘gamboling’ as well (Nishiwaki, 1972; Rose and Payne, 1991). It is likely that speeds in this species have a bimodal distribution.

Habitat

Northern right whale dolphins have frequently been seen with Pacific white-sided dolphins (Tynan et al., 2005). They have also been seen with dusky dolphins and pilot whales (Cruickshank and Brown, 1981).

Group Size

Mean group size off South Africa was 368 (Rose and Payne, 1991). Survey efforts off the coast of California found that most schools (13 of 15 sighted) had a mean group size of 9.9, while two larger schools had a mean of 75.7 dolphins (Barlow, 1995).

Harbor Porpoise (Phocena phocena)

Surface Time

Mean surface time was reported as 3.9 sec (Otani, 2000).

Dive Depth

Maximum observed dive depth for a free-ranging harbor porpoise was 64.7 m (Otani, 2000). However, the same study reported that >90% of dives were less than 10 m. Another TDR study with seven animals tagged had dive depths that ranged from a mean of 14 +/- 16 m to 41 +/- 32 m, while the mean for all animals tagged was 25 +/- 30 m (Westgate et al., 1995). One large female made a very deep dive to 226 m, although dives this deep were infrequent.

Dive Time

Maximum observed dive time for a free-ranging harbor porpoise was 193 sec (Otani, 2000), although most dives were less than one minute in length. The mean dive duration of seven animals in the Bay of Fundy was 65 +/-33 sec (Westgate et al., 1995).

Speed

Mean descent speed was 0.8 m/sec (2.9 km/hr) with a maximum descent speed of 4.3 m/sec (15.5 km/hr). Ascent speeds were similar, with a mean of 0.9 m/sec (3.24 km/hr) and a maximum of 4.1 m/sec (14.5 km/hr) (Otani, 2000). TDR -tagged animals moved at least 51 km in a 24 hr period (2.125 km/hr) (Westgate et al., 1995). A captive harbor porpoise swam between 1 and 2 m/sec (3.6 to 7.2 km/hr) (Curren et al., 1994). A speed range of 2 to 7 km/hr is used in AIM to represent harbor porpoise speed.

Group Size

Off California, the mean group size of harbor porpoise was 5.0 (n=31) (Barlow, 1995).

Dall's Porpoise (Phocaenoides dalli)

Dive Depth

The mean dive depth for tagged Dall's porpoises was 33.4 m (N=17, SD = 23.9) with an absolute deepest dive of 94 m (Hanson and Baird, 1998).

Dive Time

Tagged Dall's porpoises had a mean dive duration of 1.29 min (N=17, SD = 0.84), with a maximum duration of 2.28 min. Therefore, dive times of 1 to 2 min was used in AIM analysis.

Speed

The speed of three behavioral states of Dall's porpoise have been measured in the wild (Law and Blake, 1994) (Table C-9). A shore-based study reported slow rolling speeds of 2.4 to 8.3 km/hr (Jefferson, 1987). Based on these data, a range of 6 to 16 km/hr was used in AIM.

Group Size

Off California, the mean group size of Dall's porpoise was 3.3 (n=69) (Barlow, 1995).

Table C-9. Observed speed states of the Dall's porpoise (Law and Blake, 1994).

BEHAVIOR	N	MEAN (M/SEC) (KM/HR)	S.E. (M/SEC)	MIN (M/SEC) (KM/HR)	MAX (M/SEC) (KM/HR)
Slow Rolling	4	1.8 (6.48)	0.1	1.6 (5.76)	2.1 (7.56)
Fast Rolling	4	2.6 (9.36)	0.4	1.8 (6.48)	3.4 (12.24)
Rooster-tailing	9	4.3 (15.48)	0.4	3.4 (12.24)	6.0 (21.6)

Guadalupe Fur Seal (Arctocephalus galapagoensis)

Surface Time

The activity budget of lactating females foraging at sea consisted of 73.2% of the time swimming at the surface, 24% of the time diving, and 2.8% of the time resting at the surface.

Dive Depth

Average dive depth of lactating females foraging at sea was 26 ± 14.3 m; median dive depth was 24.5 m; and max dive depth was 115 m, with an average max dive depth of 82 ± 23.7 m (Kooyman and Trillmich, 1986). The frequency distribution of dive depths was about 42% less than 20 m depth (minimum of 5 m depth to be considered a dive), about 50% between 21 and 50 m depth, and about 8% greater than 51 m depth (Kooyman and Trillmich, 1986).

Dive Time

Maximum average duration of dives of lactating females foraging at sea was 4.2 min, maximum dive time ranging from 2.4 to 7.7 min (Kooyman and Trillmich, 1986).

Speed

Estimated velocity based on body size is about 2 m/sec (Gentry et al., 1986).

Habitat

Guadalupe fur seals are the *only Arctocephalus* sp. in the northern hemisphere. They are non-migratory, existing near the equator where tropical conditions are moderated by cool water currents, creating upwelling conditions, most pronounced from June to December (Trillmich, 1986). Throughout the year, however, they are forced to deal with rock surface temperatures that may reach 60°C and sea surface temperatures that never drop below 15°C. Because of the harsh energetic demands, pups suckle until 2 years of age or older (Trillmich, 1986). Lactating females were studied to determine their foraging behavior (Kooyman and Trillmich, 1986). The average distance traveled to feeding areas was 19 km and the average duration of feeding trips was 16.4 hr (ranging from 0.5 to 1.3 days).

Northern Fur Seal (Callorhinus ursinus)

Surface Time

The activity budget during feeding trips of 7 lactating females consisted of diving 26% of the time while at sea and either resting (17%) or swimming (57%) at the surface (Gentry et al., 1986). Between deep dives, the surface time was calculated as 0.8 min, whereas between shallow dives, the surface time was 0.5 min (Goebel et al., 1991).

Dive Depth

Three types of diving patterns: deep dives, shallow dives, and mixed dives. Deep dives (to depths >125 m) occur throughout the day and night and represent foraging dives over the continental shelf (<200 m water depth) to the sea floor. Shallow dives (to depths <75 m) occur primarily at night in areas with deep water depths (Ponganis et al., 1992). Gentry et al. (1986) measured modal dive depths of 50 to 60 m for shallow dives and 175 m for deep dives. Goebel et al. (1991) calculated average dive depths of 36 (± 23) m for shallow dives and 86 (± 26) m for deep dives.

Dive Time

Goebel et al. (1991) calculated average dive durations of 4.1 ± 0.2 min for shallow dives and 7.3 ± 0.5 min for deep dives. This is similar to other measured modal durations of less than 2 min for shallow dives and between 3 and 5 min for deep dives (Ponganis et al., 1992).

Speed

Three females tagged during the winter migration exhibited average traveling speeds of 1.1 to 1.7 km/hr (Baba et al., 2000). During summer foraging trips, mean dive velocities on shallow dives were 1.5 and 1.2 m/sec, and on deep dives 1.8 and 1.5 m/sec (Ponganis et al., 1992). During the winter migration, an overall surface swim speed of 48 (± 12.4) cm/sec (1.7 km/hr) was measured (Ream et al., 2005).

Habitat

The majority of the population of northern fur seals breeds on the Pribilof Islands of Alaska (74%) or the Commander Islands of Russia (17%) (Gentry, 2002). From November to March, they are foraging north of about 35° N; March and April, animals move to continental shelf breaks and begin to migrate north. Pups are mainly born in July, weaned in October or November, and begin southbound migration with rest of population (Gentry, 2002). Animals that breed at San Miguel Island and adult males of all breeding colonies are non-migratory.

Steller Sea Lion (Eumetopias jubatus)

Surface Time

During the summer, adult females spent a mean (± 1 SE) of 23 ± 2.8 hr at sea (50.0 to 58.1% of time) and 19 ± 4.6 hr on land. During the winter, they spent a mean (± 1 SE) of 204 ± 104.6 hr at sea (89.9% of the time).

Dive Depth

Merrick and Loughlin (1997) reported dive depths between 150 and 250 m for adult females in the summer. During the winter maximum dive depths were greater than 250 m. Females with young of the year had shallower dive depths, with a maximum of 72 m.

Dive Time

Merrick and Loughlin (1997) reported maximum dive durations of greater than 8 min for adult females in summer with a maximum of 8 min in winter. The median values were 1.3 and 2.0 min respectively. Adult females with young of the year had a median duration of 1.0 and a maximum greater than 6.0 min.

Speed

Common filter for satellite-linked telemetry data is a maximum swim speed of 10 km/hr, based on the highest documented swim speed + 25% observed during at-sea tracking of sea lions and fur seals (Merrick and Loughlin, 1997). Inter-haulout swim speed (combining times animals are traveling and resting) was estimated at 2.82 ± 0.31 km/hr, with a maximum distance traveled in a 24-h period of 127 km (Raum-Suryan et al., 2004). Ascent rate is similar to descent rate of 1.4 m/sec (Merrick et al., 1994).

Habitat

Steller sea lion pups are born late May—early July, with a peak in June. Pups enter the water 2 to 3 weeks after birth and begin to disperse from the rookery when 2 to 3 months old, traveling up to 120 km (Raum-Suryan et al., 2004). Adults remain within 500 km of their natal rookery (Raum-Suryan et al., 2002). Like other otariids, Steller sea lions spend their time at sea either at the surface resting and traveling, or diving to capture prey (Merrick and Loughlin, 1997). During the summer, adult females stayed on the continental shelf for most foraging trips, whereas two of the five winter adult females transited directly to the seamounts in the center of the Gulf of Alaska and spent long periods foraging over water depths greater than 2 km (Merrick and Loughlin, 1997).

California Sea Lion (Zalophus californianus)

Surface Time

California sea lions exhibit three behavior states during average foraging trips that last 52.8 ± 24.5 hr (mean ± SD): diving in bouts (mean duration 3.3 ± 1.5 hr), swimming between bouts (mean duration 2.2 ± 3.1 hr), and resting at the surface (mean duration 0.4 ± 0.7 hr) (Feldkamp et al., 1989). During the duration of a foraging trip, 32.7 ± 12.6% of time diving in bouts, 22.8% of time at surface between dives in dive bouts, 41.4 ± 18.0% of time swimming between dive bouts, and 3.1 ± 3.1% of time resting on surface (Feldkamp et al., 1989). Dive bouts are broken into actual diving (32.7 ± 12.6% of the time, performing 16.4 ± 3.1 dives/hr) and surface time between dives (22.8% of the time). A recent study comparing diving behavior in normal and El Niño years found that during normal years surface intervals were short (mean = 1.5, S.E. = 0.9 min), while during El Niño years, the sea lions had to swim farther offshore and had significantly longer surface intervals (mean =2.5, S.E.= 0.8 min) (Weise et al., 2006).

Dive Depth

96% of dives of breeding females are between 8 and 75 m (Melin and DeLong, 1999). Average mean dive depth 61.76 ± 44.13 m, average max dive depth of 224.1 m for 10 breeding females (Feldkamp et al., 1989). A recent study comparing diving behavior in normal and El Nino years found that during normal years, California sea lions dove primarily on the continental shelf to shallow depths (mean = 33 m, S.E. = 37m) (Weise et al., 2006).

Dive Time

92% of dives of breeding females are less than 4 min in duration (Melin and DeLong, 1999). Average mean duration 2.07 ± 1.27 min, average max duration 7.71 min for 10 breeding females (Feldkamp et al., 1989). During “normal” years the dive duration of California sea lions had a mean duration of 1.9 min (S.E. = 1.6 min) (Weise et al., 2006).

Speed

Mean estimated swim velocity of 9 km/hr (Feldkamp et al., 1989). This is consistent with the measured swim velocity of Galapagos sea lions (*Zalophus wollebaeki*) in a laboratory setting (Gentry et al., 1986).

Habitat

California sea lions congregate to pup and breed primarily at San Miguel and San Nicolas islands in the Channel Islands, California (Stewart and Yochem, 1999). Females pup from May to June and breed in July. During the breeding season, adult males establish territories, fasting for 1 to 45 days in order to maintain their territory. Males that cannot establish territories retreat to nearshore waters or to “bachelor” beaches nearby (Heath, 2002). During breeding and while suckling their pups, female California sea lions alternate 2- to 3-day at-sea foraging trips with 1- to 2-day nursing visits on land. From August to May, all age classes except lactating females and their pups migrate to central and northern California, Oregon, Washington, and British Columbia (Stewart and Yochem, 1999).

Group Size

California sea lions aggregate in large groups ashore, and may travel at sea in groups of a dozen or more (Reeves et al., 2002).

Hawaiian Monk Seal (Monachus schauinslandi)

Dive Depth

Monk seals were observed to dive between 50 and 500 m (Parrish et al., 2002). The overwhelming majority of the foraging dives recorded with an animal-mounted video recorder were to 50 to 60 m in depth (Parrish et al., 2000).

Dive Time

Maximum dive times of 12 min were observed (Neves, 1998).

Speed

No swim speeds have been reported for Hawaiian monk seals. Therefore, the 2.35 m/sec (9 km/hr) value for harbor seals was used (Lesage et al., 1999).

Habitat

Hawaiian monk seals are found primarily on the Hawaiian leeward islands north of Kaua'i, although they are occasionally seen on the main islands. They haul out on the shores and return to the water to feed. Their atoll habitat makes deepwater available close to shore, and they are known to dive to the bottom in at least 500 m of water.

Group Size

Hawaiian monk seals are solitary, except for mothers and calves (Reeves et al., 2002).

Northern Elephant Seal (Mirounga angustirostris)

Surface Time

Surface times reported for northern elephant seals include: 2 min (Burgess et al., 1998); 2.8 ± 0.5 min (Le Boeuf et al., 1988); average mean surface interval 2.37 min (Le Boeuf et al., 1989). For post-breeding females mean surface interval is 2.1 ± 0.5 min; for pregnant females mean surface interval is 2.1 ± 0.6 min; and for adult males mean surface interval is 2.7 ± 0.9 min (Le Boeuf, 1994).

Dive Depth

Average dive depths for northern elephant seals have been reported as 900 m (Burgess et al., 1998). Modal dive depths are 500 to 700 m, mean 504 ± 125 m, and average max 1031 m (Le Boeuf et al., 1989). Also, modal dive depths of 350 to 650 m, mean 400 ± 156 m, and max 822 ± 76 m have also been reported (Higgins et al., 1988). Post-breeding migration dive depths have been reported for males at 366 ± 37.5 m and for, females at 522 ± 26.8 m. Post-molt migration dive depths have been reported for males at 366 ± 57.5 m and females at 486 ± 49.1 m (Stewart and DeLong, 1995). Post-breeding females max dive depth is 1273 m, mean 509 ± 147 m; pregnant females max dive depth is 1181 m, mean 473 ± 151 m; and adult males max dive depth is 1503 m, mean 330 ± 127 m (Le Boeuf, 1994).

Dive Time

Dive times are 10 to 20 min (Burgess et al., 1998). Mean dive duration are reported at 19.2 ± 4.3 min, max duration 37.4 ± 6.3 min (Le Boeuf et al., 1988) and at 19.95 ± 4.3 min, average max 46.6 min (Le Boeuf et al., 1989). Post-breeding migration are reported for males at 22.4 ± 1.7 min and for females at 21.8 ± 1.0 min. Postmolt migrationare reported for males at 23.8 ± 2.3 min and females at 24.5 ± 2.4 min (Stewart and DeLong, 1995). Post-breeding max dive duration are reported for females at 47.5 min, mean 20.8 ± 4.1 min; for pregnant females at 67.9 min, mean 27.7 ± 6.4 min; and adult males at 66.7 min, mean 21.2 ± 4.6 min (Le Boeuf, 1994).

Speed

Descent rate of 1.1 ± 0.1 m/sec and ascent rate of 1.0 ± 0.2 m/sec have been reported (Williams et al., 2000). Mean daily transit rates were 0.65 ± 0.11 m/sec (2.3 km/hr) in 1998 (El Niño year) not statistically different from non-El Niño years at 0.71 ± 0.23 m/sec (2.6 km/hr) (Crocker et al., 2006). Rates of travel for post-breeding migration females are 91 ± 16 km/day, for post-breeding migration males are 103 ± 90 km/day, post-molt migration females are 73 ± 12 km/day, and post-molt males are 90 ± 16 km/day (Stewart and DeLong, 1995). Velocity on descent 1.5 m/sec except for second descent segment of Type C dives was 0.59 m/sec; velocity on bottom and ascent averaged 1.0 m/sec (Crocker et al., 1994). Descent angles were 30° to 56° with ascent angles of 52° to 82° (Crocker et al., 1994).

Habitat

Individuals return to the same foraging areas during post-breeding and post-molting movements (Stewart and DeLong, 1995). Seals dive continually to depths of 250 to 550 m during both migrations and traveled linear distances of at least 18,000 km (females) to 21,000 km (males) during the 250 days (males) to 300 days (females) they were at sea (Stewart and DeLong, 1995). Adult males migrated farther north and fed off Alaska along the continental margins during the post-breeding and post-molt migrations, whereas females foraged farther south and out in the open ocean of the central Pacific (Le Boeuf, 1994, Stewart and DeLong, 1995). All seals traveled north immediately upon entering the water, traveling 90 to 100 km/d (1.04 to 1.15 m/sec) for 16 ± 7.6 days (females) to 38 ± 5.7 days (males). Then travel speeds slowed and animals remained in somewhat more defined geographic areas for 36 ± 5.2 days (females) and 51 ± 6.4 days (males) where average distance covered was less than 32 km over 3 or more consecutive days.

Group Size

Elephant seals at sea are presumably solitary (Reeves et al., 2002).

Harbor Seal (Phoca vitulina)

Surface Time

Harbor seals dive in bouts. Adult females spend 44.6 ± 4.68% of their time hauled out on land and 55.4 ± 4.68% of time at sea. While at sea, they spend 8.9 ± 2.89% of time diving (Bowen et al., 1999). Five different dive types yield surface intervals of: 42.6 ± 23.5 s, 43.8 ± 60.7, 40.2 ± 31.0 s, 38.6 ± 34.8 s, 44.8 ± 31.9 s (Lesage et al., 1999)

Dive Depth

Approximately 50% of dives are shallower than 40 m, while 95% of dives are shallower than 250 m (Gjertz et al., 2001). Most dives (40 to 80%) were < 20 m, though dives from 50 to 150 m were not uncommon and dives to 508 m were recorded (Hastings et al., 2004). For 20 lactating females mean dive depth is 11.3 ± 0.83 m (Bowen et al., 1999). Five different dive types yielded dive depths of: 19.6 ± 5.8 m, 5.8 ± 2.8 m, 7.8 ± 2.7 m, 7.9 ± 2.7 m, and 12.2 ± 7.2 m (Lesage et al., 1999). Harbor seals in Monterey Bay had an absolute maximum dive depth of 481 m, while median dive depths were between 5 and 100 m (Eguchi and Harvey, 2005).

Dive Time

Mean dive durations for individual seals (14 females and 11 males) ranged from 46 s to 2.9 min with a high proportion of dives being less than 2 min; max duration was 31 min (Ries et al., 1997). Approximately 50% of dives lasted 2 to 4 min, 90% lasted less than 7 min, and 97% less than 10 min (Gjertz et al., 2001). Most dives were < 4 min in duration (Hastings et al., 2004). For 20 lactating females: mean dive duration was 1.6 ± 0.09 min (Bowen et al., 1999). Five different dive types yielded dive durations of: 135.7 ± 37.5 s, 40.1 ± 29.8 s, 122.4 ± 50.9 s, 142.3 ± 52.9 s, 167.9 ± 80.1 s (Lesage et al., 1999).

Speed

For 20 lactating females mean ascent rate is 0.6 ± 0.03 m/sec and mean descent rate is 0.6 ± 0.03 m/sec (Bowen et al., 1999). Five different dive types yielded: median swim speed (bottom) of: 1.00 ± 0.47 m/sec, 0.47 ± 0.56 m/sec, 1.21 ± 0.44 m/sec, 0.68 ± 0.40 m/sec, 0.15 ± 0.25 m/sec (Lesage et al., 1999). Five different dive types yielded angles of ascent (deg) of 70.0 ± 27.8, 59.0 ± 33.6, 48.0 ± 29.3, 31.2 ± 26.8, 75.9 ±24.1 (Lesage et al., 1999). Five different dive types yielded angles of descent (deg) of 63.6 ± 29.8, 59.8 ± 34.4, 32.1 ± 28.9, 64.0 ± 28.6, 71.8 ±27.4 (Lesage et al., 1999).

Habitat

Animals may move among different haul-out sites or among favored haul-out sites and foraging areas, but these are usually less than 50 km apart (Gjertz et al., 2001). Harbor seals are generally considered to feed close to the seafloor at depths between 4 to 200 m (Gjertz et al., 2001). Five different dive types have been identified (Lesage et al., 1999).

Group Size

Harbor seals are solitary at sea (Reeves et al., 2002).

C-2.3.3 Acoustic Propagation Modeling

Sound Source Waypoints

Each modeled site in an operating area (OPAREA) is defined by a latitude and longitude with the source ship driving a triangular pattern[4] (Figure C-12). The site position was used as the location of the center of the triangle (as opposed, e.g., to using the site position as the starting point). For input into AIM, a MATLAB subroutine was created to determine the waypoints as a function of time. The input parameters for the subroutine were latitude and longitude of the site, ship speed, number of hours following a bearing, duration of operation, and source depth. The output of the subroutine was a file of waypoints (latitude, longitude, course, depth of source, and leg duration [minutes on heading]) for use in AIM (Table C-10). To take into account the curvature of the earth, spherical trigonometry was used to find the triangular height, and the approximation: 1º longitude = 60 × Cosine of latitude was used to correct the longitude values for a given latitude. For all modeled sites, the ship speed was 4 kts, and in all cases the time on each bearing was 8 hours (480 min). The overall duration of the mission in each OPAREA was 7 days.

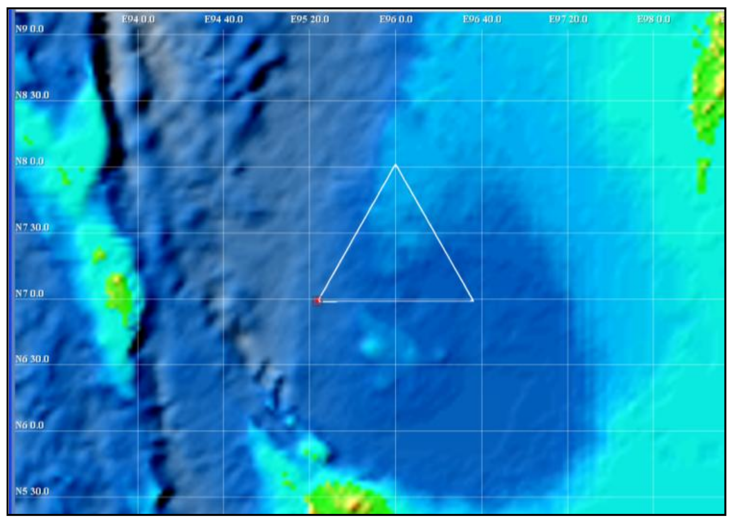


Figure C-12. Pattern driven by source ship for OPAREA 17, which is defined at 7.5°N and 96°E for latitude and longitude, respectively.

4 The SURTASS LFA sonar vessel almost always operates in a racetrack or triangular geometry, which optimizes the LFA system coverage, while accounting for the slow vessel speed (nominally only 3 kts) and the need to minimize the number of vessel turns (when the SURTASS array is not straight and therefore unable to accurately process sonar echoes).

Table C-10. SURTASS LFA sonar source waypoints for OPAREA 17.

LATITUDE (DEGREES NORTH)	LONGITUDE (DEGREES EAST)	COURSE (° T)	SOURCE DEPTH (M)	LEG DURATION (HOURS)
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8
6.980375	95.395519	090	120	8
6.980375	96.604480	330	120	8
8.019624	96.000000	210	120	8

Transmission Loss and Modeling Area

To model the sound fields created by the SURTASS LFA sonar source, the Navy standard parabolic equation (PE) model was used. PE was chosen for four reasons: 1) historically it has been the model used for AIM analysis of low frequency (LF) sources in the FOEIS/EIS (DoN, 2001) and FSEIS (DoN, 2007a); 2) this model has been tested by the U.S. Navy and has adequate performance for the frequencies and range of depths examined in this analysis; 3) its resolution of TL in depth and range from the source is adequate; and 4) it is compatible with the supporting databases that were used. PE is integrated into AIM and a number of parameters may be specified. The bathymetry used was the 2-minute Gridded Global Relief Data set (ETOPO2, v2) from the National Geophysical Data Center (NGDC)

(NGDC, 2006). The sound velocity profiles for each location and season were obtained from Generalized Digital Environmental Model (GDEM) (OAML, 2000), a standard U.S. Navy database. A wind speed of 15 knots was used to calculate surface losses using the Bechmann-Spezzichino formula modified by Leibiger (1978). For bottom loss, province 5 and curve 5 from the consolidated bottom loss upgrade (CBLUG) database (OAML, 2000) were used for all sites. Four bearings were modeled per location and a nominal vertical half-beam width of 45 degrees was used. Spherical spreading was assumed within 0.1 km of the source.

The LFA source was modeled as a vertical line array using the actual LFA element spacing, transmitting at a nominal frequency and nominal source level. For this modeling effort a single frequency of 300 Hz (i.e., the middle of the 100 to 500 Hz band of the system), and an individual element source level of 215 dB re 1 µPa @ 1 m (rms) (SPL) (or an array source level of about 227.5 dB re 1 µPa @ 1 m (rms) (SPL) in the far-field) were used as these nominal values. To determine the range extent for the PE model, an initial run with a range of 1,000 km was conducted. The distance at which the TL became at least 100 dB was determined. This number was used as the radial extent for calculating TL in the PE model. Thus, essentially the modeled area included all received levels down to about 128 dB re 1 µPa (rms) (SPL). Note that this does not cover the entire range of the risk continuum but the risk for SPL of 128 dB is about 0.000008%, and it represents a negligible contribution to the overall risk calculation. To finalize the boundaries of the simulation area and to populate the area with animats, approximately 100 km was added to the radial extent determined for the PE model so that source movement could be accounted for. AIM was set to recalculate the TL after the source had moved for 5 min in distance (Table C-11).

Table C-11. Acoustically modeled SURTASS LFA sonar OPAREAs.

OPAREA	Simulation Area Boundaries				PE Radius (km)	Number of Animats (approx.)
	North	South	East	West		
1	42.0° N	34.0° N	152.0° E	144.0° E	500	60,000
2	32.0° N	26.0° N	139.0° E	133.0° E	500	40,000
3	24.0° N	18.0° N	128.0° E	122.0° E	1000	40,000
4	12.5° N	8.5° N	147.0° E	143.0° E	350	20,000
5	42.0° N	35.5° N	135.0° E	128.5° E	450	35,000
6	27.0° N	24.5° N	126.5° E	123.0° E	250	10,000
7	24.0° N	19.0° N	121.0° E	117.0° E	300	15,000
8	35.5° N	25.5° N	171.0° E	159.0° E	600	60,000
9	18.0° N	12.0° N	168.0° E	161.5° E	300	45,000
10	28.5° N	22.0° N	154.5° W	165.0° W	500	35,000
11	21.5° N	17.0° N	156.0° W	162.0° W	300	30,000
12	34.5° N	28.0° N	117.0° W	124.5° W	500	45,000
13	32.5° N	27.5° N	74.0° W	80.5° W	400	30,000

Table C-11. Acoustically modeled SURTASS LFA sonar OPAREAs.

OPAREA	Simulation Area Boundaries				PE Radius (km)	Number of Animats (approx.)
	North	South	East	West		
14	61.5° N	50.5° N	7.5° W	20.0° W	600	40,000
15	44.5° N	37.0° N	10.0° E	3.5° E	650	35,000
16	23.0° N	15.75° N	68.5° E	61.0° E	400	30,000
17	9.0° N	5.5° N	94.0° E	97.5° E	300	15,000
18	7.0° N	2.0° N	79.0° W	85.0° W	400	35,000
19	2.75° S	19.0° S	161.5° E	150.0° E	600	65,000

C-2.4 Results of AIM Modeling

C-2.4.1 Animat Exposure Histories

AIM simulations create a realistic animal movement track for each animat and are based on the best available animal behavioral data. Collectively, the animat tracks derived for each simulation (area/species combination) are representative of the movements of animals in the population under consideration. Within AIM, the acoustic sound field for each source was also determined and convolved with the animat tracks so that the output of AIM is the time history of exposure for each animat. The cumulative energy was calculated as a ‘single ping equivalent’ (SPE) and used as input to the risk continuum function (described below) in order to assess the potential risk of MMPA Level B harassment.

C-2.5 Biological Risk and Determination of Risk Function

Reiteration of Risk Analysis Process from the FOEIS/EIS (DoN, 2001)

For the convenience of the reader, Sections C-2.5 through C-2.84 in this document have been duplicated from the FOEIS/EIS (DoN, 2001) and included here. These sections originally appear in that document as Subchapters 4.3.2 through 4.3.6.4 and 4.3.7.5. The pertinent changes made to them here were to: a) remove internal references to other chapters/subchapters of the original FOEIS/EIS to improve readability; b) correct references to include figures and tables to be consistent with this appendix: c) add reference units (if omitted) where dB units are used: d) correct other minor grammar or spelling, as discovered, or due to the editing just described, and e) provide updated or additional data/information where appropriate to assist in reader understanding.

Over the last ten years, AIM capability has been constantly upgraded and improved. This, and the advancements in computer technology, have allowed a greatly improved and expanded AIM functionality. As an example, the original AIM needed to “seed” the animats in gridded areas of the ocean, while the latest version allows you to select various areas graphically and seed different densities to better conform to the published science for that species.

To determine the potential impacts that exposure to LF sound from SURTASS LFA sonar operations could have on marine mammals, biological risk standards were defined with associated parameters of exposure. Based on the MMPA, the potential for biological risk was defined as the probability for injury or behavioral harassment of marine mammals. In this analysis, behavioral harassment is assumed to be a significant change in a biologically important behavior, which is consistent with the National Research Council's characterization (NRC, 2000). The potential for biological risk is a function of an animal's exposure to a sound that would potentially cause hearing, behavioral, psychological or physiological effects. The measurement parameters for determining exposure were RL in decibels, length of the signal (ping), and number of pings received.

This analysis of risk is an alternative to the use of all-or-nothing thresholds. The subsequent discussion of the risk function emphasizes the advantages of a smoothly varying model of biological risk in relation to sound exposure. However, for the purpose of the SURTASS LFA sonar analyses presented in this SEIS/SOEIS, all marine mammals exposed to RLs ≥180 dB SPE are evaluated as if they are injured.

When SURTASS LFA sonar transmits, there is a boundary that encloses a volume of RLs at or above 180 dB re 1 µPa (rms) (SPL), and a volume outside this boundary that experiences RLs below 180 dB re 1 µPa (rms) (SPL). In this analysis, the 180-dB re 1 µPa (rms) (SPL) figure is emphasized because the level of risk for marine mammals depends on their location in relation to the LFA mitigation zone.

SPL and SPE

- For the acoustic modeling, the LFA source was modeled as a point source, with an effective source level (SL) in dB re 1 µPa @ 1 m (SPL), a 60 sec duration signal, and a beam pattern that was correct for the number and spacing of the individual source elements. This source model, when convolved with the three dimensional transmission loss (TL) field generated by the PE propagation model, defines the received level (RL) (in SPL) field surrounding the source for a 60 sec LFA signal. These RLs for each modeled location and for any animats at that location are then recorded in the exposure history of each animat and used to generate its SPE value. Therefore, SPE values are a function of SPL, not SEL.
- The 180 dB SPE previously identified as the onset of injury includes the volume containing the 180 dB re 1 µPa (rms) (SPL) isopleth, but it also extends beyond it due to the multiple transmissions included during the SPE calculation. Additionally, due to ship and animal movement and the depth of the source, it is highly unlikely that any animal would be within the 180 dB re 1 µPa (rms) (SPL) isopleth for more than a single transmission, so this isopleth is a valuable reference, which can be used to estimate the SPE for a single transmission. Thus, the 180 dB re 1 µPa (rms) (SPL) isopleth is a reasonable volume for minimizing injury to marine mammals during operations, and the 180 dB SPE calculation used to estimate injury in the impact calculations below is a conservative threshold which includes acoustic energy from all of the transmissions of the entire operation.
- The following is the equation for SPE as a function of SPL:

$$SPE = 5 \times Log_{10}\left(\sum_{n}\left(10^{(P_N/10)}\right)^2\right)$$

Where:

SPE is the Single Ping Equivalent of the N received transmissions at the animal,

N is the number of received transmissions at the animal, and

P_N is the received level or pressure in dB re 1 µPa, (i.e., an SPL value) at the animal for each received transmission.

Before the biological risk standards could be applied to realistic SURTASS LFA sonar operational scenarios, two factors had to be considered, which resulted in the development of the risk continuum approach. In assessing the potential risk of significant change in a biologically important behavior, two questions must be resolved:

- How does risk vary with repeated exposure?
- How does risk vary with RL?

These questions have been addressed by the use of a function that translates the history of repeated exposures (as calculated in the Acoustic Integration Model) into an equivalent RL for a single exposure with a comparable risk. This approach is similar to those adopted by previous studies of risk to human hearing (Richardson et al., 1995b; Crocker, 1997).

C-2.5.1 Effects of Repeated Exposure

The human model provides the most extensive data and is presently the best objective foundation for an assessment of repeated exposure. Long term hearing loss in humans is accelerated by chronic daily 8-hour workplace exposure (over time scales on the order of tens of years) to sounds at levels of 85 dB(A) re 20 μPa (A-weighted; i.e., in air) or greater (Guide for Conservation of Hearing in Noise, American Academy of Ophthalmology and Otolaryngology, 1969; Ward, 1997). The sound power reference unit dB(A) is the accepted convention for frequency-weighted measure of hearing in humans. In young healthy humans, 0 dB(A) is the nominal threshold of best hearing, and measured free-field thresholds for the frequencies of best binaural hearing (400 to 8,000 Hz) vary between –10 to + 10 dB re 20 μPa (Beranek, 1954; Harris, 1998), depending on measurement objective and technique used.

It is intuitive to assume that the effects of exposure to multiple LF sounds would be greater than the effects of exposure to a single sound. A formula is needed to address the potential for accumulation of effects over a 7 to 20-day period (estimated maximum SURTASS LFA sonar mission period), allowing for varying RLs and a duty cycle of 20 percent or less. There are no published data on marine mammals regarding responses to repeated exposure to LF sound. Two lines of evidence from human studies were used to devise a plausible formula.

Richardson et al. (1995b), citing Kryter et al. (1966), discusses workplace damage risk criteria relative to exposure to continuous narrowband (one-third octave) noise. To relate to workplace data, note that during an 8-hour exposure during normal SURTASS LFA sonar operations, the pings would add up to a total of 48 to 96 min of LF sound transmission. The workplace damage risk criteria change from 88 dB to 82 dB to 80 dB re 20 µPa SPL, as the duration of exposure changes from 8 to 2 hours to 30 min. These changes indicate that the effects of increased exposure are not constant across this range of durations. When continuous exposure increases from 30 min to 2 hr per day, the effect scales with 10 $\log_{10}$(T). When continuous exposure increases from 2 to 8 hr per day, the effect scales with 3.3 $\log_{10}$(T). These values do not account for the probable reduction of effect due to the long intervals between SURTASS LFA sonar pings.

The second line of evidence comes from repeated exposure to impulsive sounds. Richardson et al. (1995b), citing Kryter (1985) and Ward (1968), discussed the relationship between repeated exposures of the human ear to impulsive sound and a TTS in the subject's hearing. The risk threshold is lowered by 5 dB per ten-fold increase in the number of pulses per exposure if the number of pulses per exposure is less than 100. These findings are consistent with qualitative statements by Crocker (1997). Following this logic, if a ping of level L (in dB SPL) is repeated N times, the SPE level is defined as L + 5 $\log_{10}$(N) in dB SPE. For example, using this formula, 100 pings at RL 170 dB re 1 µPa (rms) (SPL) are equivalent to one ping at 180 dB SPE.

Due to the lack of information on behavioral responses, the 5 $\log_{10}$(N) formula has been chosen for assessing the risk to a marine mammal for significant change in a biologically important behavior due to repeated exposures to LF sound such as SURTASS LFA sonar transmissions. In 2001, at the time of the initial FOEIS/EIS, this was true, especially for operations lasting up to 20 days, and for the most part it is still true today. There are no scientific reports, beyond the Low Frequency Sound Scientific Research Program (LFS SRP) data discussed below, that have reported on LF signals and behavior, especially for smaller cetaceans that have reduced hearing sensitivity at low frequencies. Additionally, at the time of the

FOEIS/EIS, there were no reports on how TTS grew with increased signal duration or frequency of transmission. The following provides some mathematical details of how the 5 $\log_{10}(N)$ factor was implemented for repeated exposure to varying levels:

- For each animal in the AIM simulation, the RL of each ping was calculated as the animal moved in relation to the sound source;
- These RLs were converted into raw acoustic intensities (proportional to the intensity of the signal, or the variance of the waveform);
- To correctly summarize the intensities, their values were squared and summed together; and
- This sum was converted back to an equivalent dB value by taking the base 10 logarithm of the sum, and multiplying it by 5.

In this process, an SPE RL is larger than the maximum SPL RL of any single ping in a sequence (see text box below). Also, the SPE for a sequence consisting of a single loud ping and a long series of much softer pings is almost the same as the level of the single loud ping. A ping duration (length) of 60 sec was assumed in the modeling and risk assessment calculations using SPE. The adoption of 60 sec and 20% as the standard ping duration and duty cycle respectively, for calculations in the FOEIS/EIS, provides a reasonable estimate of the potential for effects from real-world operations without sacrificing the conservative nature of the analysis process. (The current duty cycle is nominally 7.5 to 10.0%: thus, the FOEIS/EIS modeling that was done at higher duty cycles must be considered conservative.)

Sample Single Ping Equivalent (SPE) and Risk Examples

A generic example to illustrate the calculations used for translating the number of pings into an SPE is shown in Figure C-13a. This illustration assumes a marine mammal is exposed to a total of ten SURTASS LFA sonar transmissions, or pings, at received levels (RL) between 150-159 dB re 1 µPa (rms) (SPL). The pings are delineated by individual bins of one dB each. The example illustration shows that the animal was exposed to two pings at RL 150 dB re 1 µPa (rms) (SPL), none at RL 151 dB re 1 µPa (rms) (SPL), three pings at RL 152 dB re 1 µPa (rms) (SPL), etc. To arrive at a total SPE for the entire exposure, the intensity level for each ping is first calculated (i.e., 1×10^{15} µPa for each of the two 150 dB RL exposures, 1.58×10^{15} µPa for each of three 152 dB RL exposures, etc). These intensity values are then squared and added together. Taking 5 $\log_{10}$ of this sum of the squared intensities (1.24×10^{32}) results in a total of 160.47 dB SPE.

An example of the effect of increased RL can be seen in Figure C-13b, which displays the probability function for a single ping. At an RL of 150 dB SPE, the risk of significant change in a biologically important behavior is 2.5%. The RL corresponding to 50% risk on this curve is 165 dB SPE. At 180 dB SPE, the risk of significant change in a biologically important behavior is 95%. For the above SPE example, the risk function would predict a 24.48% probability of significant change in a biologically important behavior.

C-2.5.2 DETERMINATION OF RISK FUNCTION

Prior to the research and analyses documented in the FOEIS/EIS (DoN, 2001), the definition of biological risk to marine mammals had generally been based on a received sound level threshold for individual species. For example, 120 dB re 1 µPa (rms) (SPL) has been used as a threshold for behavioral modification (NRC, 1994). However, this approach set a discrete threshold below which any RL value was considered risk-free, and any value above it had been considered certain to cause responses by marine mammals. Nonetheless, it was unreasonable to assume that in a large animal stock a one decibel RL increase (say, from 119 to 120 dB re 1 µPa (rms) (SPL)) would cause a change from no behavioral

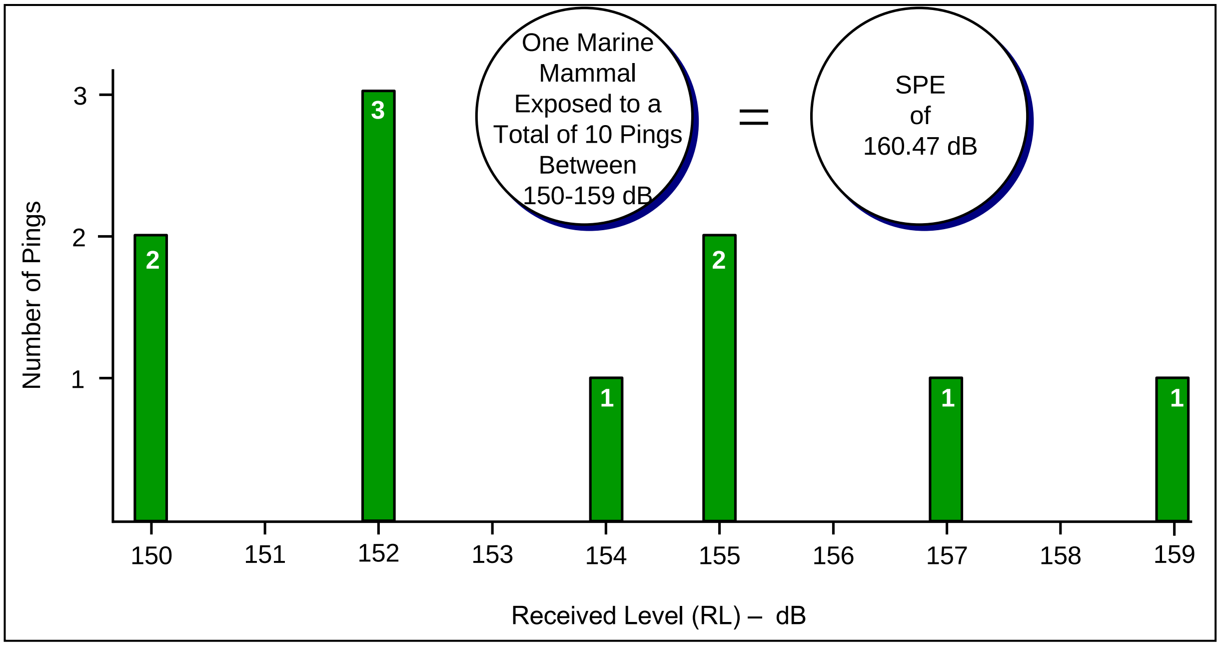


Figure C-13a. Sample single ping equivalent (SPE) calculation.

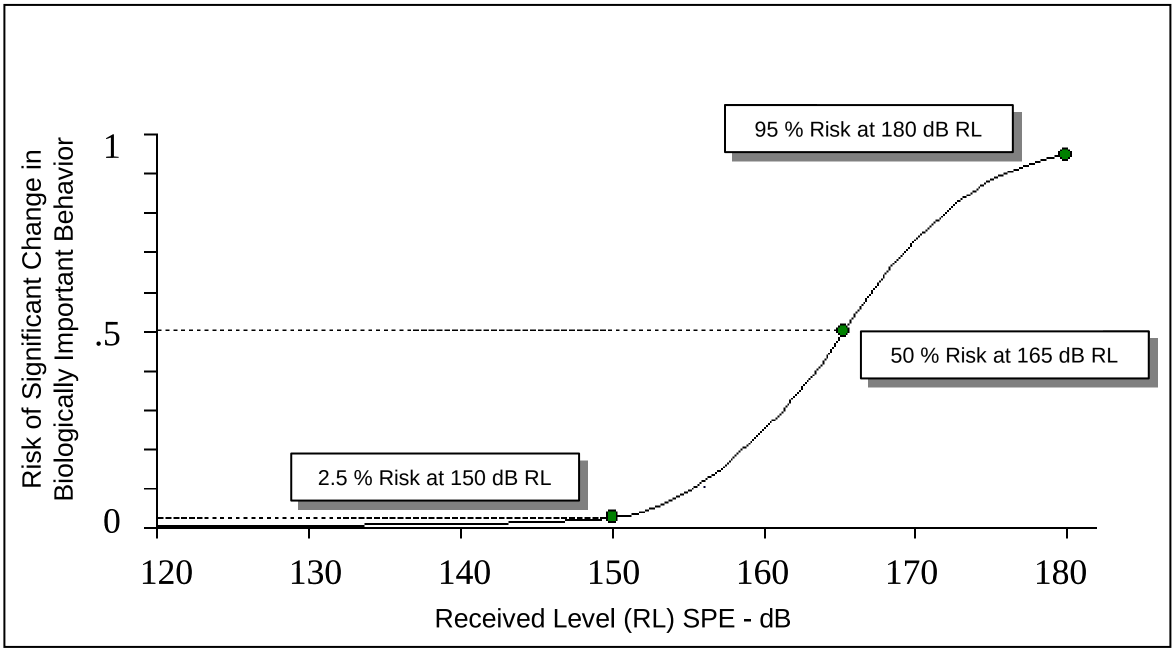


Figure C-13b. Single ping equivalent risk function.

response to all animals in the stock responding. Additionally, note that the LFA use of an SPE for this basement value is conservative because it is adding the potential impact of many signals, not just the loudest received.

The widely adopted approach used in the FOEIS/EIS to assess biological risk was a smooth, continuous function that mapped RL to risk. Scientifically, this acknowledges that individuals may vary in responsiveness. Mathematically, this eliminated the possibility for dramatic changes in estimated impact as a result of small changes in parameter values. As a result, the potential for misleading results was greatly reduced. These were the reasons for developing the risk continuum.

To represent a probability of risk, the function should have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfied this criterion was cumulative probability distributions, or cumulative distribution functions (CDFs). In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on regions of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

The function used here is adapted from the solution in Feller (1968):

$$R = \frac{1-\left(\frac{L-B}{K}\right)^{-A}}{1-\left(\frac{L-B}{K}\right)^{-2A}}$$

Where: R = risk (0-1.0);

L = RL in dB SPE;

B = basement RL in dB SPE, below which risk is negligible (119 dB SPE);

K = the RL increment above basement in dB at which there is 50% risk (46 dB); and

A = risk transition sharpness parameter (10).

In order to use this function, the values of the three parameters (B, K, and A) need to be established. The values used in the FOEIS/EIS (DoN, 2001) analysis were based on the results of the 1997 to 1998 LFS SRP. Prior to the LFS SRP, a 50% probability of avoidance might have been associated with a RL of 120 dB re 1 µPa (rms) (SPL) (Malme et al., 1983, 1984). It was also hypothesized, prior to the LFS SRP, that marine mammals exposed to RLs near 140 dB re 1 µPa (rms) (SPL) would depart the area (e.g., Richardson et al., 1995b). It was critical, therefore, to examine the logic that motivated the selection of experiments for the LFS SRP, how those results related to earlier data, and how the LFS SRP results related to the development of the risk continuum.

C-2.6 LOW FREQUENCY SOUND SCIENTIFIC RESEARCH PROGRAM (LFS SRP)

In 1997, there was a widespread consensus that cetacean response to LF sound signals needed to be better defined using controlled experiments. In response, the Navy worked with scientists to develop the LFS SRP. The LFS SRP was designed to supplement the data from previous studies. Also, the Navy made the SURTASS LFA sonar vessel (R/V *Cory Chouest*) available to the LFS SRP, which enabled greater control over RL due to the dynamic range of the ship's transmission system and the quality of its environmental acoustic modeling capabilities. Logistical constraints limited the experimental use of the SURTASS LFA sonar to the North Pacific.

C-2.6.1 Previous Studies

Prior to the LFS SRP, the best information regarding whale responses to continuous, LF, anthropogenic noise was summarized by Richardson et al. (1995b):

> "Some marine mammals tolerate, at least for a few hours, continuous sound at received levels above 120 dB re 1 μPa (rms). However, others exhibit avoidance when the noise level reaches ~120 dB (re 1 μPa [rms] [SPL]). It is doubtful that many marine mammals would remain for long in areas where received levels of continuous underwater noise are 140+ dB (re 1 μPa [rms] [SPL]) at frequencies to which the animals are most sensitive."

There have been several studies that have demonstrated responses of marine mammals to exposure levels ranging from detection threshold to 120 dB re 1 μPa (rms) (SPL):

- One study examined responses of gray whales migrating along the California coast to various sound sources located in their migration corridor (Malme et al., 1983, 1984). Gray whales showed statistically significant responses to four different underwater playbacks of continuous sound at RLs of approximately 120 dB re 1 μPa (rms) (SPL). The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform. This study was replicated in Phase II of the LFS SRP using SURTASS LFA sonar stimuli. However, the Phase II research demonstrated that it may be invalid to apply the inshore (2 km [1.1 nmi] from shore) response model (when 50 percent of the whales avoided SURTASS LFA sonar stimuli at RL of 141 ±3 dB re 1 μPa [rms] [SPL]) to sources that were offshore (4 km [2.2 nmi] from shore) of migrating whales where the whales did not avoid offshore sources at RLs of 140 dB re 1 μPa (rms) (SPL).

- Two other studies concern Arctic animals. Belugas (white whales) and narwhals showed behavioral responses to noise from an icebreaker at 50 km (27 nmi). At this range, the RL of the noise is near the detection threshold. Richardson et al. (1995b) point out that the strong reactions to icebreaker noise are unique in the marine mammal disturbance literature. These reactions appeared similar to the responses of each species to their most significant predator, the killer whale (Finley et al., 1990). It is not known why these animals were so sensitive to icebreaker noise and responded as if it were a predator. But, if these animals are responding to ice breakers as if to predators, it was understandable why these animals would show strong responses at detection threshold. This response has not been noted for other sound stimuli, only playback of killer whale calls. The sensitive responses of the Arctic species may relate to the fact that these animals are hunted using motorized boats. Other factors specific to the Arctic that may contribute to this sensitivity are sounds of ice-breaking that may mimic a potentially dangerous movement of ice, scarcity of ships in the high Arctic, and low background noise and good underwater sound propagation in Arctic waters.

- Controlled playback experiments and observations around actual industrial sources show bowhead whales avoid drill ship noise at estimated RLs of 110 to 115 dB re 1 μPa (rms) (SPL) and seismic sources at estimated RLs of 110 to 132 dB re 1 μPa (rms) (SPL) (Richardson et al., 1995a; Richardson, 1997, 1998).

C-2.6.2 Selection of Species and Study Sites

The selection of species and study sites for the LFS SRP emerged from an extensive review in several workshops by a broad group of interested parties: academic scientists, federal regulators, and representatives of environmental and animal welfare groups. The outcome of this group's decisions was that baleen whales became the focus of all three projects, since they were thought most likely among all marine species to have sensitive hearing in the SURTASS LFA sonar frequency band, because of their protected status and because of prior evidence of avoidance responses to LF sounds. Study sites were selected that offered the best opportunities for detailed observations combined with previous research that documented undisturbed patterns of behavior and distribution, or avoidance reactions to anthropogenic sound at low RLs.

This focus on the most sensitive species and the best sites for detecting a response was intended to produce a model of response that could be applied to other species for which data were lacking. This was a critical element of the logic of the LFS SRP. Extrapolation was unavoidable. By selecting marine mammal species that probably have the most sensitive LF hearing, the LFS SRP results produced a model of response that is likely to overestimate the responses of other species.

The species and settings chosen for the three phases of the LF sound playback experiments were:

- Blue and fin whales feeding in the Southern California Bight (Phase I) (September-October 1997);
- Gray whales migrating past the central California coast (Phase II) (January 1998); and
- Humpback whales off Hawaii (February-March 1998) (Phase III).

These studies included three important behavioral contexts for baleen whales: feeding, migrating, and breeding. The first phase also involved some studies of northern elephant seals tagged with acoustic data loggers. Elephant seals are considered among the most sensitive pinnipeds to LF sound and are deep divers (Le Boeuf, 1994). The third phase was designed to include playbacks with sperm whales, but no animals were encountered during the offshore portions of the cruise schedule. Sperm whales are listed by the U.S. as endangered under the ESA, and they were suspected to be the toothed whale most sensitive to LF sound (Ketten, 1997). There have also been reports of sperm whales being sensitive to anthropogenic transient noise (Watkins and Schevill, 1975; Watkins et al., 1985; Bowles et al., 1994; Mate et al., 1994b). (Based on the most recent scientific data, it is believed that the hearing of sperm whales is most sensitive at frequencies between 5 and 20 kHz [see Chapter 3 of this document for more details].)

C-2.6.3 Research Program

The 1997-98 LFS SRP was designed to ensure that no marine mammal was exposed to RLs exceeding 160 dB re 1 µPa (rms) (SPL). The LFS SRP produced new information about responses to the SURTASS LFA sonar sounds at RLs from 120 to 155 dB re 1 µPa (rms) (SPL). The LFS SRP team explicitly focused on situations that promoted high RLs (maximum 160 dB re 1 µPa [rms] [SPL]), but were seldom able to achieve RLs in the high region of this exposure range due to the natural movements of the whales and maneuvering constraints of the LF source vessel.

During the first phase of LFS SRP research, the source ship operated routinely with the full source array (18 source projectors) at source levels similar to those that would be used in normal Navy operations (Clark et al., 2001). The ship also approached whales while operating two of the projectors at full power levels. Over the 19-day period, there were no immediately obvious responses from either blue or fin whales as noted during observations made from any of the research vessels during playback of LFA sounds (Croll et al., 2001b).

In the second phase of LFS SRP research, migrating gray whales showed responses similar to those observed in earlier research (Malme et al., 1983, 1984) when the source was moored in the migration corridor (2 km [1.1 nmi] from shore). The study extended those results with confirmation that a louder SL elicited a larger scale avoidance response. However, when the source was placed offshore (4 km [2.2 nmi] from shore) of the migration corridor, the avoidance response was not evident. This implies that the inshore avoidance model—in which 50% of the whales avoid exposure to levels of 141 $\pm$3 dB re 1 µPa (rms) (SPL)—may not be valid for whales in proximity to an offshore source (Buck and Tyack, 2000).

The third phase of LFS SRP research examined potential effects of SURTASS LFA sonar transmissions on singing humpback whales. These whales showed some apparent avoidance responses and cessation of song during specific LFA sound transmissions at RLs ranging from 120 to 150 dB re 1 µPa (rms) (SPL). However, an equal number of singing whales exposed to the same levels showed no cessation of song during the same LFA sound transmissions. Of the whales that did stop singing, there was little response to subsequent LFA sound transmissions; most joined with other whales or resumed singing within less then an hour of the possible response. Those that did not stop singing, sang longer songs during the period of LFA transmissions, and returned to baseline after transmissions stopped (Miller et al., 2000; Clark et al., 2001; Fristrup et al., 2003). Further analysis is required to establish how often male humpbacks stop singing in the absence of the SURTASS LFA sonar transmissions, and to evaluate the significance of the song cessation observed during playbacks.

This kind of brief interruption, followed by resumption of normal interactions, was similar to that seen when whales interrupt one another or when small vessels approach whales (Miller et al., 2000). If whales are in a breeding habitat where vessel interactions are frequent, then the aggregate impact of all disruptive stimuli could become significant. However, because the SURTASS LFA sonar system would be operated well offshore of these humpback breeding areas, it is likely that the cumulative impact of numerous inshore vessels would be significantly greater on these animals than that caused by an occasional offshore series of SURTASS LFA sonar transmissions.

In summary, the scientific objective of the LFS SRP was to conduct independent field research in the form of controlled experimental tests of how baleen whales responded to SURTASS LFA sonar signals. Taken together, the three phases of the LFS SRP do not support the hypothesis that most baleen whales exposed to RLs near 140 dB re 1 µPa (rms) (SPL) would exhibit disturbance of behavior and avoid the area. These experiments, which exposed baleen whales to RLs ranging from 120 to about 155 dB re 1 µPa (rms) (SPL), detected only minor, short-term behavioral responses. Short-term behavioral responses do not necessarily constitute significant changes in biologically important behaviors. The fact that none of the LFS SRP observations revealed a significant change in a biologically important behavior helped determine an upper bound for risk. The LFS SRP results cannot, however, be used to prove that there is zero risk at these levels. Accordingly, the risk continuum presented below assumes that risk is small, but not zero, at the RLs achieved during the LFS SRP. The risk continuum modeled a smooth increase in risk that culminates in a 95 percent level of risk of significant change in a biologically important behavior at 180 dB SPE. In this region, the risk continuum is unsupported by observations. However, the AIM simulation results indicate that a small fraction of any marine mammal stock would be exposed to sound levels exceeding 155 dB re 1 µPa (rms) (SPL).

C-2.7 RISK CONTINUUM ANALYSIS

The values of B, A, and K need to be specified to utilize the risk function in Subsection C-2.5.2. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment. In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on a stock.

C-2.7.1 Basement Value for Risk—The B Parameter

The B parameter defines the basement value for risk, below which the risk is so low that calculations are impractical. This 119-dB SPE level is taken as the estimate of RL (SPE) below which the risk of significant change in a biologically important behavior approaches zero for the SURTASS LFA sonar risk assessment. This level is the value at which avoidance reactions have been noted in bowhead, beluga and gray whales (which are mitigated by geographic restrictions on SURTASS LFA sonar operations [see Subsection C-2.6.1]). The Navy recognizes that for actual risk of changes in behavior to be zero, the signal-to-noise ratio at the animal must also be zero. However, the present convention of ending the risk calculation at 119 dB SPE has a negligible impact on subsequent calculations, because the risk function does not attain appreciable values until RLs (SPEs) exceed 130 dB SPE (Figure C-13b).

C-2.7.2 Risk Transition—The A Parameter

The A parameter controls how rapidly risk transitions from low to high values with increasing RL (SPE). As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response. The value used here (A=10) (Figure C-13b) produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies

(Malme et al., 1984). The choice of a more gradual slope than the empirical data was consistent with all other decisions to make conservative assumptions when extrapolating from other data sets.

C-2.7.3 The K Parameter

Given the lack of consistent and sustained response in all three LFS SRP phases, the RL (SPE) at which 50% risk may occur is above 150 dB SPE. Thus, the LFS SRP data cannot be used to specify the value of K directly. Instead, this analysis set the value of K (in conjunction with A) such that the risk for an SPE exposure of 150 dB SPE was 2.5% and the risk at 180 dB SPE was 95%. Thus, K equals 46 dB, which is the RL (SPE) increment above basement at which there is 50 percent risk, leading to an estimated 50 percent risk at an SPE of 165 dB (i.e., 119 dB + 46 dB). The 2.5% risk estimate at 150 dB SPE reflects the fact that tens of experimental trials at RLs (SPEs) up to 155 dB failed to reveal any response that could be construed as affecting survival or reproduction. The 95% risk value at 180 dB SPE reflects the assumption that most individuals may be at risk but that a small fraction (5%) of the population would not be at risk.

C-2.7.4 Biological Context

Reiteration of Biological Context in Analysis Process from the FOEIS/EIS (DoN, 2001)

This Subsection was originally Subchapter 4.2.7.5 of the FOEIS/EIS and it is included below to completely address the thinking surrounding the implementation of the Risk Continuum at the time of the FOEIS/EIS, and as a basis for the current implementation. It is important to remember that all of the LFS SRP results were based on a 60-sec LFA transmission. Thus, by addressing each transmission's RL by its SPL level in dB re 1 μPa (rms), it is and was understood that an equivalent SEL value for that signal would be 17.7 dB higher (i.e., 10 × Log(60 seconds) = 17.7 dB). Similarly, the SPE values would 17.7 dB higher if the energy for the signal duration was included in that value. Additionally, since most, if not all, of the scientific data at the time were measured or estimated using SPL values, an SPL-based view was used in this discussion. It must be emphasized that all three of the LFS SRPs and the 2001 analysis recognized and included the duration of the LFA signal (and the contribution of multiple signals) as a critical and significant part of the estimation of potential impacts on marine mammals. Essentially, this approach was conservatively estimating (and including) the potential effects of both SPL and SEL, both for Level A and Level B impacts, long before the science was able to show the need to do so. Finally, the conservativeness built into these calculations remains valid even after ten or more years of focused scientific investigations.

The LFS SRP field research provided important results on and insights into the types of responses of whales to SURTASS LFA sonar signals and how those responses scaled relative to RL and context. Prior to the LFS SRP, marine mammal scientists expected immediately obvious responses from whales at exposure levels > 140 dB re 1 μPa (rms) (SPL) and statistically significant responses at RLs around 120 dB re 1 μPa (rms) (SPL). This expectation was based on responses detected in previous research to continuous industrial sounds (Malme et al. 1983, 1984; Richardson et al. 1995b).

The LFS SRP results showed that some whales responded to SURTASS LFA sonar signals: some whales either changed their levels of vocal activity, moved away from or approached the SURTASS LFA source vessel, or did both. In Phase II, there was a statistically significant avoidance response when the source was inshore (but not offshore) (Buck and Tyack, 2000). The level of response was in proportion to the level of sound received at the whale. In Phase III, some whales reduced vocal activity or avoided the SURTASS LFA sonar vessel. Those that continued singing, increased song length, but the tendency for these responses did not increase with increasing RL (Tyack and Clark 1998; Miller et al., 2000). However, in all cases, responding whales resumed normal activities within a few tens of minutes after initial exposure to the LFA signal.

Thus, overall, the LFS SRP results confirmed that some portion of the whales exposed to the SURTASS LFA sonar responded behaviorally, but the responses were short-lived.

It is important to raise the question of what level of behavioral response could result in a stock-level impact and, therefore, threaten a species' survival. Calculations carried out in this appendix provide the basis for the conclusion that the potential impact on any stock of marine mammals from injury due to SURTASS LFA sonar operations is negligible. The primary potential effect from SURTASS LFA sonar is significant change in a biologically important behavior. For this to translate into a stock-level impact, a significant portion of a population would have to be exposed to and respond to SURTASS LFA sonar so as to effectively reduce the chances of individual survival or breeding. The most likely scenario that marine biologists could hypothesize under which this might happen was if SURTASS LFA sonar was operated in a concentrated breeding area throughout an entire breeding season, or operated in a feeding area for months at a time. The Navy's plans for SURTASS LFA sonar operation significantly reduce the chances of such scenarios, because: 1) the SURTASS LFA sonar will not be operated within 22 km (12 nmi) of the coastline, or in places and during times of the year when marine mammals are engaged in critical activities, and 2) because of short (maximum 20-day) mission lengths (The FSEIS in 2007 and this SEIS/SOEIS now identify 7-20 days as the typical length of a mission.)

Another possible concern would be that a large percentage of a marine mammal stock could be exposed to moderate to low received sound levels over the long term. If animals are affected at these moderate to low exposure levels such that they experience significant changes in biologically important behaviors after long-term exposure, then such exposures could have an impact on rates of reproduction or survival. Analysis results discussed below address this concern.

The AIM estimations (incorporating LFS SRP results) help quantify the exposure statistics at the stock level. In order to understand the significance of the normalized percentages of a stock estimated at risk (i.e., the typical value used to present LFA potential impacts on a stock), it is necessary to consider how this risk might affect an animal's life history (including the potential for long-term impacts). For example, and purely as a hypothetical case, in an open ocean breeding area, some fraction of the animals might have a reduced probability of breeding during the 7 to 20 days of transmissions (maximum time for a typical at-sea mission in an operational area). Using a very conservative assumption that half of the animals lost one quarter of their breeding season, this would represent a loss of from 1 to 5% of an animal's lifetime reproduction potential (1% of total lifetime breeding periods for larger, long-lived animals; 5% for smaller, short-lived animals).

For example, one-half of 1,000 animals in an open ocean breeding area = 500 animals; assume 20 breeding seasons in a lifetime, so loss of one quarter of one season = 1 ÷ (20 x 4) = 0.0125, or approximately 1% of an animal's lifetime potential. Thus, in this example, 500 of the animals in this breeding area would lose 1% of their lifetime breeding potential. The larger fraction of 5% would be associated with some of the smaller marine mammals; however, the potential severity of this effect is mitigated at the stock level by their larger stock sizes and shorter generation times.

Thus, the percentage of the stock affected biologically would be a very small fraction of the overall stock. These types of assessments that include a potential for long-term impact at the individual level have been the basis for the estimate of very small, if not negligible, potential for impacts at the stock level, and emphasize the conservativeness of the AIM risk estimates.

The impact on foraging animals might be comparable to that in breeding areas. Here, it is assumed that the impact would involve reduced foraging efficiency for at most 20 days out of a foraging season of perhaps 90 days. Even with a 25% reduction in foraging efficiency for all of the 20 days, this would represent only a 5% reduction in food intake for that season. For example, 25% of 20 days = 5 days; 5 days out of 90 days = 5.5% (5 ÷ 90 = 0.055). In both cases, 20 days of exposure is certainly an overestimate of the duration, because most of the SPE exposure for individuals with high risk values takes place during a small fraction of the SURTASS LFA sonar exercise, when the individuals happen to pass close to the ship.

The preceding discussion assumes that animals at risk do not move away from the SURTASS LFA sonar source to lessen its effects. Richardson et al. (1995b) stated that it would be unlikely that any marine mammal would remain for long in areas where there was continuous underwater noise exceeding RL 140 dB re 1 µPa (rms) (SPL). However, no reduction in sighting rates (see LFA Technical Report #1 for the FOEIS/EIS Tables B-1, 2 and 3 [LFS SRP Phase I], and Tables D-1, 2 and 3 [Phase III]) or acoustic detection was found within the vicinity of the SURTASS LFA sonar source vessel during LFS SRP projects (lasting for a few weeks). Thus, avoidance of the >140 dB re 1 µPa (rms) (SPL) zone of exposure occurred much less than expected.

C-2.8 SAMPLE MODEL RUN

The following two examples were presented in the FOEIS/EIS (DoN, 2001). They were intended to illustrate the PE model and AIM simulation and the subsequent analysis of the resulting data using the risk continuum, including the steps of the risk analysis as well as the inputs and outputs of each process (Figure C-14). Each of these elements will be described in the following examples. These selected sites are representative of the type of detail and methodology of the analysis used for LFA impact analyses, and they were those actually used in the FOEIS/EIS (DoN, 2001).

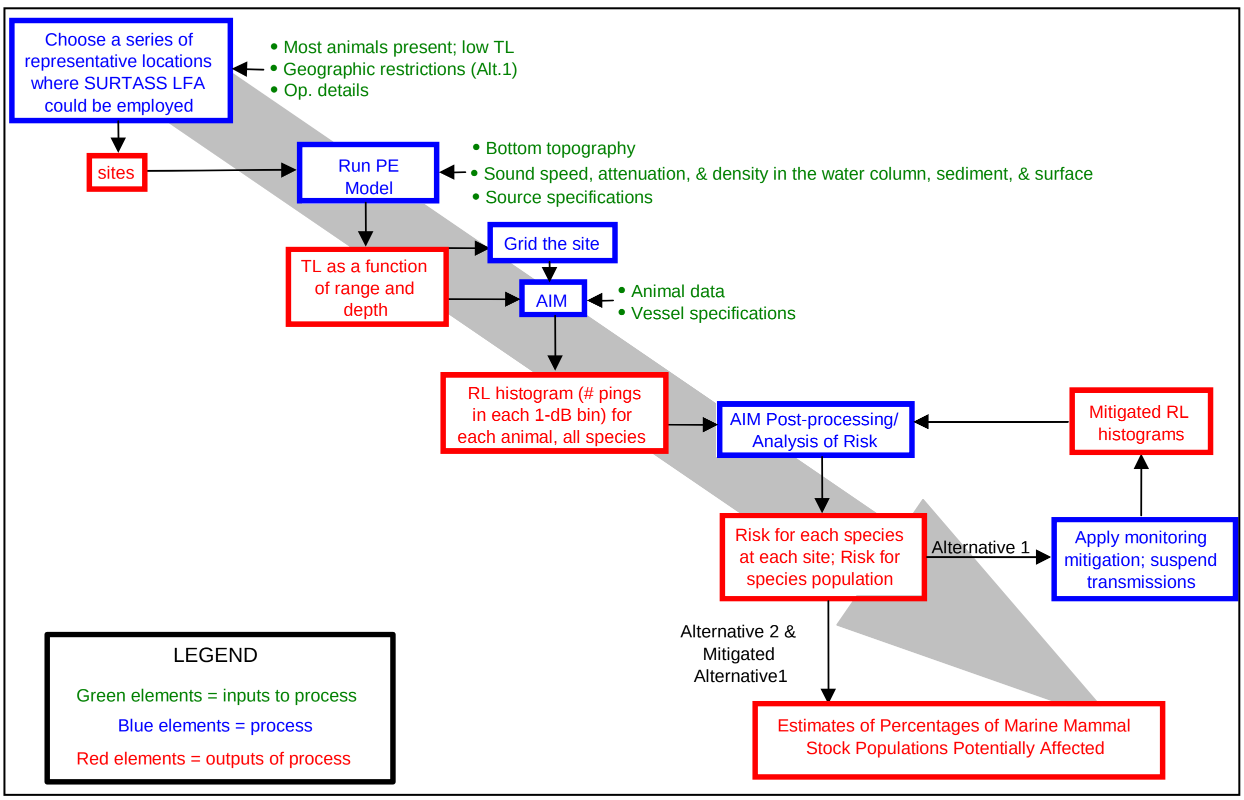


Figure C-14. Flowchart of SURTASS LFA sonar risk analysis.

C-2.8.1 PE Model Input Parameters and Data

Table C-12 provides many of the acoustic and positional parameters required for the acoustic modeling in these two examples. The Navy standard PE acoustic model, with the accompanying data bases, was

Table C-12. PE input parameters.

PARAMETER	GULF OF ALASKA	ONSLOW BAY
Location	57°N, 147°W	33°5' N, 76°15' W
Season	Summer	Spring
Source Depth	400 ft (120 m)	400 ft (120 m)
Source Beam Pattern	Omni-directional source	Omni-directional source
Frequency	300 Hz (nominal)	300 Hz (nominal)
Repetition Rate	Every 15 min	Every 15 min
Azimuthal Radials Modeled	000, 090, 180, 270°True (T)	000, 090, 180, 270°T

used to model the environment and examine four azimuths. Two sample PE field plots showing the 000º true bearing are provided as Figure C-15 and Figure C-16. These figures show the TL predicted for each site as a function of range from the source and depth in the ocean. In each figure, the source is in the upper far left of the plot (i.e., where the small arrow points to the depth axis at 120 m [400 ft]) where the TL values are lowest. For the Gulf of Alaska case note the presence of the duct as indicated by the low level of TL (approximately 80 to 85 dB and colored yellow) at the 120 to 150-m (400 to 500-ft) depth out to over 185 km (100 nmi) from the source. In the Onslow Bay case, the propagation mode is strongly bottom interactive (bottom bounce) due to the water depth and sound speed profile, with the energy in the water column decreasing rapidly as it propagates up-slope and toward shore.

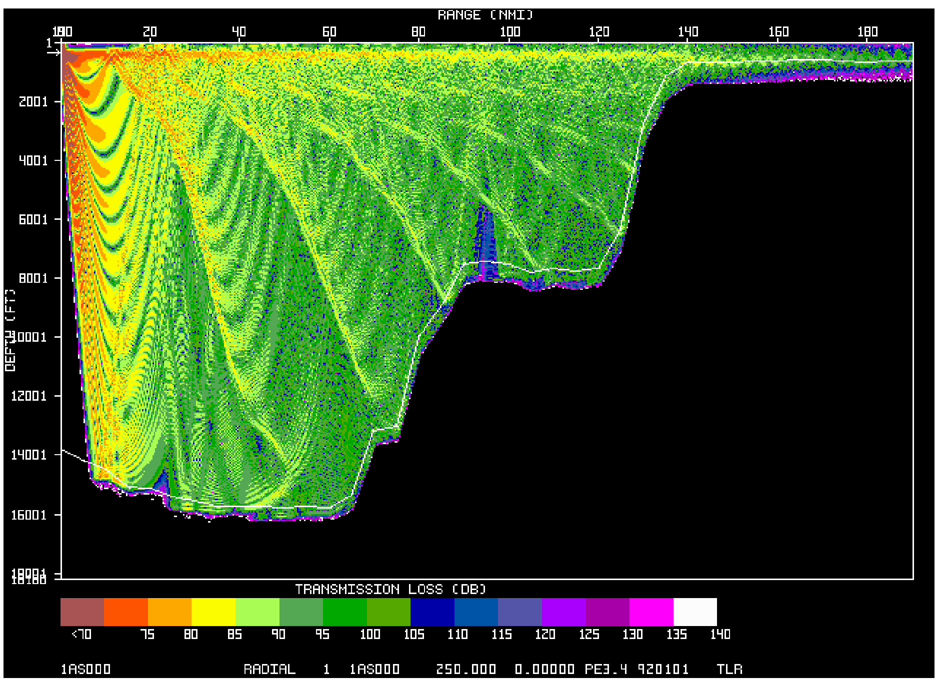


Figure C-15. PE field plot for the Gulf of Alaska, 000°T azimuth.

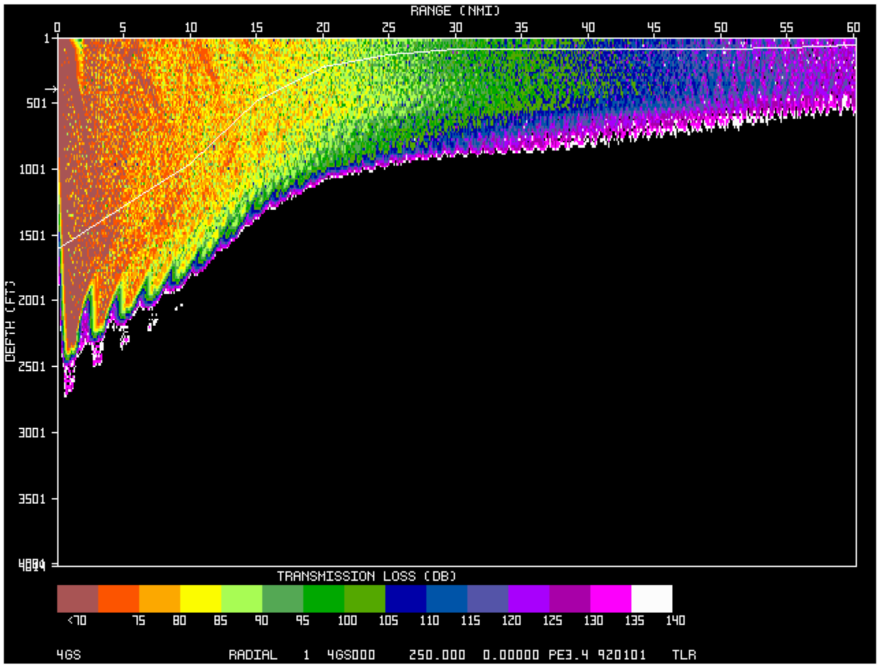


Figure C-16. PE field plot for Onslow Bay, 000°T azimuth.

The locations of these examples can be seen in Figure C-17 and Figure C-18 as the dots. Also shown on these figures is the sectioning, or grid spacing, used to create the initial distribution of the marine animals. In the first case (Gulf of Alaska), the source is well offshore (approximately 330 km [180 nmi]) and in relatively deep water, while for the Onslow Bay case the source is in water less than 305 m (1,000 ft) deep, and closer (111 km [60 nmi]) to shore.

C-2.8.3 AIM Input Parameters and Data

The initial distribution of marine animals is provided to AIM by a Monte Carlo method (see box). In this method, each of the sections (i.e., the rectangles shown in Figures C-17 and C-18) is assigned an animal weight or density for each of the modeled species, and the Monte Carlo method distributes the start positions of the animals in the sections. The distributions of the initial positions for two of these species, blue and humpback whales, are provided in Figure C-19 and Figure C-20, respectively for the Gulf of Alaska case.

Monte Carlo Method
The Monte Carlo Method is a technique for obtaining an approximate solution to certain mathematical and physical problems, characteristically involving the replacement of a probability distribution by sample values and usually done on a computer (Neufeldt, 1997).

Figure C-21 and Figure C-22 show the initial positions of northern right whales and beaked whales in the Onslow Bay site. Note that in the Gulf of Alaska, the humpbacks are concentrated primarily near shore, while the blue whales remain offshore (i.e., greater than 110 km [60 nmi] offshore). In the Onslow Bay

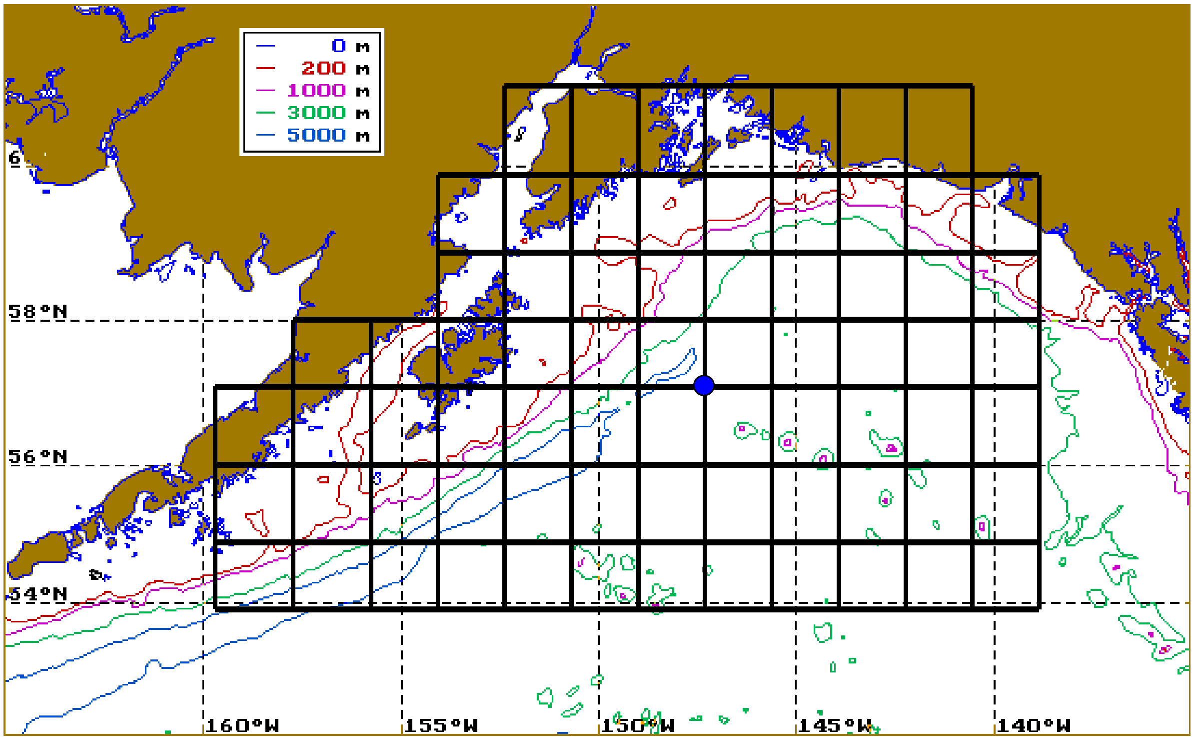


Figure C-17. AIM site 1, northern Gulf of Alaska (dot is example locations).

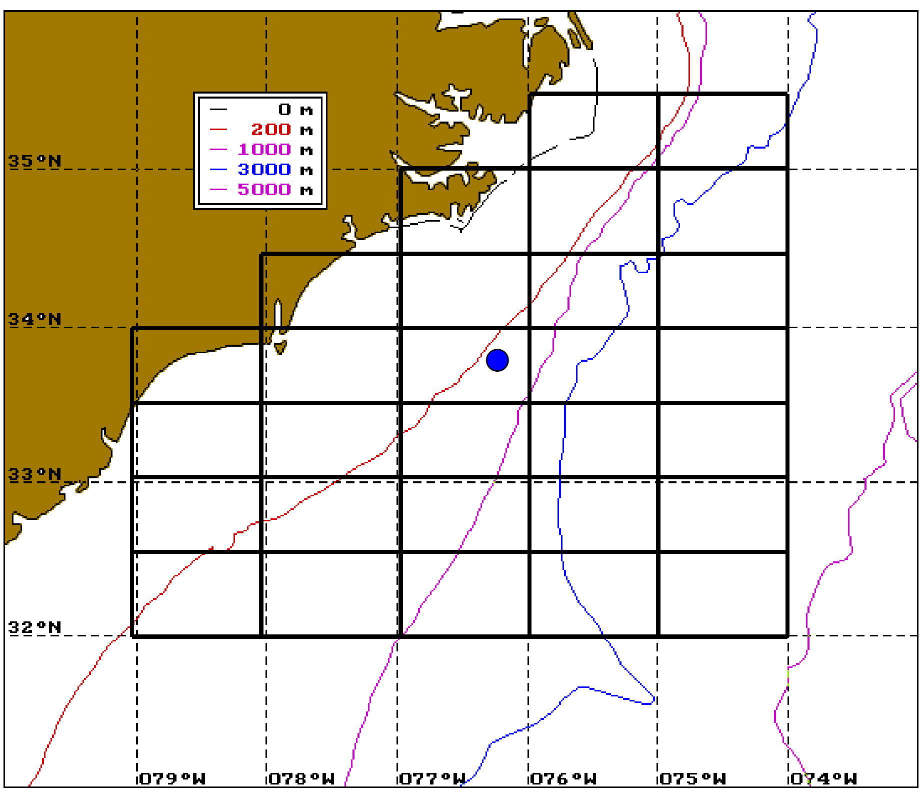


Figure C-18. AIM Site 28, Onslow Bay (dot is example location).

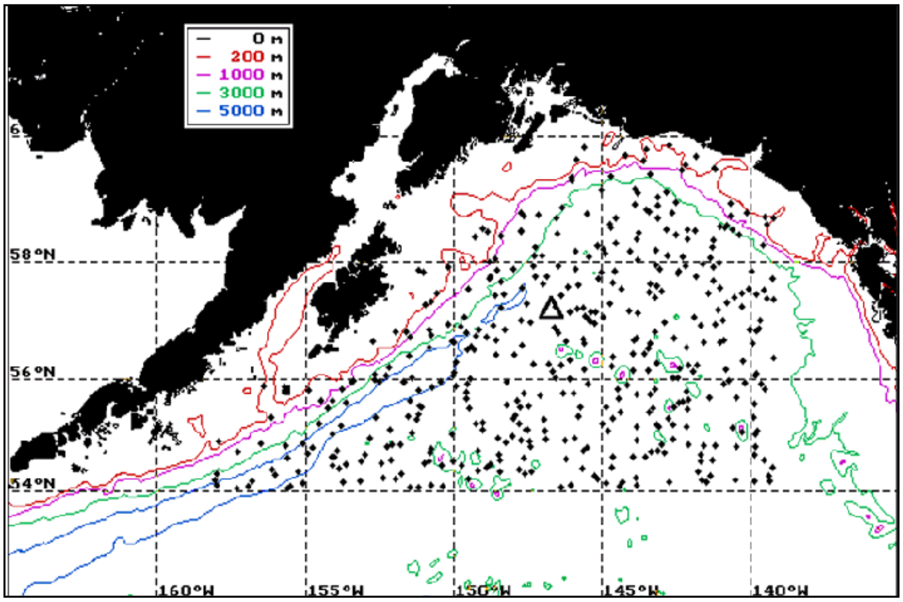


Figure C-19. Initial blue whale positions, Gulf of Alaska.

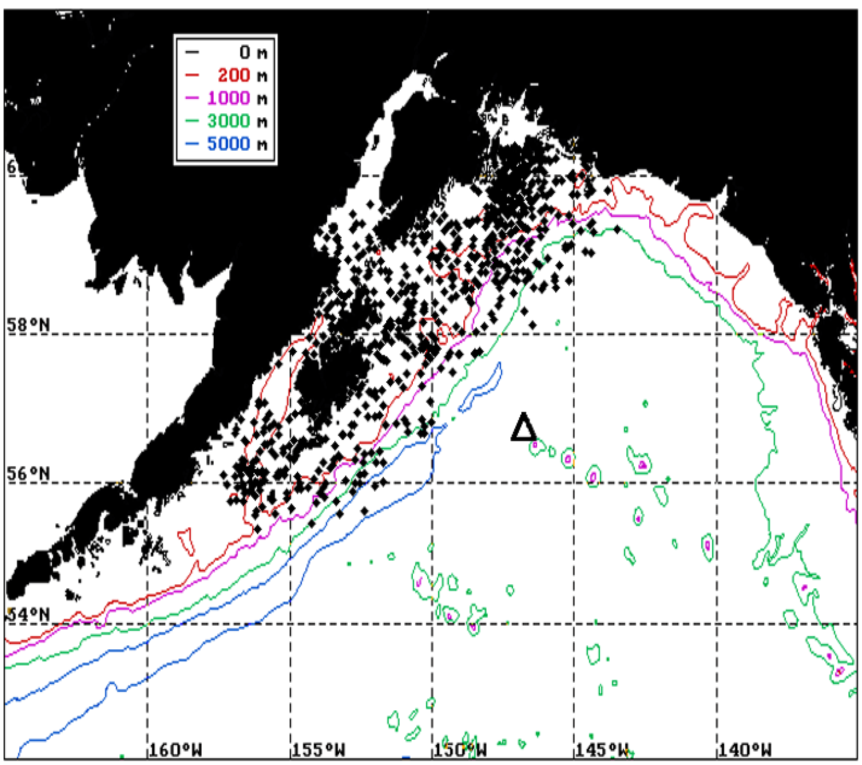


Figure C-20. Initial humpback whale positions, Gulf of Alaska.

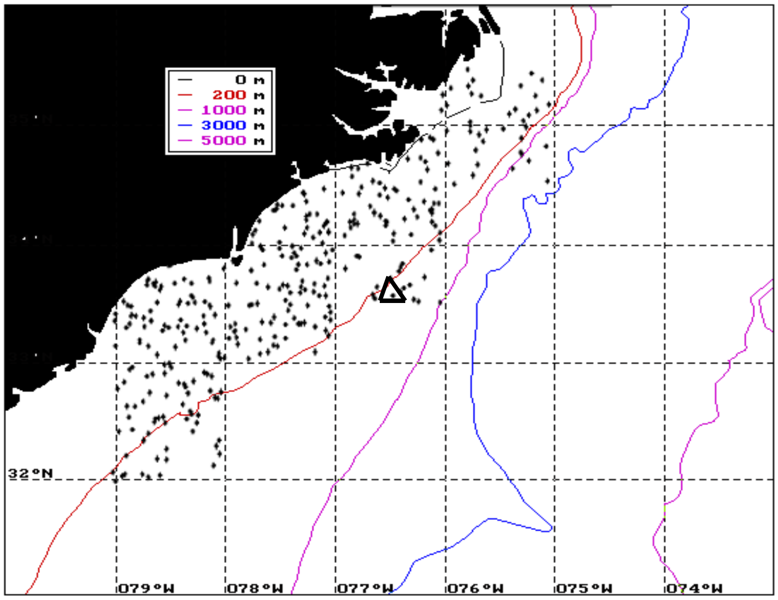


Figure C-21. Initial northern right whale positions, Onslow Bay.

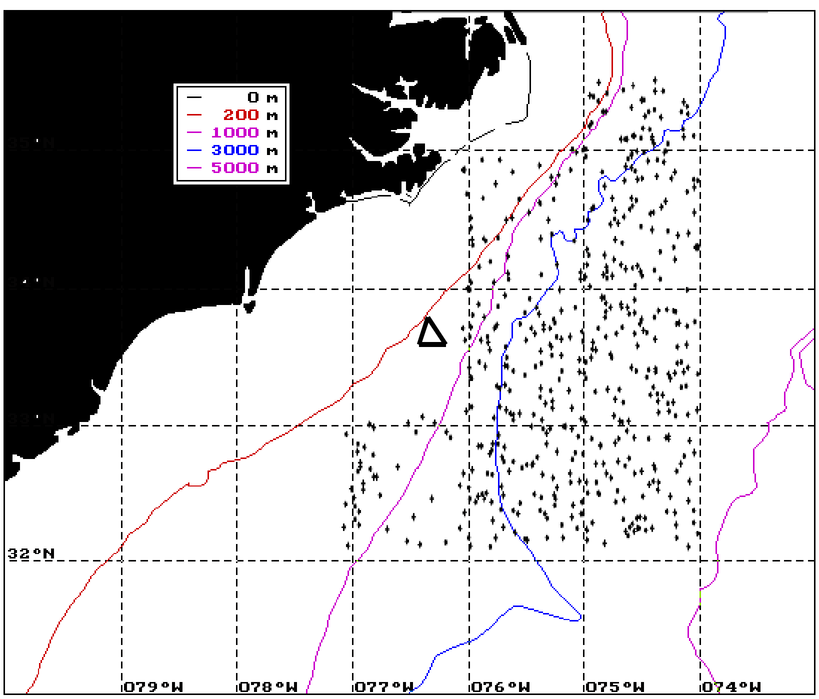


Figure C-22. Initial beaked whale positions, Onslow Bay.

site, the northern right whales are also concentrated near shore, while the beaked whales remain farther offshore, distributed in deeper water. Each of these figures also shows the ship track (triangle) for a typical 24-hour period.

It should be noted that the best available scientific data for each species were used to model their individual dive profiles (animal dive data were used when available; otherwise surrogate animal data were used) and distributions in the modeled areas. This precluded homogeneously-distributed animal densities in the three dimensions of latitude, longitude, and depth, as can be seen in the initial animal positions shown in Figures C-19, C-20, C-21, and C-22. Furthermore, the percentage of the stock that is included in the modeled area compared to the entire stock region is unique to each species. For example, 43.6% of the eastern North Pacific humpback stock is expected in the Gulf of Alaska case, whereas only 4.4% of the eastern North Pacific pelagic dolphin stock is expected in the Gulf of Alaska site. Obviously, these factors (dive profile, local distribution pattern, and regional stock distribution pattern) will influence the percentage of the stock potentially affected, and the resulting take estimates.

Table C-13 identifies most of the other critical parameters used with AIM. The animal decision interval, which in this analysis coincided with the transmission cycle, allowed animals to maneuver in three dimensions. The animal cone direction specified in the table was the variation in direction that the animal was allowed to take at any one of these decision points. In these cases, the animals could maneuver in azimuth in an unrestricted manner. Table C-14 identifies the four diving zones for the blue, humpback, northern right and beaked whales used in this example and the percentage of time the animals are assumed to spend at each depth.

Table C-13. AIM input parameters.

PARAMETER	VALUE
Source Vessel Speed	3 knots (1.5 m/sec)
Source Vessel Courses	150, 270, 030°T
Source Leg Duration	8 hours (3 legs per day)
Mission Duration	20 days (repeat triangle 20 times)
Animal Speed	3 knots (1.5 m/sec)
Animal Decision Interval	15 min
Animal Directional Cone	360°

In these regions, for these two modes of propagation (ducted and bottom interactive), it was determined that at least 100 and 200 animals (for the 20-day period with a 15-minute transmission repetition rate) were required to achieve statistical significance for the Gulf of Alaska and Onslow Bay cases, respectively. In these cases, 460 blue and humpback whales were modeled for the Gulf of Alaska, while 520 northern right whales and 380 beaked whales were modeled for Onslow Bay, based on density estimates.

As stated earlier, the number of animals modeled does not represent the actual estimated abundance in the area. Once the model is run and a statistically significant result is obtained, this result is scaled (i.e., multiplied or divided by a scaling factor) until it is appropriate for the actual estimated animal abundance in the modeled site area. For example, if 460 whales were modeled and the abundance estimate was actually 920 whales, the results would be scaled up (multiplied) by a factor of 2 (i.e., 920 ÷ 460 = 2).

Table C-14. Diving regimes.

ZONES	BLUE AND HUMPBACK		NORTHERN RIGHT		BEAKED	
	DEPTH RANGE (FT/M)	PERCENT OF TIME IN REGIME	DEPTH RANGE (FT/M)	PERCENT OF TIME IN REGIME	DEPTH RANGE (FT/M)	PERCENT OF TIME IN REGIME
Surface	0-50/ 0-15.2	12	0-50/ 0-15.2	80	0-50/ 0-15.2	17
Transition	50-270/ 15.2-82	40	50-150/ 15.2-45.7	5	50-1200/ 15.2-365.8	13
Average Diving	270-522/ 82-159	43			1200-1800/ 365.8-548.6	50
Maximum Diving	522-612/ 159-186.5	5	150-250/ 45.7-76.2	15	1800-3500/ 548.6-1066.8	20

C-2.8.4 Processing AIM Results Using the Risk Continuum

The AIM results were then processed using the risk continuum to derive percentages (Tables C-15 and C-16). These percentages estimate the portion of the stock potentially affected due to SPE levels ≥180 dB, and potentially affected due to all SPE levels, for Alternative 1 (geographic mitigation only, and geographic plus monitoring mitigation). These values were corrected to account for the percentage of animals affected in relation to the area's stock. The mathematics of processing the AIM results using the risk continuum consists of the following steps:

- AIM output data, histograms of number of transmissions in each RL bin, were translated into an SPE RL for each individual in a modeled stock;
- SPE RLs were translated into risk probabilities using the single-ping risk function;
- The risk probabilities for all individuals were summed to obtain an aggregate risk value expressed as the percentage of the modeled stock potentially affected; and
- The risk probability for the modeled stock was multiplied by the ratio of the actual stock to the modeled stock to obtain a normalized risk value for the regional stock.

For example, suppose SPE risks for a modeled stock of five animals from an actual stock of 100 animals are calculated as 2.5, 1.1, 5.3, 3.4, and 1.7%. The risk to the modeled stock is the average of the five individual risks (2.8%). The risk to the actual stock would then be 0.14% (i.e., 2.8 x 5/100). This value is used as the percentage of stock potentially affected.

C-2.8.5 Discussion of the Validity of the SPE Method for LFA Energy Summation

A recent paper by Finneran et al. (2010a) stated that, "The SPE approach…resulted in increasing underestimation of TTS_4 (TTS_4 refers to TTS measured 4 min after exposure to the fatiguing stimulus), with little accumulation of TTS as the number of exposures increased." This would tend to indicate that the SURTASS LFA sonar impact analysis, which relies on SPE as a core metric, underestimates potential impacts from TTS. While the above quote is correct for the data presented in Finneran et al. (2010a; 2010b) on bottlenose dolphins, the extrapolation to the entire SURTASS LFA sonar analysis is inappropriate.

Table C-15. Potentially affected stock (geographic mitigation only).

SITE	SPECIES	POTENTIAL FOR EFFECTS ≥180 DB re 1 µPa (rms) RL (%)	POTENTIAL FOR EFFECTS—ALL RLS (%)
Gulf of Alaska	Blue whales	0	6.87
	Humpback whales	0	12.39
Onslow Bay	Northern right whales	0.31	1.19
	Beaked Whales	0	0.01

Table C-16. Potentially affected stock (geographic and monitoring mitigation).

SITE	SPECIES	POTENTIAL FOR EFFECTS ≥180 DB re 1 µPa (rms) RL (%)	POTENTIAL FOR EFFECTS—ALL RLS (%)
Gulf of Alaska	Blue whales	0	6.87
	Humpback whales	0	12.39
Onslow Bay	Northern right whales	0	0.88
	Beaked Whales	0	0.01

The SURTASS LFA sonar SPE metric was primarily designed to address the non-injurious behavioral harassment issues and not TTS. SPE was used to determine the risk of significant change in biologically important behavior as the input value to single ping risk function as shown in Table C-13b. Even though considered to be injury, TTS is included as temporary physiological harassment at the upper end of the range of Level B harassments, but above 180 dB re: 1 µPa (rms) RL. When compared to injury criteria presented in Southall et al., (2007), the LFA injury criterion of 180 dB (RL) is considered to be conservative. The reality is, for the analysis of the potential effects of LFA, most if not all, TTS harassments, if they occurred, are included in the estimate of potential Level A harassments, because they will typically have an SPE of greater than 180 dB SPE, the LFA threshold for Level A harassments. For example, for a dolphin with a TTS threshold of 195 dB re 1 µPa (rms) (SPL) for a 1 second signal at 3 kHz (conservative for the LFA frequency of 300 Hz), which received a 60 second LFA signal, the adjusted TTS threshold, accounting for the 60-sec duration of the signal (18 dB), is 177 dB re 1 µPa^2-sec (rms) (SEL or SPE) (since for this case there is only 1 signal)(i.e., 195-18 = 177 dB re 1 µPa^2-sec (rms) (SEL or SPE). With the accumulated energy from multiple transmissions (although highly unlikely), this might sum to over 180 dB SPE. In a real-world LFA situation, considering the system's transmission duration and ping intervals, with the vessel moving in two dimensions and the animal moving in three dimensions, and the source at a nominal depth of 122 m (400 ft), even if mitigation was not taken into account, it is highly unlikely that an animal would be exposed to multiple signals with accumulated energy summing to over 180 dB SPE.

The data collected by Finneran et al. (2010a and 2010b) were for TTS measurements of bottlenose dolphins at about 3 kHz, where TTS is induced by exposure (RL) to 16-sec tones of 192 dB re 1 µPa (rms) (SPL). As shown in the audiograms presented in Richardson et al. (1995b), bottlenose dolphins' most sensitive hearing is between 10 and 70 kHz. Their thresholds are about 10 to 20 dB higher at 3 kHz, whereas they are about 60 dB higher for frequencies below 1 kHz. Thus, for LFA frequencies (nominally

300 Hz), bottlenose dolphin hearing capability is greatly reduced. TTS at 300 Hz would be expected at a much higher RL than that identified in the Finneran et al. (2010a) paper. Extrapolating the Finneran et al. (2010a) results to mysticetes, which are presumed to have much better hearing in the LFA frequency range, is not easy. Not only do these species likely have different hearing mechanisms, but there are no reliable measurements of their hearing thresholds, frequency ranges of greatest sensitivity, or SPLs that may induce TTS.

The Finneran et al. (2010a) appears to have been designed to address the issue of the suitability of the SURTASS LFA sonar SPE approach for analyzing the potential effects of mid-frequency active (MFA) sonar operations. For the reasons noted above and operational differences between MFA and LFA sonar noted above, this is inappropriate. Finneran et al.(2010a) not consistent with SURTASS LFA sonar analyses using SPE, and does not reflect how SPE is currently used in modeling LFA scenarios.

C-3 SUMMARY

The sensitivity/risk process, discussed above, integrates mission planning needs (Navy's training and operational ASW requirements) and a cautious assessment of the limited data available on specific marine mammal populations, and seasonal habitat and activity. In this supplemental analysis, 19 additional representative SURTASS LFA sonar operating sites have been analyzed using the most up-to-date marine mammal abundance, density, and behavioral information available. These sites were chosen because they represent, based on today's political climate, areas where SURTASS LFA sonar could potentially test, train or operate. This analysis provides updated modeling for the 11 sites under the current LOAs and eight additional sites, which could be requested for LOAs under the next 5-year Rule because they are in areas of potential strategic importance and/or areas of possible Fleet exercises.

Estimates of the percentage of marine mammal stocks affected by SURTASS LFA sonar operations in the 19 potential operating areas, for the seasons specified, have been derived for this document (Tables C-17 through C-35). The estimated stock values support the conclusion that estimates of potential effects to marine mammal stocks are below the conditions delineated by NMFS in the LOAs issued under the current 2007 Final Rule.

Under the current 2007 Rule and LOAs, NMFS provided regulations and conditions to ensure that the incidental taking of marine mammals resulting from SURTASS LFA sonar operations would have the least practicable adverse impacts on the affected marine mammal species or stocks. During the periods of the current LOAs, the Navy has ensured that the authorized harassment levels are not exceeded by utilizing the above risk assessment procedures. The Navy also uses these regulations and conditions as guides in mission planning and annual LOA applications.

Table C-17. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 1, East of Japan, in summer.

OPAREA 1 (SUMMER): EAST OF JAPAN				
SPECIES	**DENSITY (/KM2)**	**# IN STOCK**	**STOCK**	**% STOCK AFFECTED <180 DB SPE**
Blue whale	0.0002	9,250	North Pacific	0.0182
Fin whale	0.0002	9.250	North Pacific	0.0221
Sei whale	0.0006	8.600	North Pacific	0.0661
Bryde's whale	0.0006	20,501	Western North Pacific	0.0277
Common minke whale	0.0022	25,049	"O" stock Western North Pacific	0.0566
North Pacific right whale (spring/fall)	0.00001	922	Western North Pacific	< 0.0001
Sperm whale	0.0010	102.112	North Pacific	0.0060
Kogia spp.	0.0031	350,553	North Pacific	0.0079
Baird's beaked whale	0.0029	8.000	Western North Pacific	0.2603
Cuvier's beaked whale	0.0054	90,725	North Pacific	0.0427
Gingko-toothed beaked whale	0.0005	22,799	North Pacific	0.0157
Hubbs' beaked whale	0.0005	22,799	North Pacific	0.0157
False killer whale	0.0036	16,668	Western North Pacific	0.1916
Pygmy killer whale	0.0021	30,214	Western North Pacific	0.0617
Short-finned pilot whale	0.0128	53,608	Western North Pacific	0.2170
Risso's dolphin	0.0097	83,289	Western North Pacific	0.1138
Common dolphin	0.0761	3,286,163	Western North Pacific	0.0212
Bottlenose dolphin	0.0171	168,791	Western North Pacific	0.0823
Spinner dolphin	0.0005	1,015,059	Western North Pacific	0.0002
Pantropical spotted dolphin	0.0259	438,064	Western North Pacific	0.0180
Striped dolphin	0.0111	570,038	Western North Pacific	0.0059
Rough-toothed dolphin	0.0059	145,729	Western North Pacific	0.0346
Fraser's dolphin	0.0040	220,789	Western North Pacific	0.0153
Pacific white-sided dolphin	0.0082	931,000	Western North Pacific	0.0070

Table C-18. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 2, North Philippine Sea, in fall.

OPAREA 2 (FALL): NORTH PHILIPPINE SEA				
SPECIES	DENSITY (/KM2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Bryde's whale	0.0006	20,501	Western North Pacific	0.0339
Common minke whale	0.0044	25,049	"O" stock Western North Pacific	0.4023
North Pacific right whale (spring/fall/winter)	0.00001	922	Western North Pacific	0.0055
Sperm whale	0.0028	102,112	North Pacific	0.0454
Kogia spp.	0.0031	350,553	North Pacific	0.0265
Cuvier's beaked whale	0.0054	90,725	North Pacific	0.0534
Blainville's beaked whale	0.0005	8,032	North Pacific	0.0559
Gingko-toothed beaked whale	0.0005	22,799	North Pacific	0.0197
Killer whale	0.0004	12,256	North Pacific	0.0379
False killer whale	0.0029	16,668	Western North Pacific	0.2123
Pygmy killer whale	0.0021	30,214	Western North Pacific	0.0848
Melon-headed whale	0.0012	36,770	Western North Pacific	0.0398
Short-finned pilot whale	0.0153	53,608	Western North Pacific	0.5137
Risso's dolphin	0.0106	83,289	Western North Pacific	0.3337
Common dolphin	0.0562	3,286,163	Western North Pacific	0.0168
Bottlenose dolphin	0.0146	168,791	Western North Pacific	0.0548
Spinner dolphin	0.0005	1,015,059	Western North Pacific	0.0007
Pantropical spotted dolphin	0.0137	438,064	Western North Pacific	0.0429
Striped dolphin	0.0329	570,038	Western North Pacific	0.0792
Rough-toothed dolphin	0.0059	145,729	Western North Pacific	0.1109
Fraser's dolphin	0.0040	220,789	Western North Pacific	0.0411
Pacific white-sided dolphin	0.0119	931,000	Western North Pacific	0.0176

Table C-19. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 3, West Philippine Sea, in fall.

OPAREA 3 (FALL): WEST PHILIPPINE SEA				
SPECIES	DENSITY (/KM2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Fin whale	0.0002	9,250	North Pacific	0.0492
Bryde's whale	0.0006	20,501	Western North Pacific	0.0653
Common minke whale	0.0033	25,049	"O" stock Western North Pacific	0.1880
Humpback whale (winter only)	0.0000	1,107	Western North Pacific	< 0.0001
Sperm whale	0.0010	102,112	North Pacific	0.0105
Kogia spp.	0.0017	350,553	North Pacific	0.0099
Cuvier's beaked whale	0.0003	90,725	North Pacific	0.0042
Blainville's beaked	0.0005	8,032	North Pacific	0.0797
Gingko-toothed beaked whale	0.0005	22,799	North Pacific	0.0281
False killer whale	0.0029	16,668	Western North Pacific	0.2610
Pygmy killer whale	0.0021	30,214	Western North Pacific	0.1043
Melon-headed whale	0.0012	36,770	Western North Pacific	0.0490
Short-finned pilot whale	0.0076	53,608	Western North Pacific	0.1348
Risso's dolphin	0.0106	83,289	Western North Pacific	0.2284
Common dolphin	0.0562	3,286,163	Western North Pacific	0.0325
Bottlenose dolphin	0.0146	168,791	Western North Pacific	0.0927
Spinner dolphin	0.0005	1,015,059	Western North Pacific	0.0004
Pantropical spotted dolphin	0.0137	438,064	Western North Pacific	0.0230
Striped dolphin	0.0164	570,038	Western North Pacific	0.0212
Rough-toothed dolphin	0.0059	145,729	Western North Pacific	0.0769
Fraser's dolphin	0.0040	220,789	Western North Pacific	0.0284
Pacific white-sided dolphin	0.0245	931,000	Western North Pacific	0.0211

Table C-20. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 4, Offshore Guam, in summer and fall.

OPAREA 4 (Summer and Fall): Offshore Guam					
Species	**Density (/km^2)**	**# in Stock**	**Stock**	**% Stock Affected <180 dB SPE —Summer**	**% Stock Affected <180 dB SPE —Fall**
Blue whale	0.0001	2,842	Eastern North	0.0377	0.0338
Fin whale	0.0003	9,250	Eastern North	0.0376	0.0354
Sei whale	0.0003	8,600	North Pacific	0.0331	0.0330
Bryde's whale	0.0004	20,501	Western North Pacific	0.0183	0.0197
Common minke whale	0.0003	25,049	"O" stock Western	0.0110	0.0104
Humpback whale (Oct to May)	0.0000	10,103	central North Pacific	<0.0001	< 0.0001
Sperm whale	0.0012	102,112	North Pacific	0.0105	0.0104
Kogia spp.	0.0101	350,553	North Pacific	0.0373	0.0315
Cuvier's beaked whale	0.0062	90,725	North Pacific	0.0690	0.0679
Blainville's beaked whale	0.0012	8,032	North Pacific	0.1471	0.1446
Ginkgo-toothed beaked whale	0.0005	22,799	North Pacific	0.0222	0.0218
Longman's beaked whale	0.0004	1,007	Central North Pacific	0.4112	0.4043
False killer whale	0.0011	16,668	Western North Pacific	0.0699	0.0440
Pygmy killer whale	0.0001	30,214	Western North Pacific	0.0049	0.0031
Melon-headed whale	0.0043	36,770	Western North Pacific	0.1222	0.0769
Killer whale	0.0001	349	Hawaii	0.4894	0.4372
Short-finned pilot whale	0.0016	53,608	Western North Pacific	0.0350	0.0205
Risso's dolphin	0.0010	83,289	Western North Pacific	0.0141	0.0125
Common dolphin	0.0021	3,286,163	Western North Pacific	0.0007	0.0006
Bottlenose dolphin	0.00021	168,791	Western North Pacific	0.0013	0.0009
Spinner dolphin	0.0031	1,015,059	Western North Pacific	0.0027	0.0025
Pantropical spotted dolphin	0.0226	438,064	Western North Pacific	0.0444	0.0417
Striped dolphin	0.0062	570,038	Western North Pacific	0.0093	0.0087
Rough-toothed dolphin	0.0003	145,729	Western North Pacific	0.0022	0.0021
Fraser's dolphin	0.0042	10,226	Hawaii	0.4119	0.3780

Table C-21. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 5, Sea of Japan, in fall.

OPAREA 5 (FALL): SEA OF JAPAN				
SPECIES	**DENSITY (/KM^2)**	**# IN STOCK**	**STOCK**	**% STOCK AFFECTED <180 DB SPE**
Fin whale	0.0009	9,250	North Pacific	0.2345
Bryde's whale	0.0001	20,501	Western North Pacific	0.0104
Common minke whale	0.0004	25,049	Western North Pacific	0.0291
Common minke whale J stock	0.0002	893	J	0.3261
Gray whale	0.00001	121	Western North Pacific	0.0011
North Pacific right whale (spring/fall/winter)	0.00001	922	Western North Pacific	0.0255
Sperm whale	0.0008	102,112	North Pacific	0.0206
Stejneger's beaked whale	0.0014	8,000	North Pacific	0.5023
Baird's beaked whale	0.0003	8,000	Western North Pacific	0.1076
Cuvier's beaked whale	0.0043	90,725	North Pacific	0.1360
Gingko-toothed beaked whale	0.0005	22,799	North Pacific	0.0629
False killer whale	0.0027	9,777	Inshore Archipelago	0.8202
Melon-headed whale	0.00001	36,770	Western North Pacific	0.0008
Short-finned pilot whale	0.0014	53,608	Western North Pacific	0.0303
Risso's dolphin	0.0073	83,289	Western North Pacific	0.2121
Common dolphin	0.0860	3,286,163	Western North Pacific	0.0529
Bottlenose dolphin	0.0009	105,138	Inshore Archipelago	0.0134
Spinner dolphin	0.00001	1,015,059	Western North Pacific	< 0.0001
Pantropical spotted dolphin	0.0137	219,032	Western North Pacific	0.0632
Pacific white-sided dolphin	0.0030	931,000	Western North Pacific	0.0040
Dall's porpoise	0.0520	76,720	Sea of Japan	0.9218

Table C-22. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 6, East China Sea, in summer.

OPAREA 6 (SUMMER): EAST CHINA SEA				
SPECIES	**DENSITY (/KM^2)**	**# IN STOCK**	**STOCK**	**% STOCK AFFECTED <180 DB SPE**
Fin whale	0.0002	500	East China Sea	0.6200
Bryde's whale	0.0006	20,501	Western North Pacific	0.0357
Common minke whale	0.0044	25,049	Western North Pacific	0.2284
Common minke whale J stock	0.0018	893	J	2.6204
Gray whale (winter only)	0.0000	121	Western North Pacific	< 0.0001
North Pacific right whale (winter)	0.0000	922	Western North Pacific	< 0.0001
Sperm whale	0.0012	102,112	North Pacific	0.0092
Kogia spp.	0.0031	350,553	North Pacific	0.0056
Cuvier's beaked whale	0.0062	90,725	North Pacific	0.0719
Blainville's beaked	0.0012	8,032	North Pacific	0.1530
Ginkgo-toothed beaked whale	0.0005	22,799	North Pacific	0.0230
False killer whale	0.0011	9,777	Inshore Archipelago	0.1703
Pygmy killer whale	0.0001	30,214	Western North Pacific	0.0070
Melon-headed whale	0.0043	36,770	Western North Pacific	0.1746
Short-finned pilot whale	0.0016	53,608	Western North Pacific	0.0498
Risso's dolphin	0.0106	83,289	Western North Pacific	0.1833
Common dolphin	0.0461	3,286,163	Western North Pacific	0.0202
Bottlenose dolphin	0.0146	105,138	Inshore Archipelago	0.0967
Spinner dolphin	0.0031	1,015,059	Western North Pacific	0.0036
Pantropical spotted dolphin	0.0137	219032	Western North Pacific	0.0728
Striped dolphin	0.0164	570,038	Western North Pacific	0.0334
Rough-toothed dolphin	0.0059	145,729	Western North Pacific	0.0518
Fraser's dolphin	0.0040	220,789	Western North Pacific	0.0252
Pacific white-sided dolphin	0.0028	931,000	Western North Pacific	0.0041

Table C-23. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 7, South China Sea, in fall.

OPAREA 7 (FALL): SOUTH CHINA SEA				
SPECIES	DENSITY (KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Fin whale	0.0002	9,250	Western North Pacific	0.0352
Bryde's whale	0.0006	20,501	Western North Pacific	0.0416
Common minke whale	0.0033	25,049	Western North Pacific	0.1713
Gray whale (winter only)	0.0000	121	Western North Pacific	< 0.0001
North Pacific right whale (winter)	0.0000	922	Western North Pacific	< 0.0001
Sperm whale	0.0012	102,112	North Pacific	0.0125
Kogia spp.	0.0017	350,553	North Pacific	0.0087
Cuvier's beaked whale	0.0003	90,725	North Pacific	0.0042
Blainville's beaked whale	0.0005	8,032	North Pacific	0.0782
Gingko-toothed beaked whale	0.0005	22,799	North Pacific	0.0276
False killer whale	0.0011	9,777	Inshore Archipelago	0.1873
Pygmy killer whale	0.0001	30,214	Western North Pacific	0.0076
Melon-headed whale	0.0043	36,770	Western North Pacific	0.1921
Short-finned pilot whale	0.0016	53,608	Western North Pacific	0.0415
Risso's dolphin	0.0106	83,289	Western North Pacific	0.2074
Common dolphin	0.0461	3,286,163	Western North Pacific	0.0210
Bottlenose dolphin	0.0146	105,138	Inshore Archipelago	0.0796
Spinner dolphin	0.3140	1,015,059	Western North Pacific	0.3186
Pantropical spotted dolphin	0.0137	219,032	Western North Pacific	0.0646
Striped dolphin	0.0164	570,038	Western North Pacific	0.0296
Rough-toothed dolphin	0.0040	145,729	Western North Pacific	0.0467
Fraser's dolphin	0.0040	220,789	Western North Pacific	0.0257

Table C-24. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 8, NW Pacific, in summer.

OPAREA 8 (SUMMER): NW PACIFIC (25°N TO 40°N)				
SPECIES	**DENSITY (/KM^2)**	**# IN STOCK**	**STOCK**	**% STOCK AFFECTED <180 DB SPE**
Blue whale	0.0003	9,250	North Pacific	0.1064
Fin whale	0.0001	9,250	North Pacific	0.0532
Sei whale	0.0003	37,000	North Pacific	0.0400
Bryde's whale	0.0004	20,501	Western North Pacific	0.1020
Common minke whale	0.0003	25,049	Western North Pacific	0.0465
Sperm whale	0.0003	102,112	North Pacific	0.0054
Kogia spp.	0.0049	350,553	North Pacific	0.0587
Baird's beaked whale	0.0001	8,000	Western North Pacific	0.0283
Cuvier's beaked whale	0.0017	90,725	North Pacific	0.0423
Mesoplodon spp	0.0005	22,799	North Pacific	0.0711
False killer whale	0.0036	16,668	Western North Pacific	0.6998
Pygmy killer whale	0.0001	30,214	Western North Pacific	0.0150
Melon-headed whale	0.0012	36,770	Western North Pacific	0.1057
Short-finned pilot whale	0.0001	53,608	Western North Pacific	0.0014
Risso's dolphin	0.0010	83,289	Western North Pacific	0.0418
Common dolphin	0.0863	3,286,163	Western North Pacific	0.1140
Bottlenose dolphin	0.0005	168,791	Western North Pacific	0.0086
Spinner dolphin	0.00001	1,015,059	Western North Pacific	< 0.0001
Pantropical spotted dolphin	0.0181	438,064	Western North Pacific	0.0696
Striped dolphin	0.0500	570,038	Western North Pacific	0.1477
Rough-toothed dolphin	0.0003	145,729	Western North Pacific	0.0076
Pacific white-sided dolphin	0.0048	67,769	Western North Pacific	0.1544
Hawaiian monk seal	0.00001	1,129	Hawaiian	

Table C-25. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 9, NW Pacific, in winter.

OPAREA 9 (WINTER): NW PACIFIC (10°N TO 25°N)				
SPECIES	**DENSITY ($/KM^2$)**	**# IN STOCK**	**STOCK**	**% STOCK AFFECTED <180 DB SPE**
Bryde's whale	0.0004	20,501	Western North Pacific	0.0309
Sperm whale	0.0004	102,112	North Pacific	0.0034
Kogia spp.	0.0009	350,553	North Pacific	0.0044
Cuvier's beaked whale	0.0017	90,725	North Pacific	0.0197
False killer whale	0.0021	16,668	Western North Pacific	0.1965
Melon-headed whale	0.0012	36,770	Western North Pacific	0.0509
Short-finned pilot whale	0.0009	53,608	Western North Pacific	0.0373
Risso's dolphin	0.0026	83,289	Western North Pacific	0.0478
Common dolphin	0.0863	3,286,163	Western North Pacific	0.0475
Bottlenose dolphin	0.0007	168,791	Western North Pacific	0.0074
Spinner dolphin	0.0031	1,015,059	Western North Pacific	0.0054
Pantropical spotted dolphin	0.02260	438,064	Western North Pacific	0.0908
Striped dolphin	0.0110	570,038	Western North Pacific	0.0340
Rough-toothed dolphin	0.0003	145,729	Western North Pacific	0.0027

Table C-26. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 10, Hawaii North, in summer.

OPAREA 10 (SUMMER): HAWAII NORTH (25°N TO 158°W)				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Blue whale	0.0002	1548	Western North Pacific	0.2295
Fin whale	0.0007	2099	Hawaii	0.9338
Bryde's whale	0.0002	469	Hawaii	1.1855
Common minke whale	0.0002	25000	Hawaii	0.0128
Humpback whale (summer)	0.0000	10103	Hawaii	< 0.0001
Sperm whale	0.0028	6919	Central North Pacific	0.5258
Kogia spp.	0.0101	24657	Hawaii	1.0271
Cuvier's beaked whale	0.0062	15242	Hawaii	0.6698
Blainville's beaked	0.0012	2872	Hawaii	0.6697
Longman's beaked whale	0.0004	1007	Hawaii	0.6530
Killer whale	0.0001	349	Hawaii	0.7851
False killer whale	0.0002	484	Hawaii Pelagic	0.8760
	0.0002	123	Hawaii Insular	3.4472
Pygmy killer whale	0.0004	956	Hawaii	0.8870
Melon-headed whale	0.0012	2950	Hawaii	0.8624
Short-finned pilot whale	0.0036	8870	Hawaii	0.3718
Risso's dolphin	0.0010	2372	Hawaii	0.9106
Bottlenose dolphin	0.0013	3215	Hawaii	0.5087
Spinner dolphin	0.0014	3351	Hawaii	0.2347
Pantropical spotted dolphin	0.0037	8978	Hawaii	0.2340
Striped dolphin	0.0054	13143	Hawaii	0.2341
Rough-toothed dolphin	0.0036	8709	Hawaii	0.9375
Fraser's dolphin	0.0042	10226	Hawaii	0.7590
Hawaiian monk seal	0.0001	1129	Hawaii	0.1435

Table C-27. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 11, Hawaii South, in spring and fall.

OPAREA 11 (Spring/Fall): Hawaii South (19.5°N to 158.5°W)				
Species	Density (/km^2)	# in stock	Stock	% Stock Affected <180 dB SPE
Blue whale	0.0002	1,548	Western North Pacific	0.1288
Fin whale	0.0007	2,099	Hawaii	0.4369
Bryde's whale	0.0002	469	Hawaii	0.5544
Common minke whale	0.0002	25,000	Hawaii	0.0078
Humpback whale (not summer)	0.0008	10,103	Hawaii	0.0003
Sperm whale	0.0028	6,919	Central North Pacific	0.3391
Kogia spp.	0.0101	24,657	Hawaii	0.5217
Cuvier's beaked whale	0.0062	15,242	Hawaii	0.3985
Blainville's beaked	0.0012	2,872	Hawaii	0.3984
Longman's beaked whale	0.0004	1,007	Hawaii	0.3885
Killer whale	0.0001	349	Hawaii	0.3811
False killer whale	0.0002	484	Hawaii Pelagic	0.4628
	0.0002	123	Hawaii Insular	1.8211
Pygmy killer whale	0.0004	956	Hawaii	0.4686
Melon-headed whale	0.0012	2,950	Hawaii	0.4556
Short-finned pilot whale	0.0036	8,870	Hawaii	0.3527
Risso's dolphin	0.0010	2,372	Hawaii	0.4764
Bottlenose dolphin	0.0013	3,215	Hawaii	0.3514
Spinner dolphin	0.0014	3,351	Hawaii	0.2935
Pantropical spotted dolphin	0.0037	8,978	Hawaii	0.2927
Striped dolphin	0.0054	13,143	Hawaii	0.2928
Rough-toothed dolphin	0.0036	8,709	Hawaii	0.4932
Fraser's dolphin	0.0042	10,226	Hawaii	0.4037
Hawaiian monk seal	0.0001	1,129	Hawaii	0.1010

Table C-28. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 12, Offshore Southern California, in spring.

OPAREA 12 (Spring): Offshore Southern California				
Species	**Density (/km^2)**	**# in Stock**	**Stock**	**% Stock Affected <180 dB SPE**
Common minke whale	0.0007	823	CA/OR/WA	1.2685
Sei whale	0.0001	98	Eastern North Pacific	1.9876
Bryde's whale	0.00001	13,000	Eastern tropical Pacific	0.0013
Blue whale	0.0014	2,842	Eastern North Pacific	0.8374
Fin whale	0.0018	2,099	CA/OR/WA	2.2178
Humpback whale	0.0008	942	CA/OR/WA	1.0485
Gray whale	0.0510	18,813	Eastern North Pacific	0.0352
Short-finned pilot whale	0.0003	350	CA/OR/WA	1.5433
Killer whale	0.0007	810	Eastern North Pacific Offshore	1.9898
Pygmy sperm whale	0.0011	1,237	CA/OR/WA	2.5818
Sperm whale	0.0017	1,934	CA/OR/WA	1.9354
Baird's beaked whale	0.0009	1,005	CA/OR/WA	1.9439
Longman's beaked whale	0.0010	1,177	Hawaii	1.9427
Hubb's beaked whale	0.0010	1,177	CA/OR/WA	1.9427
Blainville's beaked whale	0.0010	1,177	CA/OR/WA	1.9427
Ginkgo-toothed beaked whale	0.0010	1,177	CA/OR/WA	1.9427
Perrin's beaked whale	0.0010	1,177	CA/OR/WA	1.9427
Pygmy beaked whale	0.0010	1,177	CA/OR/WA	1.9427
Stejneger's beaked whale	0.0010	1,177	CA/OR/WA	1.9427
Cuvier's beaked whale	0.0038	4,342	CA/OR/WA	1.9531
Long-beaked common dolphin	0.0192	21,902	CA/OR/WA	1.8887
Short-beaked common dolphin	0.3094	352,069	CA/OR/WA	1.8891
Risso's dolphin	0.0105	11,910	CA/OR/WA	2.3572
Pacific white-sided dolphin	0.0209	23,817	CA/OR/WA	1.0370
Northern right whale dolphin	0.0098	11,097	CA/OR/WA	2.4777
Striped dolphin	0.0167	18,976	CA/OR/WA	1.0087
Bottlenose dolphin	0.0018	2,026	CA/OR/WA Offshore	1.4497

Table C-28. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 12, Offshore Southern California, in spring.

OPAREA 12 (SPRING): OFFSHORE SOUTHERN CALIFORNIA				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Dall's porpoise	0.0755	85,955	CA/OR/WA	0.9666
Guadalupe fur seal	0.0070	7,408	Mexico	0.7172
Northern fur seal	0.0000	9,424	San Miguel Island	< 0.0001
California sea lion (on shelf)	0.5400	238,000	California	0.9507
California sea lion (offshore)	0.0000	238,000	California	< 0.0001
Northern elephant seal (on shelf)	0.0045	124,000	California (breeding)	0.0191
Northern elephant seal (offshore)	0.0000	124,000	California (breeding)	< 0.0001
Harbor seal	0.0095	34,233	California	0.2559

Table C-29. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 13, Western Atlantic, in winter.

OPAREA 13 (WINTER): WESTERN ATLANTIC (JAX OPAREA)				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Humpback whale	0.0006	11,570	Western North Atlantic	0.0663
North Atlantic right whale (on shelf)	0.0012	438	Western North Atlantic	0.1217
Short-finned pilot whale (on shelf)	0.00004	31,139	Western North Atlantic	0.0001
Short-finned pilot whale (off shelf)	0.0271	31,139	Western North Atlantic	2.2997
Pygmy sperm whale	0.0010	580	Western North Atlantic	4.4579
Dwarf sperm whale	0.0010	580	Western North Atlantic	4.4579
Sperm whale (on shelf)	0.0000	4,804	Western North Atlantic	< 0.0001
Sperm whale (off shelf)	0.0005	4,804	Western North Atlantic	0.1691
Beaked whales (on shelf)	0.0000	3,513	Western North Atlantic	< 0.0001
Blainville's beaked whale (off shelf)	0.0006	3,513	Western North Atlantic	0.3642
Gervais' beaked whale (off shelf)	0.0006	3,513	Western North Atlantic	0.3642
Cuvier's beaked whale (off shelf)	0.0006	3,513	Western North Atlantic	0.3642
True's beaked whale (off shelf)	0.0006	3,513	Western North Atlantic	0.3642
Sowerby's beaked whale (off shelf)	0.0006	3,513	Western North Atlantic	0.3642
Rough-toothed dolphin	0.0005	274	Western North Atlantic	2.5226
Coastal bottlenose dolphin (on shelf)	0.2132	12,482	Southern Migratory Coast	0.7515
	0.2132	3,064	Northern Florida Coast	3.0615
	0.2132	6,318	Central Florida Coast	1.4847
Bottlenose dolphin (off shelf)	0.1163	81,588	Western North Atlantic	2.8506
Risso's dolphin (on shelf)	0.0009	20,479	Western North Atlantic	0.0054
Risso's dolphin (off shelf)	0.0181	20,479	Western North Atlantic	1.9744
Common dolphin	0.00002	120,743	Western North Atlantic	0.0003
Pantropical spotted dolphin	0.0223	12,747	Western North Atlantic	2.8452
Clymene dolphin	0.0106	60,86	Western North Atlantic	2.8470
Striped dolphin	0.00003	94,462	Western North Atlantic	0.0006
Atlantic spotted dolphin (on shelf)	0.4435	50,978	Western North Atlantic	0.4089
Atlantic spotted dolphin (off shelf)	0.0041	50,978	Western North Atlantic	0.1311

Table C-30. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 14, Eastern North Atlantic, in summer.

OPAREA 14 (SUMMER): EASTERN NORTH ATLANTIC (NW APPROACHES)				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Common minke whale	0.0068	107,205	Eastern North Atlantic	0.6518
Sei whale	0.0113	14,152	Eastern North Atlantic	9.2473
Blue whale	0.00001	100	Eastern North Atlantic	0.7726
Fin whale	0.0031	10,369	Eastern North Atlantic	3.4018
Humpback whale	0.0019	4,695	Eastern North Atlantic	1.1710
Sperm whale	0.0049	6,375	Eastern North Atlantic	2.3498
False killer whale	0.0001	484	Eastern North Atlantic	1.2615
Long-finned pilot whale	0.0121	778,000	Eastern North Atlantic	0.0857
Killer whale	0.0001	6,618	Eastern North Atlantic	0.1607
North Atlantic bottlenose whale	0.0003	5,827	Eastern North Atlantic	0.1654
Sowerby's beaked whale	0.0013	3,513	Eastern North Atlantic	1.3685
Blainville's beaked whale	0.0013	3,513	Eastern North Atlantic	1.3685
Cuvier's beaked whale	0.0013	3,513	Eastern North Atlantic	1.3685
Pygmy sperm whale	0.0001	580	Eastern North Atlantic	1.3386
Dwarf sperm whale	0.0001	580	Eastern North Atlantic	1.3386
Harbor porpoise	0.2299	341,366	Eastern North Atlantic	1.4294
Common dolphin	0.2380	273,150	Eastern North Atlantic	9.1833
Risso's dolphin	0.0063	20,479	Eastern North Atlantic	2.1137
Striped dolphin	0.0765	94,462	Eastern North Atlantic	4.8839
Bottlenose dolphin	0.0094	81,588	Eastern North Atlantic	1.0419
Atlantic white-sided dolphin	0.0027	11,760	Eastern North Atlantic	1.4759
White-beaked dolphin	0.0027	11,760	Eastern North Atlantic	1.4759
Harbor seal	0.0230	23,500	Ireland/Scotland stock	3.2031
Gray seal	0.0270	113,300	Eastern North Atlantic	3.7559

Table C-31. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 15, Mediterranean Sea, in summer.

OPAREA 15 (SUMMER): MEDITERRANEAN SEA, LIGURIAN SEA				
SPECIES	**DENSITY (/KM^2)**	**# IN STOCK**	**STOCK**	**% STOCK AFFECTED <180 DB SPE**
Fin whale	0.0040	3,583	Mediterranean	7.0332
Sperm whale	0.0049	6,375	Western Mediterranean	1.7525
Cuvier's beaked whale	0.0013	3,513	Eastern North Atlantic	1.0139
Long-finned pilot whale	0.0121	778,000	Eastern North Atlantic	0.0754
Risso's dolphin	0.0075	5,320	Western Mediterranean	6.7105
Striped dolphin	0.2400	117,880	Western Mediterranean	8.8565
Bottlenose dolphin	0.0410	23,304	Western Mediterranean	10.3802
Common dolphin	0.0144	19,428	Western Mediterranean	4.4472

Table C-32. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 16, Arabian Sea, in summer.

OPAREA 16 (SUMMER): ARABIAN SEA				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Bryde's whale	0.0001	9,176	Indian Ocean	0.0134
Humpback whale	0.0004	200	Stock X / Arabian Sea	1.5275
Sperm whale	0.0125	24,446	Indian Ocean	0.4530
Pygmy killer whale	0.0026	22,029	Indian Ocean	0.3187
Melon-headed whale	0.0661	64,600	Indian Ocean	2.7627
False killer whale	0.0003	144,188	Indian Ocean	0.0056
Dwarf sperm whale	0.0145	10,541	Indian Ocean	4.1267
Longman's beaked whale	0.0016	16,867	Indian Ocean	0.1880
Blainville's beaked whale	0.0016	16,867	Indian Ocean	0.1880
Ginkgo-toothed beaked whale	0.0016	16,867	Indian Ocean	0.1880
Cuvier's beaked whale	0.0001	27,272	Indian Ocean	0.0073
Common dolphin	0.0265	1,819,882	Indian Ocean	0.0373
Risso's dolphin	0.0125	452,125	Indian Ocean	0.0357
Rough-toothed dolphin	0.0081	156,690	Indian Ocean	0.0663
Bottlenose dolphin	0.0164	785,585	Indian Ocean	0.0393
Pantropical spotted dolphin	0.0127	736,575	Indian Ocean	0.0072
Striped dolphin	0.0706	674,578	Indian Ocean	0.0437
Spinner dolphin	0.0100	634,108	Indian Ocean	0.0066
Short-finned pilot whale	0.0034	268,751	Indian Ocean	0.0078

Table C-33. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 17, Andaman Sea, in summer.

OPAREA 17 (SUMMER): ANDAMAN SEA				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Bryde's whale	0.0001	9,176	Indian Ocean	0.0094
Sperm whale	0.0125	24,446	Indian Ocean	0.5369
Short-finned pilot whale	0.0034	268,751	Indian Ocean	0.0079
Killer whale	0.0001	12,593	Indian Ocean	0.0079
Dwarf sperm whale	0.0145	10,541	Indian Ocean	1.5682
Pygmy killer whale	0.0026	22,029	Indian Ocean	0.0970
Melon-headed whale	0.0661	64,600	Indian Ocean	0.8411
False killer whale	0.0003	144,188	Indian Ocean	0.0017
Longman's beaked whale	0.0016	16,867	Indian Ocean	0.1214
Blainville's beaked whale	0.0016	16,867	Indian Ocean	0.1214
Ginkgo-toothed beaked whale	0.0016	16,867	Indian Ocean	0.1214
Cuvier's beaked whale	0.0001	27,272	Indian Ocean	0.0047
Common dolphin	0.0265	1,819,882	Indian Ocean	0.0130
Risso's dolphin	0.0125	452,125	Indian Ocean	0.0337
Pantropical spotted dolphin	0.0127	736,575	Indian Ocean	0.0104
Striped dolphin	0.0706	674,578	Indian Ocean	0.0632
Spinner dolphin	0.0100	634,108	Indian Ocean	0.0095
Rough-toothed dolphin	0.0081	156,690	Indian Ocean	0.0724
Bottlenose dolphin	0.0164	785,585	Indian Ocean	0.0122

Table C-34. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 18, Panama Canal, in winter.

OPAREA 18 (Winter): Panama Canal (Western Approaches)				
Species	**Density (/km^2)**	**# in Stock**	**Stock**	**% Stock Affected <180 dB SPE**
Bryde's whale	0.0003	13,000	Eastern Tropical Pacific	0.0197
Blue whale	0.0001	2,842	Eastern North Pacific	0.0287
Humpback whale	0.0004	1,391	Eastern North Pacific	0.0034
Killer whale	0.0002	8,500	Eastern Tropical Pacific	0.0116
Short-finned pilot whale	0.0058	160,200	Eastern Tropical Pacific	0.0288
Dwarf sperm whale	0.0145	11,200	Eastern Tropical Pacific	1.711
Pygmy killer whale	0.0014	38,900	Eastern Tropical Pacific	0.0316
Melon-headed whale	0.0174	45,400	Eastern Tropical Pacific	0.3324
False killer whale	0.0004	39,800	Eastern Tropical Pacific	0.0082
Sperm whale	0.0047	22,700	Eastern Tropical Pacific	0.1604
Longman's beaked whale	0.0003	25,300	Eastern Tropical Pacific	0.0112
Blainville's beaked whale	0.0013	25,300	Eastern Tropical Pacific	0.0502
Ginkgo-toothed beaked whale	0.0016	25,300	Eastern Tropical Pacific	0.0617
Pygmy beaked whale	0.0016	25,300	Eastern Tropical Pacific	0.0617
Cuvier's beaked whale	0.0025	20,000	Eastern Tropical Pacific	0.1204
Common dolphin	0.0490	3,127,203	Eastern Tropical Pacific	0.0153
Risso's dolphin	0.0161	110,457	Eastern Tropical Pacific	0.1724
Pantropical spotted dolphin	0.0669	640,000	Northeastern Offshore Pacific	0.0549
Striped dolphin	0.1199	964,362	Eastern Tropical Pacific	0.0653
Spinner dolphin	0.0070	450,000	Eastern	0.0082
Rough-toothed dolphin	0.0146	107,633	Eastern Tropical Pacific	0.1744
Bottlenose dolphin	0.0157	335,834	Eastern Tropical Pacific	0.0363
Fraser's dolphin	0.001	289,300	Eastern Tropical Pacific	0.0030

Table C-35. Estimates of the percentages of marine mammal stocks potentially affected for SURTASS LFA sonar potential OPAREA 19, Northeast Australia, in spring.

OPAREA 19 (SPRING): NORTHEAST AUSTRALIA COAST				
SPECIES	DENSITY (/KM^2)	# IN STOCK	STOCK	% STOCK AFFECTED <180 DB SPE
Common minke whale	0.0044	25,000	Western South Pacific	0.2466
Bryde's whale	0.0006	22,000	Western South Pacific	0.0389
Blue whale	0.0002	9,250	Western South Pacific	0.0311
Fin whale	0.0002	9,250	Western South Pacific	0.0392
Humpback whale inshore (<200 m)	0.0143	3,500	Group V East Australia	7.1143
Humpback whale offshore (>200 m)	0.0004	3,500	Group V East Australia	0.1990
Killer whale	0.0004	12,256	Western South Pacific	0.0594
Short-finned pilot whale	0.0153	53,608	Western South Pacific	0.5580
Long-finned pilot whale	0.0153	53,608	Western South Pacific	0.5580
Pygmy sperm whale	0.0031	350,553	Western South Pacific	0.0187
Dwarf sperm whale	0.0031	350,553	Western South Pacific	0.0187
Sperm whale	0.0029	102,112	Western South Pacific	0.0367
Pygmy killer whale	0.0021	30,214	Western South Pacific	0.1768
Melon-headed whale	0.0012	36,770	Western South Pacific	0.0830
False killer whale	0.0029	16,668	Western South Pacific	0.4427
Southern bottlenose whale	0.0005	22,799	Western South Pacific	0.0375
Longman's beaked whale	0.0005	22,799	Western South Pacific	0.0375
Blainville's beaked whale	0.0005	8,032	Western South Pacific	0.1065
Ginkgo-toothed beaked whale	0.0005	22,799	Western South Pacific	0.0375
Arnoux’s beaked whale	0.0005	22,799	Western South Pacific	0.0375
Cuvier's beaked whale	0.0054	90,725	Western South Pacific	0.1018
Common dolphin	0.0562	3,286,163	Western South Pacific	0.0265
Risso's dolphin	0.0106	83,289	Western South Pacific	0.2586
Fraser's dolphin	0.004	220,789	Western South Pacific	0.0280
Dusky dolphin	0.0002	12,626	Western South Pacific	0.0228
Pantropical spotted dolphin	0.0137	438,064	Western South Pacific	0.0400
Striped dolphin	0.0329	570,038	Western South Pacific	0.0738
Spinner dolphin	0.0005	1,015,059	Western South Pacific	0.0006
Rough-toothed dolphin	0.0059	145,729	Western South Pacific	0.0837
Bottlenose dolphin	0.0146	168,791	Western South Pacific	0.1438

C-4 LITERATURE CITED

Airoldi, S., F. Bendinoni, A. Azzellino, V. Fadda, and A. Profice. 2005. Abundance estimate of Risso's dolphins (*Grampus griseus*) in the western Ligurian Sea through photographic mark-recapture. Nineteenth Annual Conference of the European Cetacean Society, La Rochelle, France.

Allen, B.M., and R.P. Angliss. 2010. Alaska marine mammal stock assessments, 2009. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-206. 276 pages.

Alves, F., L. Freitas, and A. Dinis. 2006. Occurrence and diving behaviour of false killer whale off Madeira archipelago (NE Atlantic). ECS 2006. Gydnia, Poland.

Amano, M., and M. Yoshioka. 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. Marine Ecology Progress Series 258:291-295.

American Academy of Ophthalmology and Otolaryngology. 1969. Guide for conservation of hearing in noise.

Anderson, R.C., R. Clark, P. T. Madsen, C. Johnson, J. Kiszka, and O. Breysse. 2006. Observations of Longman's Beaked Whale (*Indopacetus pacificus*) in the Western Indian Ocean. Aquatic Mammals 32(2):223-231.

ANSI (American National Standard Institute). 2006. ANSI reference quantities for acoustical levels, ANSI-S1-8-1989, revised 2006. New York, New York: Acoustic Society of America.

Aoki, K., M. Amano, M. Yoshioka, K. Mori, D. Tokuda, and N. Miyazaki. 2007. Diel diving behavior of sperm whales off Japan Marine Ecology Progress Series 349:277-287.

Archer, F.I., II and W.F. Perrin. 1999. *Stenella coeruleoalba*. Mammalian Species 603:1-9.

Baba, N., A.I. Boltnev, and A.I. Stus. 2000. Winter migration of female northern fur seals *Callorhinus ursinus* from the Commander Islands. Bulletin of the National Research Institute of Far Seas Fisheries 37:39-44.

Bain, D.E., J.C. Smith, R. Williams, and D. Lusseau. 2005. Effects of Vessels on behavior of southern resident killer whales (*Orcinus* spp.). 15th Biennial Conference on the Biology of Marine Mammals.

Baird, R.W. 1994. Foraging behavior and ecology of transient killer whales (*Orcinus orca*). degree of Doctor of Philosophy in Biological Sciences, Simon Fraser University. 159 pages.

Baird, R.W. 2005. Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. Pacific Science 59(3):461-466.

Baird, R.W., A.D. Ligon, and S.K. Hooker. 2000. Sub-surface and night-time behavior of humpback whales off Maui, Hawaii: A preliminary report.

Baird, R.W., A.D. Ligon, S.K. Hooker, and A.M. Gorgone. 2001. Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawai'i. Canadian Journal of Zoology 79:988-996.

Baird, R.W., J.F. Borsani, M.B. Hanson, and P.L. Tyack. 2002. Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. Marine Ecology Progress Series 237:301-305.

Baird, R.W., M.B. Hanson, and L.M. Dill. 2005. Factors influencing the diving behaviour of fish-eating killer whales: sex differences and diel and interannual variation in diving rates. Canadian Journal of Zoology 83(2):257-267.

Baker, C.S., and L.M. Herman. 1989. The behavioral responses of summering humpback whales to vessel traffic: Experimental and opportunistic observations. Kewalo Basin Marine Mammal Laboratory, Honolulu, June, 1989.

Ballance, L.T,. and R.L. Pitman. 1998. Cetaceans of the western tropical Indian Ocean: Distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. Marine Mammal Science 14(3):429-459.

Barlow, J. 1995. The abundance of cetaceans in California waters: Part I. Ship surveys in summer and fall of 1991. U S National Marine Fisheries Service Fishery Bulletin 93(1):1-14.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464.

Barlow, J., and K. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin 105**:**509-526.

Barlow J., and S. Rankin. 2007. False killer whate abundance and density: Preliminary estimates for the Piceas study area south of Hawaii and new estimates for the EEZ around Hawaii. NOAA Southwest Fisheries Science Center, Administartive Report LJ-07-02. La Jolla, California

Barlow, J., M.C. Ferguson, W.F. Perrin, L. Balance, T. Gerrodette, G. Joyce, C.D. MacLeod, K. Mullin, D. L. Palka, and G. Waring. 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). Journal of Cetacean Research and Management 7(3):263-270.

Bauer, G.B., J.R. Mobley, A S. Frankel, D.A. Helweg, and L.M. Herman. 1995. Behavior characteristics of humpback whales in Hawaii. Eleventh Biennial conference on the Biology of Marine Mammals, Orlando, Florida.

Baumgartner, M.F., and B.R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. Marine Ecology-Progress Series 264:123-135.

Baumgartner, M.F., K.D. Mullin, L.N. May and T.D. Leming. 2001. Cetacean habitats in the northern Gulf of Mexico. Fishery Bulletin Seattle 99(2):219-239.

Benoit-Bird, K.J. and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (*Stenella longirostris*) over a range of spatial and temporal scales. Behavioral Ecology and Sociobiology 53(6):364-373.

Beranek, L.L. 1954. Acoustics. New York, New York: McGraw-Hill.

Best, P.B., J.L. Bannister, R.L. Brownell, Jr., and G.P. Donovan, Eds. 2001. Right whales: Worldwide status. Journal of Cetacean Research and Management (Special Issue 2)**:**1-309.

Bishop, G.C., W.T. Ellison, and L.E. Mellberg. 1987. A simulation model for high-frequency under-ice reverberation. Journal of the Acoustical Society of America 82(1):275-285.

Bowen, W., D. Boness and S. Iverson. 1999. Diving behaviour of lactating harbour seals and their pups during maternal foraging trips. Canadian Journal of Zoology 77:978-988.

Bowles, A.E., M. Smultea, B. Würsig, D.P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America 96(4):2469-2484.

Brown, S.G. 1977. Some results of sei whale marking in the southern hemisphere. Report of the International Whaling Commission Si1: 39-43.

Buck, J.R., and P.L. Tyack. 2000. Response of gray whales to low-frequency sounds. Journal of the Acoustical Society of America 107(5, pt. 2):2774-2774.

Buckland, S.T., K.L. Cattanach, and T. Miyashita. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. Report of the International Whaling Commission 42:387-392.

Buckland, S.T., K.L. Cattanach, and R.C. Hobbs. 1993a. Abundance estimates of Pacific white-sided dolphin, northern right whale dolphin, Dall's porpoise and northern fur seal in the North Pacific, 1987-1990. International North Pacific Fisheries Commission Bulletin 53:387-407.

Buckland, S.T., D. Bloch, K.L. Cattanach, T. Gunnlaugsson, K. Hoydal, S. Lens, and J. Sigurjónsson. 1993b. Distribution and abundance of long-finned pilot whales in the North Atlantic estimated from NASS-1987 and NASS-89 data. Report of the International Whaling Commission Special Issue 14:33-50.

Burgess, W.C., P.L. Tyack, B.J. LeBoeuf and D.P. Costa. 1998. A programmable acoustic recording tag and first results from free-ranging northern elephant seals. Deep Sea Research Part II: Topical Studies in Oceanography 45(7):1327-1351.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. Leduc, D. Mattila, L. Rojas-, J. M. S. Bracho, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. and J. H. Havron, and N. Maloney. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific. Final report for Contract AB133F-03-RP-00078. Report prepared for U.S. Dept of Commerce, Western Administrative Center, Seattle, Washington*:* Cascadia Research, Olympia, Washington.

Caldwell, D.K., M.C. Caldwell, and R.V. Walker. 1976. First records for Fraser's dolphin (*Lagenodelphis hosei*) in the Atlantic and the melon-headed whale (*Peponocephala electra*) in the western Atlantic. Cetology 25:4.

Cañadas, A. 2006. Towards conservation of dolphins in the Alborán Sea. Ph.D. Dissertation, Departmento de Zoologia, Universidad Autónoma de Madrid.

Cañadas, A., R. Sagarminaga, and T.S. Garcia. 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. Deep Sea Research Part I Oceanographic Research Papers 49(11):2053-2073.

Cañadas, A., G. Desportes, and D. Borchers. 2004. The estimation of the detection function and g(0) for short-beaked common dolphins (*Delphinus delphis*), using double-platform data collected during the NASS-95 Faroese survey. Journal of Cetacean Research and Management 6(2):191-198.

Cañadas, A. and P.S. Hammond. 2006. Model-based abundance estimates for bottlenose dolphins off southern Spain: Implications for conservation and management. Journal of Cetacean Research and Management 8(1):13-27.

Carretta, J. V., K.A. Fornery, M.S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, M.M. Muto, D. Lynch, and L. Carswell. 2010. U.S. Pacific marine mammal stock assessments: 2009. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-434*.* La Jolla, California: Southwest Fisheries Science Center, National Marine Fisheries Science Center.

Charif, R.A., D.K. Mellinger, K.J. Dunsmore, and C.W. Clark. 2002. Estimated source levels of fin whale *(Balaenoptera physalus)* vocalizations: Adjustments for surface interference. Marine Mammal Science 18(1):81-98.

Chaudry, F.A. 2006. A comparison of east Australian humpback whale migratory behaviour between the northern and southern migrations. ECS 2006*.* Gydnia, Poland.

Chittleborough, R.G. 1953. Aerial observations of the humpback whale (*Megaptera nodosa*). Australian Journal of Marine and Freshwater Research 4:219-226.

Chu, K.C. 1988. Dive times and ventilation patterns of singing humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology 66(6):1322-1327.

Clapham, P. J. 1993. Social organization of humpback whales on a North Atlantic feeding ground. Symposium of the Zoological Society of London 66:131-145.

Clark, C.W., P. Tyack, and W.T. Ellison. 1999 (Revised 2001). Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar Technical Report 1: Low Frequency Sound Scientific Research Program Technical Report (Responses of Four Species of Whales to Sounds of SURTASS LFA Sonar Transmissions). For the Department of the Navy. February 1999 (Revised January 2001).

Coakes, A.K. and H. Whitehead. 2004. Social structure and mating system of sperm whales off northern Chile. Canadian Journal of Zoology 82(8):1360-1369.

Crocker, M.J. 1997. Encyclopedia of acoustics. New York, New York: John Wiley & Sons, Inc.

Crocker, D.E., B.J. Le Boeuf, Y. Naito, T. Asaga, and D.P. Costa. 1994. Swim speed and dive function in a female northern elephant seal. Pages 328-339 in B. J. Le Boeuf and R. M. Laws, eds. Elephant seals: Population ecology, behavior, and physiology. Berkeley, California: University of California Press.

Crocker, D. E., D. P. Costa, B. J. L. Boeuf, P. M. Webb, and D. S. Houser. 2006. Impact of El Niño on the foraging behavior of female northern elephant seals. Marine Ecology Progress Series 309:1-10.

Croll, D.A., A. Acevedo-Gutierrez, B.R. Tershy, and J. Urban-Ramirez. 2001a. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology 129(4):797-809.

Croll, D.A., C.W. Clark, J. Calambokidis, W.T. Ellison, and B.R. Tershy. 2001b. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4**:**13-27.

Croll, D. A., B. R. Tershy, R. P. Hewitt, D. A. Demer, P. C. Fiedler, S. E. Smith, W. Armstrong, J. M. Popp, T. Kiekhefer, V. R. Lopez, J. Urban, and D. Gendron. 1998. An integrated approach to the foraging ecology of marine birds and mammals. Deep Sea Research II 45: 1353-1371.

Cruickshank, R. A., and S. G. Brown. 1981. Recent observations and some historical records of southern right-whale dolphins *Lissodelphis peronii*. Fish. Bull. S. Afr. 15: 109-121.

Cummings, W. C. 1985. Bryde's whale *Balaenoptera edeni* Anderson, 1878. Pages 137-154 *in* S. H. Ridgway and R. Harrison, eds. Handbook of marine mammals, Vol. 3: The sirenians and baleen whales. London: Academic Press.

Curren, K., N. Bose, and J. Lien. 1994. Swimming kinematics of a harbor porpoise (*Phocoena phocoena*) and an Atlantic white-sided dolphin (*Lagenorhynchus acutus*). Marine Mammal Science 10(4):485-492.

Dahlheim, M.E., and R.G. Towell. 1994. Occurrence and distribution of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) in southeastern Alaska, with notes on an attack by killer whales (*Orcinus orca*). Marine Mammal Science 10(4):458-464.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K.Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Marine Mammal Science 14(3):490-507.

Davis, R.W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino, and W. Gilly. 2007. Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico. Marine Ecology Progress Series 333:291-302.

Davis, R.W., G.A.J. Worthy, B. Würsig, S.K. Lynn, and F.I. Townsend. 1996. Diving behavior and at-sea movements of an Atlantic spotted dolphin in the Gulf of Mexico. Marine Mammal Science 12(4):569-581.

de Haro, J.C., and M.A. Iniguez. 1997. Ecology and behaviour of the Peale's dolphin, *Lagenorhynchus australis* (Peale, 1848), at Cabo Virgenes (52° 30'S, 68° 28'W), in Patagonia, Argentina. Report of the International Whaling Commission 47:723-727.

Department of the Environment and Heritage. 2005. Humpback whale recovery plan 2005-2010. Wildlife Conservation Branch, Department of the Environment and Heritage, Canberra, Australia. <http://www.deh.gov.au/biodiversity/threatened/recovery/list-common.html>.

Doi, T. 1974. Further development of whale sighting theory. Pages 359-368 in W.E. Schevill, ed. The Whale Problem: A status report. Cambridge, Massachusetts: Harvard University Press.

Dolar, L., and W. Perrin. 2003. Dwarf sperm whale (*Kogia sima*) habitats in the Philippines. Pages 44 15th Biennial conference on the biology of marine mammals. Greensboro, NC.

Dolar, M.L.L., W.A. Walker, G.L. Kooyman, and W.F. Perrin. 2003. Comparative feeding ecology of spinner dolphins (*Stenella longirostris*) and Fraser's dolphins (*Lagenodelphis hosei*) in the Sulu Sea. Marine Mammal Science 19(1):1-19.

Dolar, M.L.L., W.F. Perrin, B.L. Taylor, G.L. Kooyman, and M.N.R. Alava. 2006. Abundance and distributional ecology of cetaceans in the central Philippines. Journal of Cetacean Research and Management 8(1):93-111.

Dolphin, W.F. 1987a. Dive behavior and estimated energy expenditure of foraging humpback whales in southeast Alaska. Canadian Journal of Zoology 65(2):354-362.

Dolphin, W.F. 1987b. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology 65(1):83-90.

Dolphin, W.F. 1988. Foraging dive patterns of humpback whales *Megaptera novaeangliae* in Southeast Alaska USA: A cost-benefit analysis. Canadian Journal of Zoology 66(11):2432-2441.

DoN (U.S. Department of the Navy). 2001. Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Washington, D.C: Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2007a. Final supplemental environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Washington, D.C: Department of the Navy, Chief of Naval Operations.

DoN (Department of the Navy). 2007b. Navy OPAREA Density Estimates (NODE) for the Northeast OPAREAs: Boston, Narragansett Bay, and Atlantic City. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic.

DoN (Department of the Navy). 2008a. Hawaii Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). Pacific Missile Range Facility. Kekaha Kauai, Hawaii. May 2008.

DoN (Department of the Navy). 2008b. Southern California (SOCAL) Range Complex Final Environmental Impact Statement/ Overseas Environmental Impact Statement. Naval Facilities Engineering Command Southwest. San Diego, California.

DoN (Department of the Navy). 2008c. Final Atlantic Fleet Active Sonar Training Environmental Impact Statement/ Overseas Environmental Impact Statement. United States Fleet Forces Command. Norfolk, Virginia.

Edwards, E.F. 2006. Duration of unassisted swimming activity for spotted dolphin (*Stenella attenuata*) calves: implications for mother-calf separation during tuna purse-seine sets. Fishery Bulletin 104(1):125-135.

Eguchi, T. and J.T. Harvey. 2005. Diving behavior of the Pacific harbor seal (*Phoca vitulina richardii*) in Monterey Bay, California. Marine Mammal Science 21(2):283-295.

Ellison, W.T., R.M. Sonntag and C.W. Clark. 1987. Comparison of measured bowhead whale, *Balaena mysticetus*, migration parameters with results from the tracking algorithm. Reports of the International Whaling Commission 37:309-311.

Evans, W.E. 1994. Common Dolphin, white bellied porpoise (*Delphnis delphis*, LInnaeus, 1758). Pages 191-224 *in* S. Ridgway and R. Harrison, eds. Handbook of Marine Mammals. Academic Press.

Feldkamp, S.D., R.L. Delong, and G.A. Antonelis. 1989. Diving patterns of California sea lions, *Zalophus californianus*. Canadian Journal of Zoology 67(4):872-883.

Feller, W. 1968. Introduction to probability theory and its application. Volume 1. 3rd ed. New York, New York: John Wiley & Sons.

Ferguson, M.C., and J. Barlow. 2001. Spatial distribution and density of cetaceans in the eastern Pacific Ocean based on summer/fall research vessel surveys in 1986-96. NOAA Administrative Report LJ-01-04. NOAA, NMFS, SWFSC, La Jolla, California.

Ferguson, M.C., and J. Barlow. 2003. Addendum: Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Administrative Report LJ-01-04 (Addendum). Southwest Fisheries Science Center, National Marine Fisheries Service.

Fertl, D., T.A. Jefferson , I.B. Moreno, A.N. Zerbini, and K.D. Mullin. 2003. Distribution of the Clymene dolphin *Stenella clymene*. Mammal Review 33(3-4):253-271.

Finley, K.J., G.W. Miller, R.A. Davis, and C.R. Greene. 1990 Reactions of belugas, *Delphinapterus leucas,* and narwhals, *Monodon monoceros,* to ice-breaking ships in the Canadian high arctic. Canadian Bulletin of Fisheries and Aquatic Science 224:97-117.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010a. Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. Journal of the Acoustical Society of America 127(5):3267-3272.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010b. Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. Journal of the Acoustical Society of America 127(5):3256-3266.

Fish, F. E. and J. J. Rohr. 1999. Review of dolphin hydrodynamics and swimming performance. SPAWAR.

Forcada, J., and P.S. Hammond. 1998. Geographical variation in the abundance of striped and common dolphins of the western Mediterranean. Journal of Sea Research 39:313-325.

Forcada, J., G. Notarbartolo di Sciara, and F. Fabbri. 1995. Abundance of fin whales and striped dolphins in the Corso-Ligurian Basin. Mammalia 59(1):127-140.

Forcada, J., A. Aguilar, P.S. Hammond, X. Pastor, and R. Aguilar. 1996. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the western Mediterranean Sea during the summer. Journal of Zoology, London 238:23-34.

Forcada, J., M. Gazo, A. Aguilar, J. Gonzalvo, and M. Fernandez-Contreras. 2004. Bottlenose dolphin abundance in the northwest Mediterranean: Addressing heterogeneity in distribution. Marine Ecology Progress Series 275:275-287.

Ford, J.K.B., G.A. Ellis, D.R. Matkin, K.C. Balcomb, D. Briggs, and A.B. Morton. 2005. Killer whale attacks on minke whales: Prey capture and antipredator tactics. Marine Mammal Science 21(4):603-618.

Frankel, A.S., C.W. Clark, L.M. Herman, and C.M. Gabriele. 1995. Spatial distribution, habitat utilization, and social interactions of humpback whales, *Megaptera novaeangliae*, off Hawai'i, determined using acoustic and visual techniques. Canadian Journal of Zoology 73:1134-1146.

Fristrup, K.M., L.T. Hatch, and C.W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. The Journal of the Acoustical Society of America 113(6):3411-3424.

Fulling, G.L., P.H. Thorson, and J. Rivers. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science 65(3):321-343.

Gabriele, C.M., J.M. Straley, L.M. Herman, and R.J. Coleman. 1996. Fastest documented migration of a North Pacific humpback whale. Marine Mammal Science 12(3):457-464.

Gannier, A. 1997. Estimation de l'abondance estivale du rorqual commun *Balaenoptera physalus* (Linné, 1758) dans le basin Liguro-Provençal (Méditerranée occidentale) (Abundance estimates of the fin whale *Balaenoptera physalus* (Linné, 1758) in the Ligurian-Provençal Basin (western Mediterranean)). Revue d'Ecologie: La Terre et la Vie 52:69-86.

Gannier, A., and K.L. West. 2005. Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands (French Polynesia). Pacific Science 59(1):17-24.

Gentry, R.L. 2002. Northern fur seal *Callorhinus ursinus*. Pages 813-817 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Francisco, California: Academic Press.

Gentry, R.L., G.L. Kooyman, and M.E. Goebel. 1986. Feeding and diving behavior of northern fur seals. Pages 61-78 in R.L. Gentry and G.L. Kooyman, eds. Fur seals: Maternal strategies on land and at sea. Princeton, New Jersey: Princeton University Press.

Gerondeau, M., C. Barbraud, V. Ridoux, and C. Vincent. 2007. Abundance estimate and seasonal patterns of grey seal (*Halichoerus grypus*) occurrence in Brittany, France, as assessed by photo-identification and capture-mark-recapture. Journal of the Marine Biological Association of the United Kingdom 87(1):365-371.

Gerrodette, T., and J. Forcada. 2005. Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. Marine Ecology Progress Series 291:1-21.

Gerrodette, T., G. Watters, W. Perryman, and L. Ballance. 2008. Estimates of 2006 dolphin abundance in the eastern tropical Pacific, with revised estimates from 1986-2003. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-422. LaJolla, California: Southwest Fisheries Science Center, National Marine Fisheries Service.

Gill, P.C. 2002. A blue whale (*Balaenoptera musculus*) feeding ground in a southern Australian coastal upwelling zone. Journal of Cetacean Research and Management 4(2):179-184.

Gjertz, I., C. Lydersen and O. Wiig. 2001. Distribution and diving of harbor seals (*Phoca vitulina*) in Svalbard. Polar Biology 24(3):209-214.

Goebel, M.E., J.L. Bengston, R.L. DeLong, R.L. Gentry, and T.R. Loughlin. 1991. Diving patterns and foraging locations of female northern fur seals. Fishery Bulletin 89:171-179.

Goldbogen, J., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald, and J. A. Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. Journal of Experimental Biology 209(7):1231-1244.

Gómez de Segura, A., E.A. Crespo, S.N. Pedraza, P.S. Hammond, and J.A. Raga. 2006. Abundance of small cetaceans in waters of the central Spanish Mediterranean. Marine Biology 150:149-160.

Gunnlaugsson, T. and J. Sigurjónsson. 1990. NASS-87: Estimation of whale abundance based on observations made onboard Icelandic and Faroese survey vessels. Report of the International Whaling Commission 40:571-580.

Hammond, P.S., P. Berggren, H. Benke, D. L. Borchers, A.S. Collet, M.P. Heide-Jørgensen, S.L. Heimlich, A.R. Hiby, M.F. Leopold, and N. Øien. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology 39(2):361-376.

Hanson, M.B., and R.W. Baird. 1998. Dall's porpoise reactions to tagging attempts using a remotely-deployed suction-cup attached tag. Marine Technology Society Journal 32(2):18-23.

Harris, C.M., ed. 1998. Handbook of acoustical measurements and noise control. Woodbury, New York: Acoustical Society of America.

Harzen, S. E. 2002. Use of an electronic theodolite in the study of movements of the bottlenose dolphin (*Tursiops truncatus*) in the Sado Estuary, Portugal. Aquatic Mammals 28(3):251-260.

Hastings, K.K., K.J. Frost, M.A. Simpkins, G.W. Pendleton, U.G. Swain, and R.J. Small. 2004. Regional differences in diving behavior of harbor seals in the Gulf of Alaska. Canadian Journal of Zoology 82(11):1755-1773.

Heath, C.B. 2002. California, Galapagos, and Japanese Sea Lions. Pages 108-186 *in* W.F. Perrin, B. Wursig and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Francisco, California: Academic Press.

Heide-Jørgensen, M.P., D. Bloch, E. Stefansson, B. Mikkelsen, L.H. Ofstad, and R. Dietz. 2002. Diving behaviour of long-finned pilot whales *Globicephala melas* around the Faroe Islands. Wildlife Biology 8(4):307-313.

Heide-Jørgensen, M.P., M.J. Simon, and K.L. Laidre. 2007. Estimates of large whale abundance in Greenland waters from a ship-based survey in 2005. Journal of Cetacean Research and Management 9(2):95-104.

Heyning, J.E., and W.F. Perrin. 1994. Evidence for two species of common dolphins (genus *Delphinus*) from the eastern North Pacific. Contributions in Science 442:1-35.

Higgins, L.V., D.P. Costa, A.C. Huntley, and B.J. Le Boeuf. 1988. Behavioral and physiological measurements of the maternal investment in the Steller sea lion, *Eumetopias jubatus*. Marine Mammal Science 4(1):44-58.

Hobson, R.P., and A.R. Martin. 1996. Behaviour and dive times of Arnoux's beaked whales, *Berardius arnuxii*, at narrow leads in fast ice. Canadian Journal of Zoology 74(2):388-393.

Hohn, A., M. Scott, A. Westgate, J. Nicolas and B. Whitaker. 1995. Radiotracking of a rehabilitated pygmy sperm whale. Pages 55 Eleventh biennial conference on the biology of marine mammals. Orlando, Florida.

Hooker, S.K., and R.W. Baird. 1999a. Deep-diving behaviour of the northern bottlenose whale, *Hyperoodon ampullatus* (Cetacea: Ziphiidae). Proceedings of the Royal Society of Biological Sciences: Series B 266(1420):671-676.

Hooker, S.K. and R.W. Baird. 1999b. Observations of Sowerby's beaked whales, *Mesoplodon bidens*, in the Gully, Nova Scotia. Canadian Field-Naturalist 113(2):273-277.

Hui, C.A. 1987. Power and speed of swimming dolphins. Journal of Mammalogy 68(1): 26-132.

IWC (International Whaling Commission). 2009. Population estimates. <http:www.iwcoffice.org/conservation/estimate.htm>.

Jaquet, N., and D. Gendron. 2002. Distribution and relative abundance of sperm whales in relation to key environmental features, squid landings and the distribution of other cetacean species in the Gulf of California, Mexico. Marine Biology 141(3):591-601.

Jaquet, N., and H. Whitehead. 1999. Movements, distribution and feeding success of sperm whales in the Pacific Ocean, over scales of days and tens of kilometers. Aquatic Mammals 25(1): 1-13.

Jaquet, N., S. Dawson, and E. Slooten. 2000. Seasonal distribution and diving behaviour of male sperm whales off Kaikoura: Foraging implications. Canadian Journal of Zoology 78(3):407-419.

Jefferson, T.A. 1987. A study of the behavior of Dall's porpoise (*Phocoenoides dalli*) in the Johnstone Strait, British Columbia. Canadian Journal of Zoology 65(3): 736-744.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N. Aguilar de Soto, and P.L. Tyack. 2004. Beaked whales echolocate on prey. Proceedings of the Royal Society of London Series B-Biological Sciences 271:S383-S386.

Joyce, G., N. Øien, J. Calmabokidis, and J.C. Cubbage. 1989. Surfacing rates of minke whales in Norwegian waters. Reports of the International Whaling Commission 39: 431-434.

Kaschner, K., J.S. Ready, E. Agbayani, J. Rius, K. Kesner-Reyes, P.D. Eastwood, A.B. South, S.O. Kullander, T. Rees, C.H. Close, R. Watson, D. Pauly, and R. Froese. 2008. AquaMaps: Predicted range maps for aquatic species. World wide web electronic publication, <www.aquamaps.org>, Version 10/2008.

Kastelein, R.A., and N.M. Gerrits. 1991. Swimming, diving, and respiration patterns of a northern bottlenose whale (*Hyperoodon ampullatus*, Forster, 1770). Aquatic Mammals 17(1):20-30.

Kasuya, T. 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. Scientific Report of the Whales Research Institute 37:61-83.

Kasuya, T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. Scientific Report of the Whales Research Institute 39:31-75.

Kato, H., and T. Miyashita. 1998. Current status of North Pacific sperm whales and its preliminary abundance estimates. Report submitted to the International Whaling Commission (SC/50/CAWS/52). 6 pages.

Kenney, R.D., and H.E. Winn. 1986. Cetacean high-use habitats of the northeast United States continental shelf. Fishery Bulletin 84(2):345- 357.

Ketten, D.R. 1997. Structure and function in whale ears. Bioacoustics 8:103-135.

Kooyman, G.L., and H.T. Andersen. 1969. Deep diving. Pages 65-94 in H.T. Andersen, ed. Biology of marine mammals. San Diego, California: Academic Press.

Kooyman, G.L. and F. Trillmich. 1986. Diving Behavior of Galapagos fur seals. Pages 186-195 *in* R.L. Gentry, and G.L. Kooyman, eds. Fur seals: maternal strategies on land and at sea. Princeton, New Jersey: Princeton University Press.

Kopelman, A.H. and S.S. Sadove. 1995. Ventilatory rate differences between surface-feeding and non-surface-feeding fin whales (*Balaenoptera physalus*) in the waters off eastern Long Island, New York, U.S.A., 1981-1987. Marine Mammal Science 11(2):200-208.

Kriete, B. 2002. Bioenergetic changes from 1986 to 2001 in the southern resident killer whale population, *Orcinus orca*. Orca Relief Citizens' Alliance.

Kryter, K.D. 1985. The effects of noise on man, 2nd edition. Orlando, FLorida: Academy Press. 688 pages.

Kryter, K.D., W.D. Ward, J.D. Miller, and D.H. Eldredge. 1966. Hazardous exposure to intermittent and steady-state noise. Journal of the Acoustical Society of America 39(3):451-464.

Lagerquist, B.A., K.M. Stafford, and B.R. Mate. 2000. Dive characteristics of satellite-monitored blue whales (*Balaenoptera musculus*) off the central California coast. Marine Mammal Science 16(2):375-391.

Laurie, A.H. 1933. Some aspects of respiration in fin and blue whales. Discovery Reports 7: 365-406.

Law, T.C., and R.W. Blake. 1994. Swimming behaviors and speeds of wild Dall's porpoises (*Phocoenoides dalli*). Marine Mammal Science 10(2):208-213.

Le Boeuf, B.J. 1994. Variation in the diving pattern of northern elephant seals with age, mass, sex, and reproductive condition. Pages 237-252 in B.J. Le Boeuf, and R.M. Laws, eds. Elephant Seals: Population ecology, behavior, and physiology. Berkeley, California: University of California Press.

Le Boeuf, B.J., D.P. Costa, A.C. Huntley, and S.D. Feldkamp. 1988. Continuous, deep diving in female northern elephant seals, *Mirounga angustirostris*. Canadian Journal of Zoology 66:446-458.

Le Boeuf, B.J., Y. Naito, A.C. Huntley, and T. Asaga. 1989. Prolonged, continuous, deep diving by northern elephant seals. Canadian Journal of Zoology 67:2514-2519.

Leatherwood, S., and D.K. Ljungblad. 1979. Nighttime swimming and diving behavior of a radio -tagged spotted dolphin *Stenella attenuata*. Cetology 34:1-6.

Leatherwood, S., and W.A. Walker. 1979. The northern right whale dolphin *Lissodelphis borealis* Peale in the eastern north pacific. Pages 85-141 in Behavior of marine animals: Current perspectives in research. Plenum: H. E. Winn, B. L. Olba.

Leatherwood, S., W.F. Perrin, V.L. Kirby, C.L. Hubbs, and M. Dahlheim. 1980. Distribution and Movements of Risso's Dolphin *Grampus griseus* in the Eastern North Pacific. Fishery Bulletin Washington D C 77(4):951-964.

Leibiger, G.A. 1978. The acoustic propagation model RAYMODE: Theory and numerical treatment. U.S. Naval Underwater Systems Center (NUSC), New London, Connecticut.

Lesage, V., M.O. Hammill, and K.M. Kovacs. 1999. Functional classification of harbor seal (*Phoca vitulina*) dives using depth profiles, swimming velocity, and an index of foraging success. Canadian Journal of Zoology 77(1):74-87.

Ligon, A.D., and R.W. Baird. 2001. Diving behaviour of false killer whales off Maui and Lana'i, Hawai'i. 14th Biennial Conference on the Biology of Marine Mammals. Vancouver.

Lockyer, C. 1976. Body Weights of Some Species of Large Whales. J. Cons. int. Explor. Mer. 36(3):259-273.

Lockyer, C. 1997. Diving behaviour of the sperm whale in relation to feeding. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique Biologie 67(SUPPL):47-52.

Lockyer, C., and R. Morris. 1987. Observations on diving behavior and swimming speeds in a wild juvenile *Tursiops truncatus*. Aquatic Mammals 13(1):31-35.

Lockyer, C., and R.J. Morris. 1986. The history and behavior of a wild, sociable bottlenose dolphin (*Tursiops truncatus*) off the north coast of Cornwall (England, UK). Aquatic Mammals 12(1):3-16.

Loughlin, T.R. 1982. Observations of *Mesoplodon stejnegeri* in the central Aleutian Islands, Alaska. Journal of Mammalogy 63(3):697-700.

MacLeod, C.D., and A.F. Zuur. 2005. Habitat utilization by Blainville's beaked whales off Great Abaco, northern Bahamas, in relation to seabed topography. Marine Biology 147(1):1-11.

MacLeod, K., M.P. Simmonds, and E. Murray. 2006. Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management 8(3):247-254.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior, Phase I. BBN Report 563. Report from Bolt, Beranek, & Newman, Inc., Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, Alaska.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior, Phase II: January 1984 migration. BBN Report 586. Report from Bolt, Beranek, & Newman, Inc., Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, Alaska.

Markowitz, T.M. 2004. Social organization of the New Zealand dusky dolphin. Ph.D. dissertation, Texas A&M University, Galveston, TX. 278 pages.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Report of the International Whaling Commission Special Issue 1:71-79.

Mate, B.R. and J.T. Harvey. 1984. Ocean Movements of Radio--tagged Gray Whales. Pages 577-589 The Gray Whale. London: Academic Press.

Mate, B.R., K.M. Stafford, R. Nawojchik, and J.L. Dunn. 1994a. Movements and dive behavior of a satellite-monitored Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the Gulf of Maine. Marine Mammal Science 10(1):116-121.

Mate, B.R., K.M. Stafford, and D.K. Ljungblad. 1994b. A change in sperm whale distribution correlated to seismic surveys in the Gulf of Mexico. Journal of the Acoustical Society of America 96(5, pt. 2):3268-3269.

Mate, B.R., K.A. Rossbach, S.L. Nieukirk, R.S. Wells, A.B. Irvine, M.D. Scott, and A.J. Read. 1995. Satellite-monitored movements and dive behaviour of a bottlenose dolphin (*Tursiops truncatus*) in Tampa Bay, Florida. Marine Mammal Science 11(4):452-463.

Mate, B.R., S.L. Nieukirk, and S. D. Kraus. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61(4):1393-1405.

Mate, B.R., R. Gisiner, and J. Mobley. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology 76:863-868.

Mate, B.R., B.A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. Marine Mammal Science 15(4): 1246-1257.

Mate, B.R., B.A. Lagerquist, M. Winsor, J. Geraci, and J.H. Prescott. 2005. Movements and dive habits of a satellite-monitored longfinned pilot whale (*Globicephala melas*) in the northwest Atlantic. Marine Mammal Science 21(1):136-144.

May-Collado, L., and A.M. Ramirez. 2005. Occurrence and behavioral patterns of the spotted coastal dolphin *Stenella attenuata* (Cetacea : Delphinidae) in the Gulf of Papagayo, Costa Rica. Revista De Biologia Tropical 53(1-2):265-276.

May-Collado, L., T. Gerrodette, J. Calambokidis, K. Rasmussen, and I. Sereg. 2005. Patterns of cetacean sighting distribution in the Pacific Exclusive Economic Zone of Costa Rica based on data collected from 1979-2001. Revista De Biologia Tropical 53(1-2):249-263.

Melin, S.R. and R.L. DeLong. 1999. Observations of a Guadalupe fur seal (*Arctocephalus townsendi*) female and pup at San Miguel Island, California. Marine Mammal Science 15(3):885-888.

Merrick, R.L., and T.R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. Canadian Journal of Zoology 75:776-786.

Merrick, R.L., T.R. Loughlin, G.A. Antonelis, and R. Hill. 1994. Use of satellite-linked telemetry to study Steller sea lion and northern fur seal foraging. Polar Research 13(1):105-114.

Miller, P.J.O., N. Biassoni, A. Samuels, and P.L. Tyack. 2000. Whales songs lengthen in response to sonar. Nature 405:903.

Miller, P.J.O., M.P. Johnson, P.L. Tyack, and E.A. Terray. 2004. Swimming gaits, passive drag and buoyancy of diving sperm whales *Physeter macrocephalus*. Journal of Experimental Biology 207(11):1953-1967.

Minton, G., T. Collins, C. Pomilla, K. P. Findlay, H. Rosenbaum, R. Baldwin, and R. L. Brownell, Jr. 2008. *Megaptera novaeangliae* (Arabian Sea subpopulation). IUCN Red List of Threatened Species. Version 2009.1. <http://www.iucnredlist.org>.

Minton, G., T. Collins, K.P. Findlay, P.J. Ersts, H. Rosenbaum, P. Berggren, and R. Baldwin. In Press. Seasonal distribution, abundance, habitat use and population identity of humpback whales in Oman. Journal of Cetacean Research and Management.

Miyashita, T. 1986. Population estimates of dolphins using research vessels data. Pages 202-213 in T. Tamura, S. Ohsumi, and S. Arai, eds. Report of the investigation in search of resolution of the dolphin-fishery conflict in the Iki Island area. Tokyo, Japan: The Investigating Committee.

Miyashita, T. 1993. Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery. Reports of the International Whaling Commission 43:417-437.

Miyazaki, N., and W. F. Perrin. 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). Pages 1-21 in S.H. Ridgway, and R. Harrison, eds. Handbook of marine mammals, Volume 5: The first book of dolphins. London: Academic Press.

Miyazaki, N., and S. Wada. 1978. Frasers Dolphin *Lagenodelphis hosei* in the Western North Pacific. Scientific Reports of the Whales Research Institute Tokyo (30): 231-244.

Mobley, J.R., Jr., and L.M. Herman. 1985. Transience of social affiliations among humpback whales (*Megaptera novaeangliae*) on the Hawaiian wintering grounds. Canadian Journal of Zoology 63: 762-772.

Mobley, J.R., Jr., S. S. Spitz, K. A. Forney, R. Grotefendt and P. H. Forestell. 2000. Distribution and abundance of odontocete species in Hawaiian waters: Preliminary results of 1993-98 aerial surveys. NMFS-SWFSC Administrative Report LJ-00-14C:1-26.

Morris, C., and U. Tscherter. 2006. Site fidelity of individual minke whales (*Balaenoptera acutorostrata*) in the St. Lawrence estuary. ECS 2006. Gydnia, Poland.

Mullin, K. D., and G. L. Fulling. 2003. Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin 101(3):603-613.

Mullin, K. D., W. Hoggard and L. J. Hansen. 2004. Abundance and seasonal occurence of cetaceans in outer continental shelf and slope waters of the North-central and Northwestern Gulf of Mexico. Gulf of Mexico Science 1: 62-73.

NAMMCO (North Atlantic Marine Mammal Commission). 2006. Report of the Fourteenth Meeting of the NAMMCO Scientific Committee. NAMMCO, Reykjavik, Iceland.

NARWC (North Atlantic Right Whale Consortium). 2009. North Atlantic right whale report card for 1 November 2007 to 30 April 2009. International Whaling Commission's Scientific Committee Report #SC/61/BRG11.National Marine Fisheries Service (NMFS). 2008. Office of Protected Resources Letter to Chief of Naval Operations (N45). Jan 31, 2008.

Nawojchik, R., D. J. St Aubin and A. Johnson. 2003. Movements and dive behavior of two stranded, rehabilitated long-finned pilot whales (*Globicephala melas*) in the northwest Atlantic. Marine Mammal Science 19(1): 232-239.

Nerini, M. 1984. A Review of Gray Whale Feeding Ecology. Pages 423-448 *in* M. Jones, Swartz, S., and Leatherwood, S., ed. The Gray Whale. Orlando, FL: Academic Press, Inc.

Neufeldt, V. (ed). 1997. Webster's New World College Dictionary, 3rd Edition. Simon & Schuster, Inc., NY, NY.

Neves, H. C. 1998. Preliminary findings on the feeding behaviour and general ecology strategy of the mediterranean monk seal *Monachus monachus* - (Pinnipedia: monachinae) on the Desertas islands. Boletim do Museu Municipal do Funchal 5(SUPPL. 5 PART A): 263-271.

NGDC (National Geophysical Data Center). 2006. 2-minute gridded global relief data (ETOPO2v2). National Oceanic and Atmospheric Administration. <http://www.ngdc.noaa.gov/mgg/fliers/06mgg01.html>.

Nishiwaki, M. 1972. General biology. Pages 3-204 *in* S. H. Ridgway, ed. Mammals of the sea: Biology and medicine. Charles C. Thomas.

Norris, K.S., and T.P. Dohl. 1980. Behavior of the Hawaiian Spinner Dolphin, *Stenella longirostris*. Fishery Bulletin 77(4): 821-849.

Norris, K. S. and J. H. Prescott. 1961. Observations on Pacific cetaceans of Californian and Mexican waters. University of California Publications in Zoology 63: 291-402.

Nøttestad, L., A. Ferno and B. E. Axelsen. 2002. Digging in the deep: Killer whales' advanced hunting tactic. Polar Biology 25(12): 939-941.

Nowacek, D. P., M. P. Johnson and P. L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London Series B-Biological Sciences 271(1536): 227-231.

Nowacek, D. P., L. H. Thorne, D. W. Johnston and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2): 81-115.

NRC (National Research Council). 1994. Low-frequency sound and marine mammals: Current knowledge and research needs. Washington, D.C.: National Academy Press.

NRC (National Research Council). 2000. Marine mammals and low-frequency sound progress since 1994. Committee on low-frequency sound and marine mammals. Report to U.S. Office of Naval Research Contract No. N00014-92-J-1560/R. Washington, D.C: National Academy Press.

OAML. 2000. Database description for the General Digital Enviornmental Model - Variable Resolution (GDEM-V) Version 2.5.

Ohsumi, S. 1977. Bryde's whales in the pelagic whaling ground of the North Pacific. Report of the International Whaling Commission Special Issue 1:140-149

Øien, N. I. 2008. Distribution and abundance of large whales in Norwegian and adjacent waters based on ship surveys 1995-2001. NAMMCO Scientific Publications 7:31-47.

Øien, N., L. Folkow and C. Lydersen. 1990. Dive Time Experiments On Minke Whales in Norwegian Waters During the 1988 Season. Reports of the International Whaling Commission 40: 337-341.

Olavarria, C., L. A. Aguayo and R. Bernal. 2001. Distribution of Risso's dolphin (*Grampus griseus*, Cuvier 1812) in Chilean waters. Revista de Biologia Marina y Oceanografia 36(1): 111-116.

Olsen, E. and J. C. Holst. 2001. A note on common minke whale (*Balaenoptera acutorostrata*) diets in the Norwegian Sea and the North Sea. Journal of Cetacean Research and Management 3(2): 179-183.

Olsen, E., W.P. Budgell, E. Head, L. Kleivane, L. Nøttestad, R. Prieto, M.A. Silva, H. Skov, G.A. Víkingsson, G. Waring, and N. Øien. 2009. First satellite-tracked long-distance movement of a sei whale (*Balaenoptera borealis*) in the North Atlantic. Aquatic Mammals 35:313-318.

Otani, S. 2000. Diving behavior and swimming speed of a free-ranging harbor porpoise, *Phocoena phocoena*. Marine Mammal Science 16(4): 811-814.

Panigada, S., M. Zanardelli, S. Canese and M. Jahoda. 1999. How Deep Can Baleen Whales Dive? Marine Ecology Progress Series 187: 309-311.

Panigada, S., G. Nortarbartolo di Sciara, M. Panigada, S. Airoldi, J. Borsani and M. Jahoda. 2005. Fin whales (*Balaenoptera physalus*) summering in the Ligurian Sea: distribution, encounter rate, mean group size and relation to physiographic variables. The Journal of Cetacean Research and Management 7(2): 137-145.

Papastavrou, V., S. C. Smith and H. Whitehead. 1989. Diving behavior of the sperm whale *Physeter macrocephalus* off the Galapagos Islands, Ecuador. Canadian Journal of Zoology 67(4): 839-846.

Parks, S. E. and P. L. Tyack. 2005. Sound production by North Atlantic right whales (*Eubalaena glacialis*) in surface active groups. Journal of the Acoustical Society of America 117(5): 3297-3306.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall and B. M. Buhleier. 2000. Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. Marine Mammal Science 16(2): 392-412.

Parrish, F. A., K. Abernathy, G. J. Marshall and B. M. Buhleier. 2002. Hawaiian monk seals (*Monachus schauinslandi*) foraging in deep-water coral beds. Marine Mammal Science 18(1): 244-258.

Pastene, L.A. and M. Goto. 1998. An estimate of the mixing proportion of 'J' and 'O' stocks minke whales in subarea 11 based on mitochondrial DNA haplotype data. Report of the International Whaling Commission 48: 471-474.

Perryman, W. L., M. A. Donahue, J. L. Laake and T. E. Martin. 1999. Diel variation in migration rates of eastern Pacific gray whales measured with thermal imaging sensors. Marine Mammal Science 15(2): 426-445.

Ponganis, P. J., R. L. Gentry, E. P. Ponganis and K. V. Ponganis. 1992. Analysis of swim velocities during deep and shallow dives of two northern fur seals *Callorhinus ursinus*. Marine Mammal Science 8(1): 69-75.

Ramirez, N., D. Schulte and J. Kennedy. 2006. Finback whale (*Balaenoptera physalus*) behavior on Jeffreys Ledge in the Gulf Of Maine. ECS 2006. Gydnia, Poland.

Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease and T. R. Loughlin. 2002. Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science 18(3): 746-764.

Raum-Suryan, K. L., M. J. Rehberg, G. W. Pendleton, K. W. Pitcher and T. S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science 20(4): 823-850.

Ream, R. R., J. T. Sterling and T. R. Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. Deep Sea Research Part II: Topical Studies in Oceanography 52(5-6): 823-843.

Reeves, R. R., B. S. Stewart, J. Clapham Phillip and J. A. Powell. 2002. Guide to Marine Mammals of the World. New York: Knopf.

Reilly, S. B. and V. G. Thayer. 1990. Blue Whale *Balaenoptera musculus* Distribution in the Eastern Tropical Pacific. Marine Mammal Science 6(4): 265-277.

Rice, D. W. and A. A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). Am. Soc. Mammalog. Spec. Publ. 3.

Richardson, W.J., ed. 1997. Northstar marine mammal monitoring program, 1996: marine mammals and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. Final Report, LGL Report TA2121-2. Prepared for BP Exploration (Alaska) Inc., and Greeneridge Sciences, Inc. Anchorage: LGL Ltd.

Richardson, W.J., ed. 1998. Marine mammals and acoustical monitoring of BPXA's seismic program in the Alaskan Beaufort Sea, 1997. Final Report, LGL Report TA2150-3. Prepared for BP Exploration (Alaska), Inc. and National Marine fisheries Service by LGL, Ltd. and Greeneridge Sciences, Inc. Anchorage: LGL, Ltd.

Richardson, W.J., K.J. Finley, G.W. Miller, R.A. Davis, and W.A. Koski. 1995a. Feeding, social and migration behavior of bowhead whales, *Balaena mysticetus*, in Baffin Bay versus the Beaufort Sea regions with different amounts of human behavior. Marine Mammal Science 11:1-45.

Richardson, W. J., C. R. Greene, C. I. Malme and D. H. Thomson. 1995b. Marine mammals and noise. San Diego: Academic Press.

Ridoux, V., C. Guinet, C. Liret, P. Creton, R. Steenstrup and G. Beauplet. 1997. A video sonar as a new tool to study marine mammals in the wild: measurements of dolphin swimming speed. Marine Mammal Science 13(2): 196-206.

Ries, E. H., I. M. Traut, P. Paffen and P. W. Goedhart. 1997. Diving patterns of harbour seals (*Phoca vitulina*) in the Wadden Sea, the Netherlands and Germany, as indicated by VHF telemetry. Canadian Journal of Zoology 75(12): 2063-2068.

Ritter, F. 2002. Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. Aquatic Mammals 28(1): 46-59.

Ritter, F. and B. Brederlau. 1999. Behavioural observations of dense beaked whales (*Mesoplodon densirostris*) off La Gomera, Canary Islands (1995-1997). Aquatic Mammals 25(2): 55-61.

Robison, B. H. and J. E. Craddock. 1983. Mesopelagic Fishes Eaten by Frasers Dolphin *Lagenodelphis hosei*. Fishery Bulletin Washington D C 81(2): 283-290.

Rohr, J. J., F. E. Fish and J. W. Gilpatrick. 2002. Maximum swim speeds of captive and free-ranging delphinids: Critical analysis of extraordinary performance. Marine Mammal Science 18(1): 1-19.

Rose, B. and A. I. L. Payne. 1991. Occurrence and behavior of the southern right whale dolphin *Lissodelphis peronii* off namibia. Mar Mammal Sci 7(1): 25-34.

Rosenbaum, H. C. C. Pomilla, M. Mendez, M. S. Leslie, P. B. Best, K. P. Findlay, G. Minton, P. J. Ersts, T. Collins, M. H. Engel, S. L. Bonatto, D. P. G. H. Kotze, M. Meyer, J. Barendse, M. Thornton, Y. Razafindrakoto, S. Ngouessono, M. Velly, and J. Kiszka. 2009. Population structure of humpback whales from their breeding grounds in the South Atlantic and Indian oceans. PLoS ONE 4(10):e7318. doi:10.1371/journal.pone.0007318.

Rugh, D. J. 1984. Census of gray whales at Unimak Pass, Alaska: November-December 1977-1979. Pages 225-248 *in* M. L. Jones, S. L. Swartz and S. Leatherwood, eds. The gray whale, *Eschrichtius robustus.* Academic Press.

Schilling, M. R., I. Seipt, M. T. Weinrich, A. E. Kuhlberg and P. J. Clapham. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern gulf of maine in 1986. U S Natl Mar Fish Serv Fish Bull 90(4): 749-755.

Scott, M. D., A. A. Hohn, A. J. Westgate, J. R. Nicolas, B. R. Whitaker and W. B. Campbell. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). Journal of Cetacean Research and Management 3(1): 87-94.

Scott, T. M. and S. S. Sadove. 1997. Sperm Whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science 13(2): 317-320.

Selzer, L. A. and P. M. Payne. 1988. The distribution of white-sided (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. Marine Mammal Science 4(2): 141-153.

Shane, S. H. 1995. Behavior patterns of pilot whales and Risso's dolphins off Santa Catalina Island, California. Aquatic Mammals 21(3): 195-197.

Silber, G. K., M. W. Newcomer and H. M. Pérez-Cortés. 1990. Killer Whales (*Ornicus orca*) attack and kill a Bryde's whale (*Balaenoptera edeni*). Canadian Journal of Zoology 68: 1603-1606.

Silber, G. K., M. W. Newcomer, P. C. Silber, H. Pérez-Cortés M and G. M. Ellis. 1994. Cetaceans of the northern Gulf of California: distribution, occurrence, and relative abundance. Marine Mammal Science 10(3): 283-298.

Skaug, H. J., N. Øien, T. Schweder, and G. Bothun. 2004. Abundance of minke whales (*Balaenoptera acutorostrata*) in the Northeast Atlantic: variability in time and space. Canadian Journal of Fisheries and Aquatic Sciences 61(6):870-886.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene, Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas and P. L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations Aquatic Mammals 33(4): 411-521.

Stern, S. J. 1992. Surfacing rates and surfacing patterns of minke whales (*Balaenoptera acutorostrata*) off central California, and the probability of a whale surfacing within visual range. Report of the International Whaling Commission 42: 379-385.

Stevick, P. T., J. Allen, P. J. Clapham, N. Friday, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, J. Sigurjónsson, T. D. Smith, N. Øien, and P. S. Hammond. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258:263-273.

Stewart, B. S. and R. L. DeLong. 1995. Double migrations of the northern elephant seal, *Mirounga angustirostris*. Journal of Mammalogy 76(1): 196-205.

Stewart, B. S. and P. K. Yochem. 1999. Community ecology of California Channel Islands pinnipeds. Pages 413-420 *in* D. R. Browne, ed. Fifth California Islands Symposium. Santa Barbara Museum of Natural History, Santa Barbara, California.

Stockin, K. A., R. S. Fairbairns, E. C. M. Parsons and D. W. Sims. 2001. Effects of diel and seasonal cycles on the dive duration of the minke whale (*Balaenoptera acutorostrata*). Journal of the Marine Biological Association of the United Kingdom 81(1): 189-190.

Stone, G. S., S. K. Katona, M. Mainwaring, J. M. Allen and H. D. Corbett. 1992. Respiration and surfacing rates of fin whales (*Balaenoptera physalus*) observed from a lighthouse tower. Reports of the International Whaling Commission 42: 739-745.

Teloni, V., J. P. Mark, M. J. O. Patrick and M. T. Peter. 2008. Shallow food for deep divers: Dynamic foraging behavior of male sperm whales in a high latitude habitat. Journal of Experimental Marine Biology and Ecology 354(1): 119-131.

Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. Report of the International Whaling Commission Special Issue 1:98-106.

Trillmich, F. 1986. Attendance behavior of Galapagos fur seals. Pages 168-185 *in* R. L. Gentry and G. L. Kooyman, eds. Fur Seals: Maternal Strategies on Land and at Sea. Princeton, NJ: Princeton University Press.

Tyack, P.L. and C. W. Clark. 1998. Quicklook-Playback of low frequency sound to gray whales migrating past the central California coast in January 1998. 55 pp.

Tynan, C. T., D. G. Ainley, J. A. Barth, T. J. Cowles, S. D. Pierce and L. B. Spear. 2005. Cetacean distributions relative to ocean processes in the northern California Current System. Deep-Sea Research II 52(1-2): 145-167.

Urick, R.J. 1983. Principles of underwater sound, 3rd ed. New York, New York: McGraw-Hill.

Wade, P.R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Report of the International Whaling Commission 43:477-493.

Wahlberg, M. 2002. The acoustic behaviour of diving sperm whales observed with a hydrophone array. Journal of Experimental Marine Biology and Ecology 281(1-2): 53-62.

Ward, W. D. 1997. Effects of high intensity sound. Pages 1497-1507 in M.J. Crocker, ed. Encyclopedia of Acoustics. New York, New York: J. Wiley and Sons, Inc.

Ward, W.D. (ed.). 1968. Proposed damage-risk criterion for impulsed noise (gunfire). Committee on Hearing, Bioacoustics and Biomechanics. National Research Council, National Academy of Science, Washington, D.C.

Waring, G. T., L. Nottestad, E. Olsen, H. Skov, and G. Vikingsson. 2008. Distribution and density estimates of cetaceans along the mid-Atlantic Ridge during summer 2004. Journal of Cetacean Research and Management 10(2):137-146.

Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel, editors. 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2009. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NE-213. Woods Hole, MA. 528 p.

Waring, G., E. Josephson, K. Maze-Foley, P.E. Rosel, eds. 2010. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments–2010. NOAA Technical Memorandum NMFS-NE-219. Woods Hole, Massachusetts: Northeast Fisheries Science Center, National Marine Fisheries Service. 606 pages.

Watkins, W. A. 1981. Activities and Underwater Sounds of Fin Whales. The scientific reports of the whales research institute (33): 83-117.

Watkins, W.A., and W.E. Schevill. 1975. Sperm whales (*Physeter macrocephalus*) react to pingers. Deep-Sea Research 22:123-129.

Watkins, W.A., K.E. Moore, P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Watkins, W. A., P. Tyack, K. E. Moore and G. N. di Sciara. 1987. *Steno bredaneisis* in the Mediterranean Sea. Marine Mammal Science 3(1): 78-82.

Watkins, W. A., M. A. Daher, K. Fristrup and G. N. d. Sciara. 1994. Fishing and Acoustic Behavior of Fraser's Dolphin (*Lagenodelphis hosei*) near Dominica, Southeast Caribbean. Caribbean Journal of Science 30(1-2): 76-82.

Watkins, W. A., M. A. Daher, N. A. DiMarzio, A. Samuels, D. Wartzok, K. M. Fristrup, D. P. Gannon, P. W. Howey, R. R. Maiefski and T. R. Spradlin. 1999. Sperm whale surface activity from tracking by radio and satellite tags. Marine Mammal Science 15(4): 1158-1180.

Watkins, W. A., M. A. Daher, N. A. DiMarzio, A. Samuels, D. Wartzok, K. M. Fristrup, P. W. Howey and R. R. Maiefski. 2002. Sperm whale dives tracked by radio tag telemetry. Marine Mammal Science 18(1): 55-68.

Weinrich, M. T., C. R. Belt and D. Morin. 2001. Behavior and ecology of the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in coastal New England waters. Marine Mammal Science 17(2): 231-248.

Weir, C. R. 2000. Sightings of beaked whales species (Cetacea: Ziphiidae) in the waters to the north and west of Scotland and the Faroe Islands. European Research on Cetaceans 14: 239-243.

Weise, M. J., D. P. Costa and R. M. Kudela. 2006. Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005 compared to those of 2004. Geophysical Research Letters 33(22): 1-6.

Weller, D. W., S. H. Reeve, A. M. Burdin, B. Würsig and R. L. Brownell, Jr. 2002. A note on the spatial distribution of western gray whales (*Eschrichtius robustus*) off Sakhalin Island, Russia in 1998. Journal of Cetacean Research and Management 4(1): 13-17.

Wells, R. S., H. L. Rhinehart, P. Cunningham, J. Whaley, M. Baran, C. Koberna and C. D. P. 1999. Long distance offshore movements of bottlenose dolphins. Marine Mammal Science 15(4): 1098-1114.

Westgate, A. J., A. J. Read, P. Berggren, H. N. Koopman and D. E. Gaskin. 1995. Diving behaviour of harbour porpoises, *Phocoena phocoena*. Canadian Journal of Fisheries and Aquatic Sciences 52(5): 1064-1073.

Whitehead, H., S. C. Smith and V. Papastavrou. 1989. Diving behavior of the sperm whales, (*Physeter macrocephalus*), off the Galapagos Islands. Canadian Journal of Zoology 67(4): 839-846.

Whitehead, H., S. Brennan and D. Grover. 1992. Distribution and Behavior of Male Sperm Whales on the Scotian Shelf, Canada. Canadian Journal of Zoology 70(5): 912-918.

Williams, R., D. E. Bain, J. K. B. Ford and A. W. Trites. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4(3): 305-310.

Williams, T. M., R. W. Davis, L. A. Fuiman, J. Francis, B. B. J. Le, M. Horning, J. Calambokidis and D. A. Croll. 2000. Sink or swim: Strategies for cost-efficient diving by marine mammals. Science Washington D C 288(5463): 133-136.

Winn, H. E., J. D. Goodyear, R. D. Kenney and R. O. Petricig. 1995. Dive patterns of tagged right whales in the Great South Channel. Cont. Shelf. Res. 15(4/5): 593-611.

Witteveen, B. H., R. J. Foy, K. M. Wynne and Y. Tremblay. 2008. Investigation of foraging habits and prey selection by humpback whales (*Megaptera novaeangliae*) using acoustic tags and concurrent fish surveys. Marine Mammal Science 24(3): 516-534.

Woodley, T. H. and D. E. Gaskin. 1996. Environmental characteristics of North Atlantic right and fin whale habitat in the lower Bay of Fundy, Canada. Canadian Journal of Zoology 74(1): 75-84.

Würsig, B. and M. Würsig. 1979. Behavior and ecology of the bottlenose dolphin, (*Tursiops truncatus*) in the South Atlantic. Fishery Bulletin 77(4): 399-412.

Würsig, B., R. Wells and D. Croll. 1986. Behavior of gray whales summering near St. Lawrence Island, Bering Sea. Canadian Journal of Zoology 64(3): 611-621.

Wyrick, R. 1954. Observations on the movements of the Pacific gray whale *Eschrichtius glaucus*. Journal of Mammalogy 35(4).

Yin, S. E. 1999. Movement patterns, behaviors, and whistle sounds of dolphin groups off Kaikoura, New Zealand. M.S. thesis, Texas A & M University, College Station, Texas. 107 pages.

THIS PAGE IS INTENTIONALLY LEFT BLANK

APPENDIX D—
NMFS ANALYSIS OF SURTASS LFA SONAR MARINE MAMMAL OFFSHORE BIOLOGICALLY IMPORTANT AREAS

APPENDIX D-1: NMFS' INITIAL INSTRUCTIONS TO MARINE MAMMAL OBIA SUBJECT MATTER EXPERTS (SMES), 23 NOVEMBER 2009

To: Subject Matter Experts

From: NMFS Office of Protected Resources

Re: Identifying Marine Mammal Offshore Biologically Important Areas (OBIAs) for Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) Sonar.

Thank you for agreeing to participate and lending your expertise to this important process. We have prepared these notes in advance of our introductory meeting to explain what the process will entail and to help guide your recommendations.

Background

The U.S. Navy plans to operate four SURTASS LFA sonars that have the potential to adversely impact marine mammals. In order to ensure Marine Mammal Protection Act (MMPA) compliance, the Navy has applied for in the past, and NMFS has issued, MMPA regulations and "incidental take" authorizations that allow for impacts to marine mammals, while prescribing measures to minimize impacts. NMFS' rulemaking for the next five-year period of authorizations will begin in the near future. In preparation for that upcoming rule making, and taking into consideration court decisions issued in litigation over previous NMFS and Navy actions for SURTASS LFA sonar, NMFS and the Navy are developing a more systematic process for designating marine mammal "offshore biologically important areas" (OBIAs) for SURTASS LFA sonar. OBIAs are part of a suite of measures used in previous authorizations to minimize impacts to marine mammals. NMFS has enlisted the assistance of subject matter experts (*Experts*) to help in this process.

NMFS and the Navy will apply the best available science (including input from *Experts*) to identify OBIA Nominees and comparatively score their habitat value. Subsequently and separately, NMFS and the Navy will conduct a "practicability" assessment in accordance with the MMPA, which will rely on operational information provided by the Navy.

Process Summary for *Expert* Input

Stage 1. Identification of OBIA Nominees using Screening Criteria

a. NMFS used Screening Criteria to review existing and potential Marine Protected Areas and prior OBIAs to produce a List of Preliminary OBIA Nominees

b. *Experts* will use the same Screening Criteria to identify additional preliminary OBIA Nominees, as appropriate, and offer modifications or deletions to NMFS' List of Preliminary OBIA Nominees, if needed

c. NMFS will incorporate *Expert* input, as appropriate, to produce the final OBIA Nominees, which will be included for consideration in the Navy's 2009 draft supplemental environmental impact statement (DSEIS) for SURTASS LFA sonar.

Stage 2. OBIA Nominee Habitat Scoring

a. NMFS will seek preliminary *Expert* input regarding what factors are important for assessing comparative value (scoring) of the habitat in an OBIA Nominee.

b. At a later point, NMFS will request additional *Expert* input regarding Scoring Criteria and ask the *Experts* to comparatively score the habitat in each of the OBIA Nominees (e.g., by placing nominees in one of two or three categories).

c. NMFS will synthesize expert input and assign comparative Habitat Score for each OBIA Nominee.

Screening Criteria for Identification of OBIA Nominees

NMFS developed Screening Criteria to be used in Stage 1 to determine whether a suggested area is eligible to be considered as an OBIA Nominee. NMFS anticipates that the *Experts* will use peer-reviewed literature, technical reports, or his/her own specific expertise and professional experience, along with other data sources to justify their additions, modifications, or deletions to the list of preliminary OBIA Nominees. The Screening Criteria are described below.

Criterion 1: Outside of Coastal Standoff Distance and Non-Operational Areas

The Navy has indicated that it will not operate LFAS in certain areas of the world. No analyses will be conducted in these areas and OBIAs will not be designated that lie solely within these areas. The areas where the Navy will not operate SURTASS LFA are as follows:

- Coastal Standoff Zone - the area within 12 nm of any coast
- Non-Operational Areas:
  - Arctic –Portions of the Norwegian, Greenland, and Barents Seas, North of 72^o North latitude, plus Baffin Bay, Hudson Bay, the Bering Sea and the Gulf of St. Lawrence.
  - Antarctic –South of 60^o South latitude

Criterion 2: Biologically Important

In order to be an OBIA Nominee, an area must meet at least one of the below sub-criteria.

2a. *High Densities*

The area represents an area of high density for one or more species of marine mammals. In addition to survey data, predictive habitat or density modeling may be used to identify areas of high density. The exact definition of “high density” may differ across species and should generally be treated and justified on a stock-by-stock or species-by-species basis, although combining species or stocks may be appropriate in some situations, if well justified.

In identifying high density areas:

(1) For locations/regions and species for which adequate density information is available (e.g., most waters off the United States), high density areas should be defined as those areas where density measurably, within a definable and justifiable area, meaningfully exceeds the average density of the species or stock in that location/region regularly or regularly within a designated time period of the year.

(2) For locations/regions and species and stocks for which density information is limited or not available, high density areas should be defined (if appropriate) using some combination of the following: available data, regional expertise, and/or habitat suitability models utilizing static and/or predictable dynamic oceanographic features and other factors that have been shown to be associated with high marine mammal densities.

NMFS will work with *Experts* to ensure that all locations and regions within the Navy's operating area are addressed.

2b. *Known, Defined Breeding/Calving Grounds, Foraging Grounds, and Migration Routes*

The area includes known, defined breeding or calving areas, foraging grounds, concentrated migration routes, and any designated critical habitat.

2c. *Small, Distinct Populations with Limited Distributions*

The area contains a small, distinct population of marine mammals with limited distribution.

NMFS' Preliminary OBIA Nominee Recommendations

NMFS and the Navy have evaluated several references (including, primarily, Marine Protected Areas(MPAs)) and compiled a List of Preliminary OBIA Nominees that we think meet the Screening Criteria. This list is not comprehensive: rather, it captures some of the more well-known important marine mammal areas and clearly lays out our suggested format for this process. *We fully expect the Experts may identify some less well-known areas, and we also understand that some areas will have less information available than the more well-known MPAs included in NMFS' List of Preliminary OBIA Nominees.* See Attachments 1 and 2.

OBIA Nominee Habitat Scoring (Stage 2)

After NMFS incorporates the *Expert* input, as appropriate, to produce the final OBIA Nominees, NMFS will ask the *Experts* to score the OBIA Nominee habitat (into two or three categories). Additional details will be provided to the *Experts* in the instructions below (preliminary data-gathering) and at a later date prior to the second stage of *Expert* input.

Detailed Instructions for First Round of *Expert* Input

1. General

As a general rule, *Experts* will need to submit their information individually and independently. NMFS may consider asking Federal *Experts* to submit a joint recommendation, which would focus and streamline the efforts of both the Federal *Experts* and NMFS HQ analysts. However, this would require that one or two Federal *Experts* take a leadership role and we realize that it would need to be discussed at the Introductory Meeting.

As a starting point, NMFS and the Navy have compiled a List of Preliminary OBIA Nominees[1]. Attachment 1 (Screening Matrix) indicates the areas that NMFS and the Navy considered in our preliminary analysis, and whether we think they are eligible to be OBIA Nominee based on our preliminary analysis of whether they meet the Screening Criteria outlined in the Introduction above. Attachment 2 (Detailed Screening Document for Eligible OBIA Nominees) provides more detailed supporting information for all of the sites that were considered in the preliminary analysis, including the sites that were found eligible to be a Preliminary OBIA Nominee.

[1] The frequencies of the signals produced by SURTASS LFA sonar (frequency range of 100 to 500 Hz) are much lower than the frequencies of greatest hearing sensitivity for high frequency and mid-frequency marine mammal hearing groups (as defined in Southall et al., 2007). There are few known data documenting responses of these marine mammal hearing groups to SURTASS LFA sonar. In Stage 1 NMFS and the *Experts* will initially identify all potential OBIA nominees that meet the screening criteria, regardless of the hearing sensitivity of the species for which the area is important. Further assessments will be performed to determine whether areas that only meet the screening criteria for high and/or mid-frequency hearing specialists should be designated as OBIAs based on analyses of the specific species present and other relevant factors.

2. Adding and Modifying Preliminary OBIA Nominees

To recommend additional Preliminary OBIA Nominees or to modify or delete from NMFS' List of Preliminary OBIA Nominees, please do the following:

a) Provide an introductory list with the names of any new Preliminary OBIA Nominees you are recommending and any areas from NMFS' initial list that you have recommended modifying.
b) In the Screening Matrix (Attachment 1), add rows with information for newly recommended Preliminary OBIA Nominees in RED, and make any changes to existing information in RED.
c) To support recommended additions, modifications, or deletions to the Screening Matrix (based on the criteria definitions included in the Introduction), please make **track changes** in the Detailed Screening Document (Attachment 2) to include the following:
    - The information that supports each addition, modification, or deletion (e.g., each yes to a criterion should be specifically supported for each associated species, along with the recommended boundaries, etc.).
    - The appropriate way to cite any information provided.
    - A map of the boundaries, if possible (note – please indicate the actual estimated boundaries of the area of biological importance or high density: do not add a buffer)
    - Note - For brand new areas, please use the format provided in the Detailed Screening Document for the existing areas, i.e., with the boxes at the top that contain criteria met, species, etc.
    - Note – Only indicate a species in the Screening Matrix or in the box at the top of the page in Detailed Screening Document if the area meets one of the biological importance criteria for that species.
d) If habitat modeling is used as a basis for the addition, modification, or deletion of a Preliminary OBIA Nominee, please also include a description of the modeling methodology that includes the following information: a description of the individual factors/parameters that were used in the analysis; a description of how each factor is considered by the model (weight, etc.); and a description of any assumptions made in the model. Please provide citations for existing models that have been addressed in the literature and, if possible, supporting citations for the parameters used in any new models.

3. Preliminary List of Habitat Scoring Factors

As mentioned in the Process Summary for *Expert* Input, sometime after NMFS has incorporated *Expert* input to produce the final OBIA Nominees, we plan to ask *Experts* to help score the habitat. NMFS has compiled a preliminary list of some of the factors that should likely be considered in the comparative scoring of habitat. In the second stage of *Expert* input, NMFS will provide a habitat scoring method and request that you score the habitat in each of the final OBIA nominees.

For now, we ask that the *Experts* review the preliminary list of factors below that would likely contribute to habitat ranking and recommend additions, modifications, or deletions, as well as any other information we should consider when devising a method to rank habitat (such as the importance of some factors compared to others):

- The comparative habitat value of the identified area to the associated species (meaning the ones for which criteria are met), for example:
    - a known calving ground may have a greater weight than general high density, or
    - the single known calving ground in the world for a particular species may have a greater weight than one of twenty known for another species (so, for example, we may ask *Experts* to rank calving grounds as 1, 2, or 3)
- Total number of associated stocks/species in an area for which criteria 2a, 2b, or 2c were met
- Whether individual associated species are listed under the Endangered Species Act or on the IUCN Red List, or, if applicable but not reflected in ESA/IUCN listing: have known upward/downward population trends or have relatively low or high abundance.

- Whether any of the species for which the area is important are known to be either more or less sensitive to low frequency sound either physiologically or behaviorally.

Information to be Provided to NMFS

To recap, *Experts* should submit their information independently (unless we work out that Federal *Experts* will submit a combined report, per introductory discussion), which will include the following:

- A brief list of the added, modified, or deleted Preliminary OBIA Nominees
- The Screening Matrix with additions, modifications, or deletions indicated in RED (strikethrough if deleted)
- The Detailed Screening Document with supporting information for additions, modifications, or deletions, and associated citations, in **track changes**.
- Where habitat modeling is used, an additional description of the methodology used
- Coordinates (and also, ideally, maps, ESRI shapefiles, or Google kml files) indicating boundaries of added or modified areas
- A list of the factors and other information that should be used to score habitat in OBIA Nominees

APPENDIX D-2: DETAILED SCREENING DOCUMENT FOR ELIGIBLE OBIA NOMINEES, 23 NOVEMBER 2009

NMFS' Initial Screening Analysis for Marine Mammal Offshore Biologically Important Areas (OBIA) for the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active Sonar (LFA)

Detailed Screening Document for Eligible OBIA Nominees

National Marine Fisheries Service
Office of Protected Resources
November 19, 2009

IUCN Marine Region 3: Mediterranean Sea

Northeast Slope in the Ligurian-Corsican-Provençal Basin

Potential Criterion:	2B: Foraging Area
Species of Concern:	Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: Location inferred from Azzellino et al. (2008).	8°35'23.085"E, 43°57'14.637"N 9°6'36.592"E, 43°56'30.726"N 9°6'21.955"E, 43°26'45.04"N 8°35'37.721"E, 43°26'59.677"N *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	July through August

Background

- The total size of the fin whale population in the Mediterranean is unknown. However, one study estimates that approximately 3500 individuals range in a portion of the western basin. High whale densities, comparable to those found in rich oceanic habitats, were found in well-defined areas of high productivity. Most whales concentrate in the Ligurian-Corsican-Provençal Basin; however, neither their movement patterns throughout the region nor their seasonal cycle are clear (Notarbartolo-Di-Sciara, Zanardelli, Jahoda, Panigada, & Airoldi, 2003).
- During the summer months, the species is known to concentrate in high numbers in the Corso-Ligurian Basin, described as one of the principal feeding grounds for fin whales in the Mediterranean Sea (Notarbartolo-Di-Sciara, et al., 2003)
- One nine-year study surveyed a total of 73,046 km and reported 540 sightings of fin whales in the Ligurian Sea. Water depth was the most significant variable in describing fin whale distribution, with more than 90% of sightings occurring in waters deeper than 2,000m (Panigada, et al., 2005).
- One study sought to correlate marine mammal presence in the Ligurian Sea with physical and biological parameters collected during NATO's SACLANT Undersea Research Centre's sea trials, called Sirena. The data suggested that large (sperm and fin) whales were predominately found in the deeper portion of the basin (D' Amico, et al., 2003).
- In the western Ligurian Sea, many submarine canyons at the boundary between neritic and oceanic domains create the conditions for the accumulation of migratory micronektonic species in the continental slope waters. One study suggests that the periodic pattern of concentration of pelagic zooplankton near the bottom above the slope may provide an abundant food source for organisms living in the slope area, and it could also be the reason for the occasional presence of fin whales over the upper slope (Azzellino, Gaspari, Airoldi, & Nani, 2008)
- Most of the fin whale sightings occurred along the 2000-m depth contour. Also, Fin whales showed also a periodic east-to west pattern in their movements during the July–August period. Such a pattern suggests once more a relationship with the counter-clockwise circulation of the Liguro-Provenc- al-Catalan Current (Azzellino, et al., 2008).
- Azzellino et al. (2008) noted that bottlenose dolphin, Risso's dolphin, sperm whale and Cuvier's beaked whale were all found associated with well-defined depth and slope gradients showing very clear preferences for specific physical habitats, respectively, the shelf-edge, the upper slope and the lower slope.

IUCN Marine Region 4: Northwest Atlantic Ocean

Northwest of Challenger Bank (Bermuda)

Potential Criteria:	2B: Migration Route 2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Stone et al. (1987)	A 5-km buffer around the centroid of: 65°19'11.214"W, 32°12'16.23"N *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	March and April

Background

- Historical accounts show that humpback whales have frequented Bermuda waters, which are located half-way between wintering and summering grounds in the western North Atlantic, since the early 17th century (Stone, Katona, & Tucker, 1987). Stone et al. suggested that humpback whales from the North Atlantic feed briefly and opportunistically at Bermuda (32°20'N) while migrating (Danilewicz, Tavares, Moreno, Ott, & Trigo, 2009).
- Humpback whales were common in Bermudian coastal waters during the late winter and spring (March-May); sperm whales, in offshore waters probably throughout much of the year (Reeves, Mckenzie, & Smith, 2006)
- Humpbacks utilize Bermuda as a mid-ocean habitat through which all members of the western North Atlantic population migrate during spring (Stone, et al., 1987).
- Humpbacks returning to their northern feeding grounds may take more westerly routes that in many cases pass close to Bermuda where as suggested by Stone et al. (1987), they may linger and feed (Clapham & Mattila, 1990).
- Stone et al. (1987) suggest that the presence of humpbacks at Bermuda, a way-point during the springtime northward migration, may be attributed to increased food availability, providing the first opportunity to feed after the wintering ground fast (Baraff, Clapham, Mattila, & Bowman, 1991).
- There is also evidence suggesting that humpback whales feed at Bermuda on deep water scattering layers during their stop-over (Stone, et al., 1987).
- It seems likely that humpbacks returning to their northern feeding grounds may take more westerly routes that in many cases pass close to Bermuda where, as suggested by Stone et al. (1987), they may linger and feed (Clapham & Mattila, 1990).

Roseway Basin Right Whale Conservation Area (Canada)

Potential Criterion:	2B: Foraging Grounds
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: Canadian Government.	An area bounded by the following coordinates: NW 43° 05'N, 65° 40'W NE 43° 05'N, 65° 03'W SW 42° 45'N, 65° 40'W SE 42° 45'N, 65° 03'W
Proposed Seasonal Consideration:	TBD *(Canadian Restriction is June through December)*

Background

- In 2008, Transport Canada implemented the Roseway Basin Area to be Avoided (ATBA) following its adoption by the International Maritime Organization (IMO). The measure is seasonal and recommended for all vessels ≥ 300 gross tonnage from June through December. The aim of this ATBA is to protect the endangered North Atlantic right whale from ship strikes and to enhance maritime safety (IMO, 2007).
- From 1999 to 2001, Baumgartner et al. (2003) conducted surveys in Roseway Basin to investigate the physical and biological oceanographic factors associated with North Atlantic right whale occurrence. They noted that right whales in these regions fed on *Calanus finmarchicus*.
- Spatial variability in right whale occurrence was associated with water depth and the depth of the bottom mixed layer. *C. finmarchicus* CS aggregated over the deepest water depths in both regions, and within these areas, right whales occurred where the bottom mixed layer forced discrete layers of *C. finmarchicus* to occur shallower in the water column (allowing more efficient foraging) (Baumgartner, Cole, Clapham, & Mate, 2003).
- Baumgartner et al. (2003) concluded that annual increases in right whale occurrence appeared to be associated with decreases in sea surface temperature (SST) in both regions; however, they any further observation merits based on the short duration of the three-year study.
- Baumgartner et al. (2003) concluded that spatial variability in right whale occurrence was associated with water depth and the depth of the bottom mixed layer, within the Bay of Fundy and Roseway Basins. Copepods (*Calanus finmarchicus*) aggregated over the deepest water depths in these areas. Within these areas, right whales occurred where the bottom mixed layer forced discrete layers of *C. finmarchicus* to occur shallower in the water column, which allows more efficient foraging.
- The spatial and interannual variability in occurrences observed for right whales might be associated with the SST gradient, a proxy for ocean fronts (Baumgartner, et al., 2003).
- The summer feeding areas are in waters near Nova Scotia and the principal spring feeding ground (April-June) is in the GSC (Kenney & Wishner, 1995).

Great South Channel (United States)

Potential Criteria:	2B: Critical Habitat 2B: Foraging Area
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: U.S. Government.	It is bounded by the following coordinates: 42°30′00.0″ N, 069°45′00.0″ W 41°40′00.0″ N, 069°45′00.0″ W 41°00′00.0″ N, 069°05′00.0″ W 42°09′00.0″ N, 067°08′24.0″ W 42°30′00.0″ N, 067°27′00.0″ W 42°30′00.0″ N, 069°45′00.0″ W *This area is within designated critical habitat.*
Proposed Seasonal Consideration:	TBD *(Ship Strike Rule is April 1 to July 31)*

Background

- The Great South Channel (GSC) area lies east of Cape Cod, Massachusetts, U.S.A. between Nantucket Shoals on the west and Georges Bank on the east. Right whales are the world's most endangered large whale species, and the GSC is the principal feeding ground of the western North Atlantic population (Kenney & Wishner, 1995).
- The South Channel Ocean Productivity Experiment (SCOPEX), a multidisciplinary study of a whale-zooplankton predator-prey system in the southwestern Gulf of Maine, confirmed the co-occurrence of right whales with high density *Calanus finmarchicus* patches. Also, the whales fed on patches with higher proportions of larger lifestages of *C. finmarchius* (Kenney & Wishner, 1995).
- The summer feeding areas are in waters near Nova Scotia and the principal spring feeding ground (April-June) is in the GSC (Kenney & Wishner, 1995).
- Right whales were only rarely observed in the GSC during the fall and winter seasons. Most sightings occurred in April, May, and June, with a large peak in sighting frequency in May (Kenney, Winn, & Macaulay, 1995).
- In the Great South Channel Seasonal Management Area, NOAA has proposed an April through July requirement that all vessels over 300 gross tons travel no faster than 10 knots. To physically separate whales and vessels, NOAA has also considered designating the Great South Channel critical habitat area as an International Maritime Organization-approved Area To Be Avoided (ATBA). NMFS proposed seasonal restriction of the April through July based on the number of greatest sighting densities found in the southwest corner of the GSC Critical Habitat (Merrick & Cole, 2007).
- NMFS designated this area as critical habitat and an important feeding area for the North Atlantic right whale in 1994 (NMFS, 1994).

The Gully Marine Protected Area (Canada)

Potential Criteria:	2A: High Density 2B: Foraging Grounds
Species of Concern:	Northern bottlenose whales (*Hyperoodon ampullatus*)
Proposed Boundary Consideration: Basis: Canadian Government	An area bounded by the following coordinates: 44°13′ N, 59°06′ W to 43°47′ N, 58°35′W; 43°35′ N, 58°35′ W to 43°35′ N, 59°08′ W to 44°06′ N, 59°20′ W
Proposed Seasonal Consideration:	Year Round

Background

- The Gully, a submarine canyon off eastern Canada, was nominated as a pilot Marine Protected Area (MPA) in 1998, largely to safeguard the vulnerable population of northern bottlenose whales (Hooker, Whitehead, & Gowans, 2002).
- Northern bottlenose whales are consistently found through the year in the Gully (Whitehead, Gowans, Faucher, & McCarrey, 1997).
- A small, apparently isolated, and endangered population of approximately 130 northern bottlenose whales is found on the Scotian Slope south of Nova Scotia, Canada (Wimmer & Whitehead, 2004).
- A ship survey along the 1000 m depth contour in 2001 showed northern bottlenose whales only in the Gully, Shortland Canyon, and Haldimand Canyon. Studies in 2002 reconfirmed the presence of the whales in the other canyons, although densities were about 50% lower than in the Gully (Wimmer & Whitehead, 2004)
- Hooker et al. (2002) estimated the energy consumption of bottlenose whales in The Gully and suggested that there must be a substantial spatial subsidy in the underlying food web of the submarine canyon to support the bottlenose whales using the Gully.
- Studies of this species' diet elsewhere in the North Atlantic Ocean have suggested specialization on the deep-sea squid, *Gonatus fabricii* (Hooker, Iverson, Ostrom, & Smith, 2001).

Shortland Canyon and Haldimand Canyon (Canada)

Potential Criteria:	2A: High Density 2B: Foraging Grounds
Species of Concern:	Northern bottlenose whales (*Hyperoodon ampullatus*)
Proposed Boundary Consideration: Location inferred from Wimmer and Whitehead (2004)	An area bounded by the following coordinates: 58°38'16.385"W, 44°11'56.984"N 57°54'5.541"W, 44°31'42.32"N 57°42'35.89"W, 44°8'43.019"N 58°29'39.147"W, 43°50'23.889"N
Proposed Seasonal Consideration:	Year Round

Background

- On the Scotian Shelf, northern bottlenose whales have been sighted most often in the deep waters of three underwater canyons (the Gully, Shortland Canyon, and Haldimand Canyon) along the shelf edge. They are thought to be year-round residents but winter distribution is not understood (DFO, 2007)
- The carrying capacity (the maximum number of individuals that a given environment can support) of northern bottlenose whales on the Scotian Shelf is unknown. The density of whales is higher in the Gully than in the other two canyons. This could indicate that there is room for population expansion in Shortland and Haldimand canyons. However a large canyon such as the Gully can have proportionately higher productivity due to its oceanographic and bathymetric (ocean depths) characteristics suggesting that it would be able to support higher densities of whales than smaller canyons (DFO, 2007).
- Haldimand and Shortland canyons are clearly important habitat for this species, and should receive appropriate protection. Research in 2002 confirmed that northern bottlenose whales regularly use Shortland and Haldimand canyons (Wimmer & Whitehead, 2004).
- Northern bottlenose whales were encountered in Shortland and Haldimand canyons at a rate about half that in The Gully, which suggests about half the density. Also, the whales seem to prefer waters between about 800 and 1500 m deep within all three canyons (Wimmer & Whitehead, 2004).
- Although there have been several sightings of northern bottlenose whales in other areas on and surrounding the Scotian Slope, the only areas in which we know they can be reliably found are the Gully and Shortland and Haldimand canyons (Wimmer & Whitehead, 2004) .
- Northern bottlenose whales do move between the three canyons. The function of this movement can be considered from the perspective of optimal foraging on dispersed patches of prey. As the Gully (the richer patch) fills with more northern bottlenose whales, individuals would likely do better in terms of individual net gain to use other, albeit poorer, areas with fewer competitors (Haldimand and Shortland canyons and other areas (Wimmer & Whitehead, 2004).

IUCN Marine Region 5: Northeast Atlantic Ocean

Dogger Bank (OSPAR International)

Potential Criterion:	2A: High Density
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	TBD
Proposed Seasonal Consideration:	TBD

Background

- In 2002 and 2003, Germany's Federal Agency for Nature Conservation (BfN) conducted aerial surveys in the German EEZ and 12 nm zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. The BfN found that the densities estimated for this site were fairly high, indicating an important area for porpoises. Also, Dogger Bank was the only area where sightings of other species could be observed (white-beaked dolphin and minke whale) (Gilles, Scheidat and Siebert, 2008).
- Other studies (Siebert, et al., 2006) have collected data on the occurrence of harbour porpoises in German waters from 1988 to 2002 from dedicated aerial surveys, incidental sightings and strandings. In the article, Siebert et al. notes that aerial surveys conducted in 1995 and 1996 revealed a mean abundance of 4288 (in 1995) and 7356 harbour porpoises (in 1996) in the German North Sea study area. Further, they describe reports of 791 incidental sightings of harbour porpoise pods in German and partly Danish coastal waters of the North and Baltic Seas from 1988 to 2002.
- Siebert et al. (2006) also found that 996 harbour porpoise strandings along the German North Sea coast in the period 1990 to 2001. Only 17 animals were identified as by-catch.
- Siebert et al. (2006) noted that their observational data demonstrated a strong seasonality of harbour porpoise occurrence off the German coast with highest numbers during the summer months.

Sylt Outer Reef (Germany)

Potential Criteria:	2A: High Density 2B: Calving Grounds
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	TBD
Proposed Seasonal Consideration:	TBD

Background

- In 2002 and 2003, Germany's Federal Agency for Nature Conservation (BfN) conducted aerial surveys in the German EEZ and 12 nm zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. The BfN found that the densities estimated for this site were fairly high, indicating an important area for porpoises.
- Giles et al. (2008) noted that the highest density was estimated for Sylt Outer Reef (2002: 2.7 individuals/km^2; 2003: 3.7 individuals/km^2).
- Important habitats for harbour porpoises were detected west of the islands of Sylt and Amrum in the North Sea and around the Schlei estuary, in waters west of Fehmarn and the Fischland-Darss area in the Baltic Sea (Siebert, et al. 2006).
- In the BfN evaluation of sites in the North Sea, only the Sylt Outer Reef was delineated for porpoises using the criteria of Article 4.1 Habitats Directive. There, three selection criteria were positively validated: (1) continuous or regular presence, (2) good population density, and (3) a high ratio of mother-calf pairs (60%) (Gilles, Scheidat and Siebert, 2008).

IUCN Marine Region 6: Baltic Sea

Pommeranian Bay, Adler Ground, and Western Ronne Bank (Germany)

Potential Criterion:	2B: Breeding Area
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	TBD
Proposed Seasonal Consideration:	TBD

Background

- The harbor porpoise is the only resident cetacean species in the German Baltic Sea (Scheidat, et al. 2008).
- One study (Verfuss, et al. 2007) indicated regular presence of harbor porpoises within the Baltic Sea and noted that the porpoise usage patterns of the area indicated geographical and seasonal variation.
- In contrast, Scheidat, et al.(2008) found no obvious seasonal patterns and reported low densities for the area that includes the Pommeranian Bay, Adler Ground, and Western Ronne Bank, ranging from 0 to 0.008 ind. km^2 during all but 2 surveys (July 2002 and April 2005). During the July 2002 survey, the author notes that an unusually high number of porpoises were seen east of the island of Rugen with a mean group size of 2.63. However, the author and others (Gilles, Scheidat and Siebert 2008) note that the event was an unusual and that the most likely explanation for the observed hot spot in May and July 2002 mighthave been an unusual availability of food (Gilles, Scheidat and Siebert 2008). Finally, density of porpoises declined from west to east during all other study months and years, with the highest densities west of Pommeranian Bay, Adler Ground, and Western Ronne Bank (Scheidat, et al. 2008).
- The larger numbers of harbor porpoise detections in spring to autumn compared with winter suggests that the German Baltic Sea is an important breeding and mating area for these animals (Verfuss, et al. 2007).
- A recent Danish effort (http://www2.dmu.dk/Pub/FR657.pdf) to designate and identify areas of high harbor porpoise density has collected all relevant data on movements and density of the harbor porpoises in Danish and adjacent waters.

IUCN Marine Region 7: Caribbean

Southeastern U.S. Right Whale Seasonal Habitat (United States)

Potential Criteria:	2B: Calving Area 2B: Designated Critical Habitat
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: U.S. Government	The coastal waters between 31°15'N and 30°15' N from the coast out 15 nautical miles; and the coastal waters between 30°15' N and 28°00' N from the coast out 5 nautical miles. *This area is within designated critical habitat.*
Proposed Seasonal Consideration:	November through March

Background

- NMFS has designated critical habitat for the NARW in coastal waters of the southeastern United States (SEUS) (NMFS 1994). This area is the only known calving ground for NARW off the SEUS in the winter (Kraus, Hamilton, Kenney, Knowlton, & Slay, 2001).
- The NARW calving season extends from late November through early March with an observed peak in January. The presence of females with calves was primarily limited to the coastal waters between 27°30'N and 32°00'N latitudes (NMFS, 1994).
- Based on the number of calves and females with calves in the SEUS since 1980, NMFS considers the SEUS as the primary calving area for the population (NMFS, 1994).
- Keller et al. (2006) found that SST likely plays an important role in the distribution of right whales in the southeastern, winter habitat. Warm Gulf Stream waters, generally found south and east of delineated critical habitat, represent a thermal limit for right whales and play an important role in their distribution within the calving grounds (Keller, et al., 2006).

Silver Bank and Navidad Bank (Dominican Republic)

Potential Criteria:	2B: Breeding Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Whitehead (2009).	An area bounded by the following coordinates: 70°1'44.244"W, 20°54'55.121"N 69°39'45.454"W, 20°55'36.078"N 68°46'39.063"W, 20°17'6.149"N 68°31'13.453"W, 19°48'1.415"N 69°3'18.394"W, 19°55'40.124"N 70°2'8.817"W, 20°16'17.001"N *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	December through April

Background

- One survey conducted between 14 February and 19 March 1984 reported 317 whales were individually identified from photographs of ventral fluke patterns. Analysis of matches suggests that whales from the various high-latitude feeding stocks mix randomly on Silver Bank. Overall, the number of whales, calves, and surface-active groups observed during this study confirms the apparently singular importance of Silver Bank to the breeding ecology of western North Atlantic humpback whales (Mattila, Clapham, Katona, & Stone, 1989).
- Scott and Winn (1977) conducted aerial surveys of Silver Bank in February, 1976 and reported that the estimated number of animals on the upper half of Silver Bank ranged from 405 to 618 individuals.
- Fast moving groups containing three or more adult humpback whales are found in the winter on Silver Bank in the West Indies. Many of these gr(Mattila, et al., 1989)oups have a definite structure: a central Nuclear Animal, with or without a calf, is surrounded by escorts who compete, sometimes violently, for proximity to the Nuclear Animal (Tyack and Whitehead 1983).
- The humpback whales, which winter in the West Indies are principally found over banks which are at latitudes between 10° and 22° N, have substantial areas of flat bottom between 15 and 60 m deep, and lie less than 30 km from the North Atlantic 2000-m contour. The surface sea temperatures in these areas are between 24 and 28° C (Whitehead and Moore 1982).
- The major concentrations of the humpbacks, which feed little in winter, are on Silver and Navidad banks. On Silver Bank the humpback and humpback song densities peak in the centre of the Bank. Mothers with calves are generally found in areas of calm water, and singers are found over areas with a flat bottom, where they meander slowly. There is no evidence of whales possessing particular movement patterns, preferred ranges, or territories within the Bank. The concentration of humpbacks may be a significant feature for other humpbacks (Whitehead and Moore 1982).
- As part of a large-scale assessment called More of North Atlantic Humpbacks (MoNAH) project, extensive sampling was conducted on humpbacks in the Gulf of Maine/Scotian Shelf region and the primary wintering ground on Silver Bank during 2004-2005. The work is intended to update the YONAH assessment in preparation for a possible status review under the Endangered Species Act (Waring, Josephson, Fairfield-Walsh, & Maze-Foley, 2009).

IUCN Marine Region 13: East Asian Sea

Area in the Ombai Strait in the Savu Sea Marine Protected Area (Indonesia)

Potential Criteria:	2B: Migration Route 2B: Feeding Grounds
Species of Concern:	Blue Whale (*Balaenoptera musculus*) Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: Location inferred from Pet Soede (2002)	124°19'2.12"E, 8°40'3.814"S 125°0'5.731"E, 8°32'35.885"S 124°49'57.827"E, 8°46'59.748"S 124°26'46.047"E, 8°57'55.645"S *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	June through September

Background

- The Indonesian Marine Affairs and Fisheries Minister Freddy Numberi announced the designation of the Savu Sea National Marine Park — a blue whale hotspot, in May 2009.
- There is little species information on this area. However, The Nature Conservancy has sponsored the Solor-Alor Visual and Acoustic Cetacean Survey & Research Program in this area since 2001. Their studies consider the southeastern cape of Alor and the entrance of Ombai Strait, is considered to be a wide and important migratory corridor between Alor and East Timor (Pet Soede 2002).
- Initial comparisons between blue whale sightings south of Alor (Savu Sea) and north of Komodo (Flores Sea) suggests that blue whales enter and exit Indonesian Seas through different routes and corridors; perhaps initially migrating east towards Ombai Strait, between E Alor and Timor, and then move into the Banda Sea (Pet Soede 2002).
- The Savu Sea is located in eastern Indonesia at the nexus of the Pacific and Indian Oceans. However, many researchers believe that it is may be a significant area for oceanic cetaceans in the Indonesian Seas (Kahn 2008).
- The small passages between the Solor-Alor Islands in the Savu Sea are considered feeding grounds and corridors for cetacean migration (Mustika 2006).
- Two traditional communities (Lamalera village on Lembata Island and Lamakera village on Solor Island) hunt whales in the Savu Sea, a practice which impacts on marine mammal populations but which is poorly documented (Mustika 2006).

IUCN Marine Region 14: South Pacific

Penguin Bank (Hawaii)

Potential Criteria:	2A: High Density 2B: Breeding Area
Species of Concern:	Humpback whales (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Mobley (2001)	157°30'58.217"W, 21°10'2.179"N to 157°30'22.367"W, 21°9'46.815"N to 157°31'0.778"W, 21°6'39.882"N to 157°30'30.049"W, 21°2'51.976"N to 157°29'28.591"W, 20°59'52.725"N to 157°27'35.919"W, 20°58'5.174"N to 157°30'58.217"W, 20°55'49.456"N to 157°42'42.418"W, 20°50'44.729"N to 157°44'45.333"W, 20°51'2.654"N to 157°46'4.716"W, 20°53'56.784"N to 157°45'33.987"W, 20°56'32.988"N to 157°43'10.586"W, 21°1'27.472"N to 157°39'27.802"W, 21°5'20.499"N to 157°30'58.217"W, 21°10'2.179" *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	January through April

Background

- The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawai’i. The sanctuary, which lies within the shallow (less than 600 feet), warm waters surrounding the main Hawaiian Islands, constitutes one of the world's most important humpback whale habitats (Hawaiian Islands Humpback Whale NMS, 2009)
- With the exception of a portion of Penguin Banks, the Hawaiian Islands Humpback Whale National Marine Sanctuary is located within 12 nautical miles (nm) of the islands. Penguin Bank is a shallow area of known humpback whale concentration (Mate, Gisiner, & Mobley, 1998).
- The primary period of humpback whale presence in Hawaiian waters is January through April, with peak abundance occurring earlier near the island of Hawai‘i than the other islands (Gabriele, et al. 2003). Their report identified the highest whale densities near Keahole Point and just north of Kawaihae Harbor, and lower densities near the resorts along the shore south of Kawaihae (Gabriele, et al. 2003).
- The main Hawaiian Islands (MHI) are the primary winter reproductive area for the majority of North Pacific humpback whales. Identification photographs of individual whales, including 63 females sighted in at least 2 different years and with at least 1 calf, were collected from waters off the islands of Maui and Hawaii between 1977 and 1994 (Craig and Herman 2000).
- Calves formed a significantly larger proportion of the population off Maui than off the Big Island. The overall proportion of calves to all whales identified (crude birth rate) was 0.099 off Maui and 0.061 off the Big Island (Craig and Herman 2000).
- Aerial surveys conducted in Hawaiian waters during the winter months (Jan-Apr) of 1976-80 showed humpbacks to be most prevalent in coastal regions and shallow banks where the expanse of water less than 100-fathoms (183 m) was more extensive. Greatest densities of adult humpbacks and calf pods were found in the "four island region" (FIR) consisting of Maui, Molokai, Kahoolawe and Lanai, as well as Penguin Bank (Mobley, 2001).
- Mobley, Bauer and Herman (1999) confirmed the earlier preference of both adult humpbacks and calf pods for the FIR and Penguin Bank regions, but also showed a substantial increase of adult humpbacks in the Kauai/Niihau region (Mobley, 2001).

IUCN Marine Region 15: Northeast Pacific

Monterey Submarine Canyon (California)

Potential Criteria:	2B: Foraging Area 2B: Migration Route
Species of Concern:	Blue whale (*Balaenoptera musculus*) Pacific gray whale (*Eschrichtius robustus*) Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Location inferred from Croll et al. (2001)	122°6'16.775"W, 36°44'31.3"N to 122°5'34.617"W, 36°35'12.717"N to 122°13'28.886"W 36°28'53.303"N to 122°28'14.186"W, 36°33'27.324"N to 122°51'25.373"W, 36°9'33.98"N to 122°58'37.484"W, 36°17'59.866"N to 122°31'55.511"W, 36°41'11.053"N
Proposed Seasonal Consideration:	December through June

Background

- In the Monterey Bay, blue whales forage as stenophagic predators of marine grazers in a simplified food web (primary producers—grazers—apex predators) (Croll, et al., 2005).
- Croll et al. (2005) examined the temporal and spatial linkages between: (1) the intensity of upwelling, (2) primary production, (3) development, density and distribution of euphausiids, and (4) the distribution, abundance, and foraging behavior of blue whales in Monterey Bay, California between 1992 and 1996. The authors found that blue whales fed exclusively upon adult euphausiids *Thysanoessa spinifera* and *Euphausia pacifica* that were larger than those generally available in the Bay.
- Croll et al. (2005) also reported that foraging whales dove repeatedly to dense euphausiid aggregations between 150 and 200 m on the edge of the Monterey Bay Submarine Canyon. In addition, euphausiid aggregations where blue whales were foraging averaged approximately 2 orders of magnitude greater than mean euphausiid densities in the Bay.
- Croll et al. (2005) also notes that high euphausiid densities are supported by high primary production between April and August and a submarine canyon that provides deep water down-current from an upwelling region.
- The cyclic annual migration of the northeastern Pacific blue whale population is associated with feeding at mid- to high-latitudes throughout the highly productive summer and fall, followed by a southbound migration to tropical regions to give birth and mate in the winter and spring. Primary production off southern California typically peaks in the spring allowing particular euphausiid species to grow to maturity by summer, coinciding with the arrival of blue whales (Burtenshaw, et al., 2004).
- Each fall, gray whales migrate south along the coast of North America from Alaska to Baja California, in Mexico, most of them starting in November or December (Rugh et al. 2001). Gray whale northbound migration generally begins in mid-February and continues through May with cows and newborn calves migrating northward primarily between March and June along the U.S. West Coast (Carretta, et al., 2008).

Cordell Bank Seamount (California)

Potential Criteria:	2B: Foraging Area 2B: Migration Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Pacific gray whale (*Eschrichtius robustus*)
Proposed Boundary Consideration: Location inferred from NMS (2009)	123°28'45.354"W, 38°14'2.191"N 123°18'58.435"W, 37°55'55.305"N 123°26'52.318"W, 37°53'44.878"N 123°36'21.846"W, 38°11'38.722"N
Proposed Seasonal Consideration:	June through November

Background

- Cordell Bank is located about 80 kilometers (50 miles) northwest of San Francisco and 32 kilometers west of the Point Reyes lighthouse. It is approximately 7 kilometers wide and 15 kilometers long and sits on the edge of the continental shelf. The bank is located on the edge of an underwater peninsula and is surrounded by deep water on three sides. Within 11 kilometers of its western edge, the seafloor drops to 1,829 meters at the sanctuary's western boundary (NMS, 2009a).
- Vertical entrapment and/or forcing of prey near the surface likely plays a role in predator aggregation over Cordell Bank. Also, Cordell Bank is shallower than the diurnal depth range of many zooplankton species, especially euphausiids and could vertically trap these prey species in shallow regions within the diving depth of many predators (Yen, et al., 2004)
- Pacific white-sided dolphins are one of the most abundant marine mammals in the sanctuary and humpback and blue whales are regularly seen in the summer and fall, when they visit the sanctuary to feed (NMS, 2009b).
- Gray whales traverse these waters on their annual migrations between Arctic feeding grounds and Mexican breeding areas; however, in some years, many gray whales will also over-summer in the sanctuary to feed (NMS, 2009b).
- Blue and humpback whales are seasonally abundant, migrating into the sanctuary during late spring, summer and fall to feed in its productive waters. Northern fur seals and California sea lions are also seasonally abundant, coming here to forage during the fall through the spring. Smaller cetaceans (e.g., several dolphin and porpoise species) exhibit high variability in distribution, likely associated with local changes in oceanographic conditions and prey abundance (NMS, 2009b).

Area Southwest of Farrallon Islands (United States)

Potential Criteria:	2B: Migration Route 2B: Breeding Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Pacific gray whale (*Eschrichtius robustus*) Blue whale (*Balaenoptera musculus*) Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Location inferred from Calambokidis et al. (2000)	123°9'10.907"W, 37°46'47.697"N to 123°0'24.06"W, 37°38'55.524"N to 123°11'59.895"W, 37°30'33.529"N to 123°20'36.801"W, 37°38'15.762"N to 123°9'10.907"W, 37°46'47.697"N
Proposed Seasonal Consideration:	November through April

Background

- Large numbers of whales and dolphins, including the Pacific White-sided dolphin, the California gray whale, the endangered Pacific humpback whale, and the endangered blue whale are found in the area (NMS, 2009c).
- Gray whales migrate south through the Gulf of the Farallones beginning in November – with peak sightings during January and March. Males, newly impregnated females and juveniles come through from February through April, and females with their newborn calves follow along, from April through June. A few juveniles may appear in the gulf year-round, off the Farallon Islands and in Bodega Bay (NMS, 2009c).
- Since 1982 Steller sea lion southernmost breeding colonies are within the Monterey Bay and Gulf of the Farallones National Marine Sanctuaries at Año Nuevo Island and the Farallon Islands, respectively. Females and juveniles Steller sea lions stay within the Gulf year-round, while males migrate north and offshore during the non-breeding season from the end of August through May (NMS, 2009c).
- For a 1999 photo identification survey, Cascadia Research's noted that out of a total of 244 identifications, of 148 unique individuals were cataloged in July, September and November in the Gulf of the Farallones region (including off Bodega Bay). Close to 50 identifications were made in the Gulf of the Farallones in August to November with most of these from a single day just west of the Farallon Islands. Finally, they were unable to find high concentrations of whales in other areas off California in 1999 (Calambokidis, et al., 2000).
- http://www.cascadiaresearch.org/reports/rep-CAL00.pdf

Southern California Bight: Tanner Bank and Cortez Bank (California)

Potential Criteria:	2B: Foraging Area 2B: Migration Route
Species of Concern:	Pacific gray whale (*Eschrichtius robustus*) Blue whale (*Balaenoptera musculus*) Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: Location inferred from NMS (2009)	119°16'27.66"W, 32°56'55.422"N 118°46'41.566"W, 32°26'42.867"N 119°2'7.689"W, 32°10'23.823"N 119°32'33.474"W, 32°40'49.608"N
Proposed Seasonal Consideration:	June through November

Background

- For blue whales, feeding was noted at a significant fraction of blue whale sightings over the shelf (out to 3.5 km beyond the 200 m isobath) in three areas: around Santa Rosa and San Miguel Islands, north of San Nicolas Island, and along the mainland coast from Pt. Conception north (Fiedler, et al., 1998)
- The results of the Whale Habitat and Prey Studies (WHAPS) show that blue whales aggregated near the Channel Islands during the summer, where they feed on dense patches of krill associated with the island shelf. Krill were most abundant along the shelf on the north and west sides of San Miguel Island and the north side of Santa Rosa Island (Fiedler, et al., 1998).
- Blue whales feed off the California coast from roughly June through November, and move southward to waters off Mexico in winter and spring (Calambokidis et al. 1990).
- Identifications of blue whales were obtained just off Point Arguello in July, in the Tanner/Cortes Bank area in the southern California Bight in August, and in the Santa Barbara Channel in August. http://www.cascadiaresearch.org/reports/rep-CAL00.pdf
- A study on visual and acoustic encounter rates for blue whales in the SAB reported elevated detection rates of in the Cortez Bank and Butterfly Bank subregions, as the dynamic bathymetry in those regions may concentrate high densities of euphausiids (Oleson, Calambokidis, Barlow, & Hildebrand, 2007). Oleson et al. also notes that the similarity in the visual and acoustic encounter rates in the Cortez Bank and Butterfly Bank subregions suggests that these areas may represent portions of the Bight important to both feeding and traveling whales.

Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon (Washington)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Killer whale (*Orcinus orca*)
Proposed Boundary Consideration: Location inferred from Calambokidis et al. (2004)	125°58'38.786"W, 48°30'1.995"N to 125°38'52.052"W, 48°16'55.605"N to 125°17'10.935"W, 48°23'7.353"N to 125°16'42.339"W, 48°12'38.241"N to 125°31'14.517"W, 47°58'20.361"N to 126°6'16.322"W, 47°58'20.361"N to 126°25'48.758"W, 48°9'46.665"N *and existing OBIA boundary as defined in the 2007 Rule.*
Proposed Seasonal Consideration:	June through September

Background

- A CSCAPE survey reported that humpback whale sightings were concentrated in the northern part of the study area between Juan de Fuca Canyon and the outer edge of the continental shelf, an area known as “the Prairie” (Fig. 2). A small area east of the mouth of Barkley Canyon and north of the Nitnat Canyon where the water depth was 125−145 m had a high density of sightings in all years (Calambokidis et al., 2004). http://www.cascadiaresearch.org/reports/Fish-bul-OCSwEratum.pdf
- NOAA Technical Memorandum 406 (NMFS 2007) estimated that the abundance of humpback whales within the combined three OC strata during 2005 (208, CV=0.28) was about twice the observed abundance during 1995-2000 (range of abundance estimates: 85 - 125, CVs ~0.32), but lower than the peak year of 2002 with 562 (CV=0.21) humpback whales.
- NOAA Technical Memorandum 406 (NMFS 2007) reports that humpback whales were observed largely in the same areas of the OCNMS as during previous years and noted that regions within and to the north (Canadian waters) and west (slope waters) of the OCNMS were likely important foraging regions for West Coast humpback whales.

Gulf of Alaska Steller Sea Lion Critical Habitat (Alaska)

Potential Criterion:	2B: Designated Critical Habitat
Species of Concern:	Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Basis: U.S. Government	Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144°W longitude. 145°43'7.708"W, 60°17'41.42"N to 143°37'31.682"W, 59°38'59.715"N to 146°26'15.838"W, 59°6'38.618"N to 147°34'46.397"W, 59°30'6.865"N to 150°15'53.824"W, 58°57'45.767"N to 151°45'20.388"W, 57°8'1.26"N to 155°30'50.98"W, 55°26'1.094"N to 159°22'19.342"W, 54°24'29.203"N to 162°43'58.85"W, 53°54'32.736"N to 163°23'18.616"W, 54°12'18.436"N to 172°57'38.806"W, 51°40'49.533"N to 179°25'44.364"W, 50°49'26.613"N to 179°39'3.639"W, 51°6'34.253"N to 163°49'34.33"W, 54°21'56.96"N to 157°56'22.112"W, 56°20'3.869"N to 153°11'13.812"W, 58°25'39.894"N to 148°41'53.223"W, 59°49'8.687"N to 148°2'52.488"W, 59°38'59.715"N
Proposed Seasonal Consideration:	Year-Round

Background

- NMFS has designated critical habitat for the Steller sea lion in certain areas and waters of Alaska. Steller sea lions are dependent on these areas and features for its continued existence and any Federal action that may affect these areas or features is subject to the consultation requirements of section 7 of the ESA (NMFS, 1993).
- The critical habitat surrounding each GOA rookery and major haulout site includes not only the aquatic areas adjacent to rookeries that are essential to lactating females and juveniles, but also - encompasses aquatic zones around major haulouts which provide foraging and refuge habitat for non-breeding animals year-round and for reproductively mature animals during the non-breeding season (NMFS, 1993).
- Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in State- and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is east of 144°W longitude. Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144°W longitude (NMFS, 1993).

IUCN Marine Region 16: Northwest Pacific

Piltun and Chayvo Offshore Feeding Grounds (Russia)

Potential Criteria:	2B: Migration Route 2B: Foraging Area
Species of Concern:	Western Pacific gray whale (*Eschrichtius robustus*)
Proposed Boundary Consideration: Location inferred from IWC and Tyurneva (2006)	143°33'26.5"E, 53°30'42.938"N to 143°40'42.039"E, 53°34'13.683"N to 143°48'39.728"E, 52°41'4.409"N to 143°51'56.423"E, 52°1'44.066"N to 143°24'32.613"E, 52°2'54.314"N to 143°40'13.94"E, 52°38'43.912"N to 143°33'26.5"E, 53°30'42.938"N
Proposed Seasonal Consideration:	June through November

Background

- The critically endangered western gray whale spends the summer-fall open water period feeding off northeast Sakhalin Island (Rutenko, et al., 2007).
- A previously unknown gray whale feeding area (the Offshore feeding area) was discovered south and offshore from the nearshore Piltun feeding area. The Offshore area has subsequently been shown to be used by feeding gray whales during several years when no anthropogenic activity occurred near the Piltun feeding area (Johnson, et al., 2007).
- The western population of gray whales is one of the most endangered whale populations in the world. Total abundances from 1997 to 2003 were estimated as 64 ± 5.1 (SE), 55 to 75 (95% CI); 75 ± 4.9, 66 to 85; 86 ± 3.1, 80 to 93; 77 ± 4.7, 68 to 87; 91 ± 3.4, 84 to 98; 98 ± 4.1, 90 to 106; and 99 ± 4.9, 90 to 109, respectively. These abundance estimates, particularly the last values in the series, most likely approximate the size of the entire western gray whale population. For comparison to the trend in the abundance estimates, life history data were used to estimate the growth rate of the population. Depending on the range of potential fecundity values incorporated, the resulting growth rate estimates indicate an annual population increase that is between 2.5 and 3.2%. The extremely small population size and slow rate of increase documented here further highlight concern about the viability of this critically endangered population (Bradford, et al., 2008).
- Results of a 2001-2003 aerial survey of the area indicated that gray whales occurred in predominantly two areas, (1) adjacent to Piltun Bay, and (2) offshore from Chayvo Bay (offshore feeding areas). In the Piltun feeding area, the majority of whales were observed in waters shallower than 20 m and were distributed from several hundred meters to similar to 5 km from the shoreline. In the offshore feeding area during all years, the distribution of gray whales extended from southwest to northeast in waters 30-65 m in depth. Fluctuations in the number of whales observed within the Piltun and offshore feeding areas and few sightings outside of these two areas indicate that gray whales move between the Piltun and offshore feeding areas during their summer-fall feeding season. Seasonal shifts in the distribution and abundance of gray whales between and within both the Piltun and offshore feeding areas are thought, in part, to be a response to seasonal changes in the distribution and abundance of prey (Meier, et al., 2007).

IUCN Marine Region 17: Southeast Pacific

Costa Rica Dome (Costa Rica, Panama)

Potential Criteria:	2B: Foraging Area 2B: Wintering Ground
Species of Concern:	Blue whale (*Balaenoptera musculus*) Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration:	TBD
Proposed Seasonal Consideration:	TBD

Background

- The Costa Rica Dome is an area of the coast of Costa Rica where the strong tropical thermocline reaches to within 10 meters of the sea surface. The dome measures about 150 by 300' kilometers. It is situated near lat. 9° N., long. 89° W., at the eastern end of a ridge in the topography of the thermocline along the northern boundary of the Equatorial Countercurrent. This current, the Costa Rica Coastal Current, and parts of the North Equatorial Current form a cyclonic circulation around the dome (Wyrtki, 1964).
- The distribution of blue whales, in the eastern tropical Pacific (ETP) was analyzed from 211 sightings of 355 whales recorded during research vessel sighting surveys or by biologists aboard fishing vessels. Over 90% of the sightings were made in just two areas: along Baja California, and in the vicinity of the Costa Rica Dome. All sightings occurred in relatively cool, upwelling-modified waters. The Costa Rica Dome area was occupied year round, suggesting either a resident population, or that both northern and southern hemisphere whales visit with temporal overlap (Reilly and Thayer, 1990).
- Research conducted in the 1990s reported that some humpback whales from the North Pacific were also using Costa Rican waters as a wintering ground (Acevedo and Smultea, 1995).
- With blue whales, the greatest unknown is whether their year-round residency on the Costa Rica Dome is indicative of a distinct, non-migratory population segment or whether some individuals may choose not to migrate every year (Calambokidis et al. 1990).

IUCN Marine Region 18: Australia – New Zealand

Great Barrier Reef Between 16°S and 21°S (Australia)

Potential Criterion:	2B: Breeding Ground
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Dwarf Minke whale (*Balaenoptera acutorostrata*)
Proposed Boundary Consideration: Location inferred from Arnold (1997)	145°38'46.988"E, 16°1'49.75"S to 146°20'56.18"E, 15°52'12.917"S to 146°59'23.514"E, 17°28'21.251"S to 151°39'40.427"E, 20°16'13.65"S to 150°30'53.849"E, 20°58'22.843"S to 146°49'46.681"E, 18°51'10.893"S to 145°38'46.988"E, 16°1'49.75"S
Proposed Seasonal Consideration:	May through September

Background

- Of particular concern in the Marine Park is a population of dwarf minke whales occurring off northern Queensland, most often seen in the Ribbon Reefs area in June and July although present in the Park from about May to October (Great Barrier Reef Marine Park Authority 2000)
- Commercial swim programs with the dwarf minke whale occur seasonally (primarily June - July) within the Cairns and Far Northern sections of the Great Barrier Reef (GBR) Marine Park (Birtles et al. 2002).
- An IWC compilation of 181 sightings from the central and northern Great Barrier Reef indicated that dwarf minke whales were regularly seen between Cairns (16°55' S) and Yonge Reef (14° 36' S). Sightings occurred from May to September, with 79.5% of sightings in June and July. Observations suggest, however, that groups of animals may occur in open water on the continental shelf, inshore of the reefs where most whales have been reported. Records of stranded animals 3 m or less in length indicate calving can occur at about 24E-38E S in Australia. There were four reports of cow-calf pairs on the northern Great Barrier Reef, between 15°-16°S, but more information is needed to assess the extent to which the area is a calving/nursery ground (Arnold 1997).
- Humpback whales which migrate along the east Australian coast comprise part of the Area V (130° E - 170° W) stock. Sheltered water within the Great Barrier Reef between latitudes 16°-21° S appear to be an important breeding ground for the east Australian humpback whale stock (Paterson and Paterson, 1984).
- The humpback whales present in the marine park generally spend the summer feeding in the nutrient-rich waters of Antarctica, migrate northwards in the autumn, and winter in warm-water breeding areas, including the waters off the coast of Queensland. Humpbacks are usually present in the Marine Park from June to October. Of particular concern in the Marine Park are possible adverse effects on pregnant females and cows with young calves. Lactating females typically migrate north before pregnant females, and cows with newborn calves tend to be last to leave the breeding areas to return south to the feeding grounds. Thus, cows who are pregnant or who have young (dependent) calves are present in the Marine Park throughout the season (Great Barrier Reef Marine Park Authority 2000).

Bonney Upwelling (Australia)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Blue whale (*Balaenoptera musculus*) Pygmy blue whale (*B. m. brevicauda*) New Zealand fur seal (*Arctocephalus forsteri*) Southern right whale (*Eubalaena australis*) Australian sea lion (*Neophoca cinera*)
Proposed Boundary Consideration: Location inferred from Gill (2002)	139°31'17.703"E, 37°12'20.036"S to 139°42'42.508"E, 37°37'33.815"S to 140°22'57.345"E, 38°10'36.144"S to 141°33'50.342"E, 38°44'50.558"S to 141°11'0.733"E, 39°7'4.125"S to 139°10'52.263"E, 37°28'33.179"S
Proposed Seasonal Consideration:	November through May

Background

- The Bonney Upwelling (formerly the Blue Whale aggregation) is characterized by classical upwelling plumes regularly observed along the Bonney Coast (Robe, South Australia to Portland, Victoria).
- To assess how seasonal changes in ocean productivity influenced foraging behavior, one study fitted18 lactating New Zealand fur seals with satellite transmitters and time-depth recorders (TDRs). Using temperature and depth data from TDRs, they used the presence of thermoclines as a surrogate measure of upwelling activity in continental- shelf waters. During the austral autumn, 80% of lactating fur seals foraged on the continental shelf (114 ± 44 km from the colony), in a region associated with the Bonney upwelling. In contrast, during winter months seals predominantly foraged in oceanic waters (62%), in a region associated with the Subtropical Front (460 ± 138 km from the colony). The study concluded that lactating New Zealand fur seals shift their foraging location from continental-shelf to oceanic waters in response to a seasonal decline in productivity over the continental shelf, attributed to the cessation of the Bonney upwelling (Bayliss et al. 2008).
- A localized aggregation of blue whales, which may be pygmy blue whales, occurs in southern Australian coastal waters (between 139°45' E-143°E) during summer and autumn (December-May), where they feed on coastal krill (*Nyctiphanes australis*), a species which often forms surface swarms. While the abundance of blue whales using this area is unknown, up to 32 blue whales have been sighted in individual aerial surveys. Krill appear to aggregate in response to enhanced productivity resulting from the summer-autumn wind-forced Bonney Coast upwelling along the continental shelf. During the upwelling's quiescent (winter-spring) period, blue whales appear to be absent from the region. Krill surface swarms have been associated with 48% of 261 blue whale sightings since 1998, with direct evidence of feeding observed in 36% of all sightings. Mean blue whale group size was 1.55 (SD = 0.839), with all size classes represented including claves. This seasonally predictable upwelling system is evidently a regular feeding ground for blue whales (Gill 2002).
- http://bluewhalestudy.com/home.html

Head of Bight (Australia)

Potential Criteria:	2B: Breeding Area 2B: Calving Area
Species of Concern:	Southern right whale (*Eubalaena australis*) Australian sea lion (*Neophoca cinera*)
Proposed Boundary Consideration: Location inferred from Burnell (2001) & Australian Government	130°28'17.18"E, 31°47'2.974"S 130°51'46.337"E, 31°47'2.974"S 130°51'46.337"E, 31°57'11.243"S 130°28'17.18"E, 31°57'1.105"S
Proposed Seasonal Consideration:	May through October

Background

- The Head of Bight represents the main breeding area for southern right whales in Australia (Burnell and Bryden, 1997; Burnell, 2001).
- The duration and timing of coastal residence of individually identified southern right whales at a principal aggregation area on the southern Australian coast differed markedly between females with calves and unaccompanied whales. The mean residence period of females that calved within the aggregation area was 70.9 days, with mean residence mid-points of 20 August in 1993 and 22 August in 1994. Whales have been sighted at this aggregation area from mid May to late October (approx. 160 days), although the effective calving season (95-100% of calves born) lasted only 88 days in 1993 and 96 days in 1994 (Burnell and Bryden, 1997).
- Over 350 individual southern right whales have been photographically identified at the Head of Bight, between 1991 and 1997 (Burnell, 2001). Calving occurs on average every 3 years with over 90% of females returning to the Head of Bight (Burnell, 2001)

Works Cited

Acevedo A, Smultea A. (1995) First records of humpback whales including calves at Golfo Dulce and Isla Del Coco, Costa Rica, suggesting geographical overlap of Northern and Southern Hemisphere populations. *Marine Mammal Science*, 11, 554-560.

Arnold, P., & International Whaling Comm. (1997). Occurrence of dwarf minke whales (*Balaenoptera acutorostrata*) on the Northern Great Barrier Reef, Australia. *Report of the International Whaling Commission*. 47, 419-424.

Azzellino, A., Gaspari, S., Airoldi, S., & Nani, B. (2008). Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep-Sea Research Part I: Oceanographic Research Papers, 55*(3), 296-323.

Baraff, L., Clapham, P., Mattila, D., & Bowman, R. (1991). Feeding behavior of a humpback whale in low-latitude waters. *Marine Mammal Science*, *7*(2), 197-202.

Baumgartner, M., Cole, T., Clapham, P., & Mate, B. (2003). North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. *Marine Ecology Progress Series, 264*, 137-154.

Baylis, A. M.M., B. Page, and S.D. Goldsworthy. 2008. Effect of seasonal changes in upwelling activity on the foraging locations of a wide-ranging central-place forager, the New Zealand fur seal. *Canadian Journal of Zoology*. 86(8), 774-789.

Bradford, A. L., D. W. Weller, P. R. Wade, A. M. Burdin And R. L. Brownell, Jr. (2008). Population abundance and growth rate of western gray whales *Eschrichtius robustus*. *Endangered Species Research,* 16, 1–14.

Birtles R.A., P.W. Arnold, and A. Dunstan. (2002). Commercial Swim Programs With Dwarf Minke Whales On The Northern Great Barrier Reef, Australia: Some Characteristics Of The Encounters With Management Implications. *Australian Mammalogy* 24, 23–38.

Burnell, S.R. (2001). Aspects of the reproductive biology, movements and site fidelity of right whales off Australia. *Journal of Cetacean Research and Management*. Special issue 2, 89-102.

Burnell, S.R. and M. M. Bryden. (1997). Coastal residence periods and reproductive timing in southern right whales, *Eubalaena australis*. *Journal of Zoology*. 241(4), 613-621.

Burtenshaw, J. C., Oleson, E. M., Hildebrand, J. A., McDonald, M. A., Andrew, R. K., Howe, B. M., et al. (2004). Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. *Deep Sea Research (Part II, Topical Studies in Oceanography), 51*(10-11), 967-986.

Calambokidis, J., G.H. Steiger, J.C. Cubbage, K.C. Balcomb, C. Ewald, S. Kruse, R. Wells, and R. Sears. (1990). Sightings and movements of blue whales off central California 1986-8 from photo-identification of individuals. *Report of the International Whaling Commission* (Special Issue 12), 343-348.

Calambokidis, J., Steiger, G., Ellifrit, D., Troutman, B., & Bowlby, C. (2004). Distribution and abundance of humpback whales(*Megaptera novaeangliae*) and other marine mammals off the northern Washington coast. Fishery Bulletin, 102(4), 563-580.

Calambokidis, J., Steiger, G. H., Rasmussen, K., Urban, R. J., Balcomb, K. C., Guevara, P., et al. (2000). Migratory destinations of humpback whales that feed off California, Oregon and Washington. *Marine Ecology Progress Series, 192*, 295-304.

Carretta, J. V., Forney, K. A., Lowry, M. S., Barlow, J., Baker, J., Hanson, B., et al. (2008). *U.S. Pacific Marine Mammal Stock Assessments: 2008* (Report No. NOAA-TM-NMFS-SWFSC-434).

Clapham, P., & Mattila, D. (1990). Humpback whale songs as indicators of migration routes. *Marine Mammal Science*, *6*(2), 155-160.

Craig, A.S., and L.M. Herman. (2000). Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. *Marine Ecology Progress Series*. 193, 209-216.

Croll, D. A., Marinovic, B., Benson, S., Chavez, F. P., Black, N., Ternullo, R., et al. (2005). From wind to whales: trophic links in a coastal upwelling system. *Marine Ecology Progress Series, 289*, 117-130.

D' Amico, A., Bergamasco, A., Zanasca, P., Carniel, S., Nacini, E., Portunato, N., et al. (2003). Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. *IEEE Journal of Oceanic Engineering, 28*(1), 29-43.

Danilewicz, D., Tavares, M., Moreno, I., Ott, P., & Trigo, C. (2009). Evidence of feeding by the humpback whale (Megaptera novaeangliae) in mid-latitude waters of the western South Atlantic. *Marine Biodiversity Records, 2,* e88.

DFO. (2007). *Recovery Potential Assessment Of Northern Bottlenose Whale, Scotian Shelf Population. Science Advisory Report 2007/011*.

Fiedler, P., Reilly, S., Hewitt, R., Demer, D., Philbrick, V., Smith, S., et al. (1998). Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Research Part II, 45*(8-9), 1781-1801.

Gabriele, C.M., S.H. Rickards, S.E. Yin, and A.S. Frankel. (2003). Trends in Relative Distribution, Abundance and Population Composition of Humpback Whales, *Megaptera novaeangliae*, in Kawaihae Bay, Hawai'i 1988-2003. *Final Report August 2003 for the Department of Land and Natural Resources, State of Hawai'I and the Hawaiian Islands Humpback Whale National Marine Sanctuary, National Marine Sanctuary Program, National Oceanic and Atmospheric Administration,* U.S. Department of Commerce. 37 pp.

Gill, P. C. (2002). A blue whale (*balaenoptera musculus*) feeding ground in a southern Australian coastal upwelling zone. *Journal of Cetacean Research and Management.* 4(2), 179-184.

Gilles, A., M. Scheidat, and U. Siebert. (2008). *Harbour porpoises in German waters –evaluating proposed Natura 2000 sites*. Edited by Peter G. H. Evans. Proceedings of the ECS/ASCOBANS/ACCOBAMS Workshop Selection Criteria for Marine Protected Areas for Cetaceans. pp. 76-82.

Hawaiian Islands Humpback Whale NMS. Hawaiian Islands Humpback Whale NMS - About Us. http://hawaiihumpbackwhale.noaa.gov/about/welcome.html (accessed September 14, 2009).

Hooker, S., Iverson, S., Ostrom, P., & Smith, S. (2001). Diet of northern bottlenose whales inferred from fatty-acid and stable-isotope analyses of biopsy samples. *Canadian Journal of Zoology, 79*(8), 1442-1454.

Hooker, S., Whitehead, H., & Gowans, S. (2002). Ecosystem consideration in conservation planning: energy demand of foraging bottlenose whales (Hyperoodon ampullatus) in a marine protected area. *Biological Conservation, 104*(1), 51-58.

IMO. (2007). *International Maritime Organization, Routing measures other than Traffic Separation Schemes. Ref. T2-OSS/2.7, SN.1/Circ.263,*.

Johnson, S. R., Richardson, W. J., Yazvenko, S. B., Blokhin, S. A., Gailey, G., Jenkerson, M. R., Meier, S. K., Melton, H. R., Newcomer, M. W., Perlov, A. S., Rutenko, S. A., Wuersig, B., Martin, C. R., & Egging, D. E. (2007). A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment*. 134(1-3), 1-19.

Kahn, B. (2008). The Savu Sea of East Indonesia - SE Asia's Open Ocean Wilderness: Oceanic Cetacean Hotspot, Traditional Sperm Whaling and Indo-Pacific Marine Corridor. 2008 *Ocean Sciences Meeting: From the Watershed to the Global Ocean.* American Geophysical Union, 2000 Florida Ave., N.W. Washington, D.C., 20009 USA, 2008.

Keller, C., Ward-Geiger, L., Brooks, W., Slay, C., Taylor, C., & Zoodsma, B. (2006). North Atlantic right whale distribution in relation to sea-surface temperature in the southeastern United States calving grounds. *Marine Mammal Science, 22*(2), 426.

Kenney, R., Winn, H., & Macaulay, M. (1995). Cetaceans in the Great South Channel, 1979-1989: right whale (Eubalaena glacialis). *Continental Shelf Research, 15*(4-5), 385-414.

Kenney, R., & Wishner, K. (1995). The South Channel Ocean Productivity EXperiment. *Continental Shelf Research, 15*(4-5), 373-384.

Kraus, S., Hamilton, P., Kenney, R., Knowlton, A., & Slay, C. (2001). Reproductive parameters of the North Atlantic right whale. *Journal of Cetacean Research and Management, 2*, 231-236.

Mate, B. R., Gisiner, R., & Mobley, J. (1998). Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Canadian Journal of Zoology/Revue Canadien de Zoologie, 76*(5), 863-868.

Mattila, D., Clapham, P., Katona, S., & Stone, G. (1989). Population composition of humpback whales, Megaptera novaeangliae, on Silver Bank, 1984. *Canadian Journal of Zoology, 67*(2), 281-285.

Meier, S. K., S.B. Yazvenko, S.A. Blokhin, P. Wainwright, M.K. Maminov, Y.M. Yakovlev, and M.W. Newcomer. (2007). Distribution and abundance of western gray whales off northeastern Sakhalin island, Russia, 2001-2003. *Environmental Monitoring and Assessment*. 134(1-3), 107-136.

Merrick, R., & Cole, T. (2007). *Evaluation of northern right whale ship strike reduction measures in the Great South Channel of Massachusetts, NOAA Tech Memo NMFS NE 202*: National Oceanic and Atmospheric Administration.

Mobley, J., Jr., Spitz, S. and Grotefendt, R. (2001). *Abundance Of Humpback Whales In Hawaiian Waters: Results Of 1993-2000 Aerial Surveys*: Marine Mammal Research Consultants.

Mustika, P.L.K. (2006). Marine Mammals in the Savu Sea (Indonesia): Indeginous Knowledge, Threat Analysis and Management Options. Master's Thesis. http://eprints.jcu.edu.au/2064/

NMFS. (1993). *Designated Critical Habitat; Steller Sea Lion. 58 Federal Register 45269-45285, August 27, 1993.*

NMFS. (1994). *Designated Critical Habitat; Northern Right Whale. 59 Federal Register 28793-28834, June 3, 1994*.

NMS. (2009a, March 26, 2008). Cordell Bank Sanctuary: Seamounts And Banks. Retrieved September 2009, from http://www.sanctuarysimon.org/cordell/sections/seamounts/overview.php?sec=sm

NMS. (2009b, March 26, 2008). Cordell Bank Sanctuary: Marine Mammals. Retrieved September 2009, from http://www.sanctuarysimon.org/cordell/sections/marineMammals/overview.php?sec=mm

NMS. (2009c, March 26, 2008). Gulf of the Farrallones Sanctuary. Retrieved September 2009, from http://www.sanctuarysimon.org/farallones/index.php

Notarbartolo-Di-Sciara, G., Zanardelli, M., Jahoda, M., Panigada, S., & Airoldi. (2003). The fin whale Balaenoptera physalus (L. 1758) in the Mediterranean Sea. *Mammal Review, 33*(2), 105-150.

Oleson, E., Calambokidis, J., Barlow, J., & Hildebrand, J. B. (2007). Blue whale visual and acoustic encounter rates in the Southern California Bight. *Marine Mammal Science, 23*(3), 574-597.

Panigada, S., Notarbartolo di Sciara, G., Panigada, M., Airoldi, S., Borsani, J., & Jahoda, M. (2005). Fin whales (Balaenoptera physalus) summering in the Ligurian Sea: distribution, encounter rate, mean group size and relation to physiographic variables. *Journal of Cetacean Research Management*, *7*(2), 137-145.

Paterson, R., and P. Paterson. (1984). A study of the past and present status of humpback whales in east Australian waters. *Biological Conservation*. 29(4), 321-343.

Pet-Soede, L. (2002). The Solor and Alor islands: Expedition results, data collected during 2 reconnaissance trips; 9-12 September 2001 and 7-19 May, 2002. *Report of a joined activity by The Nature Conservancy Southeast Asia Center for Marine Protected Areas and World Wide Fund for Nature Wallacea Bioregional Program*. 110p.

Reeves, R., Mckenzie, M., & Smith, T. (2006). History of Bermuda shore whaling, mainly for humpback whales. *Journal of Cetacean Research and Management, 8*(1), 33.

Reilly, S., & Thayer, V. (1990). Blue Whale (Balaenoptera-Musculus) Distribution In The Eastern Tropical Pacific. *Marine Mammal Science, 6*(4), 265-277.

Rutenko, A. N., S.V. Borisov, A.V. Gritsenko, and M.R. Jenkerson. (2007). Calibrating and monitoring the western gray whale mitigation zone and estimating acoustic transmission during a 3D seismic survey, Sakhalin island, Russia. *Environmental Monitoring and Assessment*. 134(1-3), 21-44.

Scheidat, M., A. Gilles, K.-H. Kock, and U. Siebert. (2008). Harbour porpoise Phocoena phocoena abundance in the southwestern Baltic Sea. *Endangered Species Research*. 5, 215–223.

Scott, G.P., and H.E. Winn. (1977). An aerial sampling method for humpback whales, Megaptera novaeangliae, using vertical photographs. *Proceedings (abstracts) of the Second Conference on the Biology of Marine Mammals, San Diego, California, 12-15 December 1977.*

Shelden, K. E. W., Baldridge, A., & Withrow, D. E. (1995). Observations of Risso's dolphins, Grampus griseus with gray whales, Eschrichtius robustus. *Marine Mammal Science, 11*(2), 231-240.

Siebert, U., A. Gilles, K. Lucke, M. Ludwig, H. Benke, K.H. Kock, M. Scheidat. (2006). A decade of harbour porpoise occurrence in German waters: analyses of aerial surveys, incidental sightings and strandings. *Journal of Sea Research*. 56(1), 65-80.

Stone, G., Katona, S., & Tucker, E. J. B. C. (1987). History, migration and present status of humpback whales Megaptera novaeangliae at Bermuda. *42*(2), 133-145.

Tyack, P., and H. Whitehead. (1983). Male competition in large groups of wintering humpback whales. *Behaviour*. 83(1-2), 132-154.

Verfuss, U. .K, C.G. Honnef, A., Daehne, M. Meding, R. Mundry, and H. Benke. (2007). Geographical and Seasonal Variation of Harbour Porpoise (*Phocoena phocoena*) Presence in the German Baltic Sea Revealed By Passive Acoustic Monitoring. *Journal of the Marine Biological Association of the United Kingdom*. 87(1), 165-176.

Waring, G., Josephson, E., Fairfield-Walsh, C., & Maze-Foley, K. (2009). US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments--2008. *NOAA Tech Memo NMFS NE 210, 210*(440), 02543-01026.

Whitehead, H., and M., Moore. (1982). Distribution and movements of West Indian humpback whales in winter. *Canadian Journal of Zoology*. 60(9), 2203–2211.

Whitehead, H., Gowans, S., Faucher, A., & McCarrey, S. (1997). Population analysis of northern bottlenose whales in the Gully Nova Scotia. *Marine Mammal Science, 13*(2), 173-185.

Wimmer, T., & Whitehead, H. (2004). Movements and distribution of northern bottlenose whales, Hyperoodon ampullatus, on the Scotian Slope and in adjacent waters. *Canadian Journal of Zoology, 82*(11), 1782-1794.

Yen, P. P. W., Sydeman, W. J., & Hyrenbach, K. (2004). Marine bird and cetacean associations with bathymetric habitats and shallow- water topographies: implications for trophic transfer and conservation. *Journal of Marine Systems, 50*(1-2), 79-99.

APPENDIX D-3: NMFS INITIAL MARINE MAMMAL OBIA SCREENING MATRIX, 23 NOVEMBER 2009

MEDITERRANEAN

	GEOGRAPHY			BIOLOGY							CRITERIA		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Specie[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area2a, 2b, or 2	Nomination Status	Designation	IUCN Category
Northeast Slope in the Ligurian-Corsican-Provençal Basin	Mediterranean	International	Y	Fin whale	N	N	Y	N	N	N	Eligible	Eligible	Eligible	None	None
Pelagos Sanctuary for Mediterranean Marine Mammals	Mediterranean	International	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	SPAMI	N/A

---

[1] Marine Region as classified by the IUCN World Commission on Protected Areas (WCPA).

[2] For Eligible OBIAs, species presence is derived from peer-reviewed literature.

NW ATLANTIC

	Geography			Biology							Eligibility		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-Op Area (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Northwest of Challenger Bank	NW Atlantic	Bermuda	Y	Humpback whale	N	N	Y	Y	N	N	Eligible	Eligible	Eligible	National Cetacean Sanctuary	None
Saguenay-St Lawrence Marine Park	NW Atlantic	Canada	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine Park	None
The Gully Marine Protected Area	NW Atlantic	Canada	Y	Northern bottlenose whale	N	N	Y	N	Y	Y	Eligible	Eligible	Further Analysis Necessary	MPA	None
Shortland Canyon / Haldimand Canyon	NW Atlantic	Canada	Y	Northern bottlenose whale	N	N	Y	N	Y	Y	Eligible	Eligible	Further Analysis Necessary		None
Bay of Fundy Right Whale Conservation Area	NW Atlantic	Canada	N		Y	Y	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Conservation Area	None
Roseway Basin Right Whale Conservation Area (located between Browns and Baccaro Banks	NW Atlantic	Canada	Y	North Atlantic right whale	Y	N	Y	Y	N	N	Eligible	Eligible	Eligible	Proposed Conservation Area	None

NW ATLANTIC

	GEOGRAPHY			BIOLOGY							ELIGIBILITY		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-Op Area (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Auyuittug National Park	NW Atlantic	Canada	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Terrestrial Park	None
Manicouagan Marine Protected Area	NW Atlantic	Canada	N		N	N	Y	N	N	N	Not Eligible	Eligible	Not Eligible	Proposed MPA	None
Igaliqtuuq National Wildlife Area and Biosphere Reserve	NW Atlantic	Canada	N		N	N	Y	Y	Y	N	Not Eligible	Eligible	Not Eligible	Proposed MPA	None
Beaufort Sea Beluga Management Zone 1(a)	NW Atlantic	Canada	N		Y	N	Y	Y	Y	N	Not Eligible	Eligible	Not Eligible	Management Zone	None
Beaufort Sea Large Ocean Management Area (LOMA) (Shelf Break, Tuk Pen Inner and Outer Shelf areas)	NW Atlantic	Canada	N		Y	N	Y	Y	N	N	Not Eligible	Eligible	Not Eligible	Proposed MPA	None
Lancaster Sound National Marine Conservation Area	NW Atlantic	Canada	N		Y	N	Y	Y	Y	N	Not Eligible	Eligible	Not Eligible	Conservation Area	None

NW ATLANTIC

	GEOGRAPHY			BIOLOGY							ELIGIBILITY		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	**Marine Region[1]**	**Country**	**Outside the Coastal Standoff Distance or Non-Op Area (1)**	**Species[2]**	**High Density (2a)**	**Breeding Calving (2b)**	**Foraging Grounds (2b)**	**Migration Route (2b)**	**Critical Habitat (2b)**	**Small, Distinct Population (2c)**	**Criterion 1: Coastal Standoff Distance**	**Criterion 2: Concentration Area 2a, 2b, or 2c**	**Nomination Status**	**Designation**	**IUCN Category**
West Isles National Marine Conservation Area	NW Atlantic	Canada	N		N	N	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Proposed Conservation Area	None
Bonavista-Notre Dame Bays National Marine Conservation Area	NW Atlantic	Canada	N		U	N	U	U	N	U	Not Eligible	Unknown	Not Eligible	Proposed Conservation Area	None
Gerry E Studds Stellwagen Bank National Marine Sanctuary	NW Atlantic	United States	N	North Atlantic right whale	Y	N	Y	Y	N	N	Not Eligible	Not Eligible	Not Eligible	MPA	None
Great South Channel Northern Right Whale Seasonal Habitat	NW Atlantic	United States	Y	North Atlantic right whale	Y	N	Y	N	Y	N	Eligible	Eligible	Eligible	Federal ES Protected Area	IV
Cape Cod Bay Northern Right Whale Critical Habitat Area	NW Atlantic	United States	N		Y	N	Y	Y	Y	N	Not Eligible	Eligible	Not Eligible	Federal ES Protected Area	IV
Cape Cod Bay Ocean Sanctuary	NW Atlantic	United States	N		Y	N	Y	Y	N	N	Not Eligible	Eligible	Not Eligible	State Ocean Sanctuary	V
Cape Cod Ocean Sanctuary	NW Atlantic	United States	N		Y	N	Y	Y	N	N	Not Eligible	Eligible	Not Eligible	State Ocean Sanctuary	V

NW ATLANTIC

	GEOGRAPHY			BIOLOGY							ELIGIBILITY		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-Op Area (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Monitor National Marine Sanctuary	NW Atlantic	United States	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	MPA	None
Jeffreys Ledge (proposed MPA or proposed extension to Stellwagen Bank NMS)	NW Atlantic	United States	N		Y	N	Y	Y	Y	N	Not Eligible	Eligible	Not Eligible	Proposed MPA	None

NE ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Wadden Sea (Waddensee) Nature Reserve	NE Atlantic	Denmark, Germany, Netherlands	N		N	N	N	U	Y	Y	Not Eligible	Unknown	Not Eligible	International Reserve	None
Celtic Shelf Break Marine Protected Area	NE Atlantic	France, Ireland, France	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Proposed Offshore MPA	None
Dogger Bank Special Area of Conservation	NE Atlantic	Denmark, Germany, Netherlands, United Kingdom	Y	Harbor porpoise	Y	N	N	N	N	N	Eligible	Eligible	Further Analysis Necessary	Proposed SAC	None
Ilhéu de Baixo - Restinga Ilha Graciosa ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Costa e Caldeirão - Ilha do Corvo ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Caldeira e Capelinhos - Ilha do Faial ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Monte da Guia - Ilha do Faial ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Morro de Castelo Branco - Ilha do Faial ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None

NE ATLANTIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Costa Nordeste - Ilha das Flores ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Ponta dos Rosais - lha de S Jorge ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Costa NE e Ponta do Topo - Ilha de S Jorge ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Caloura-Ponta da Galera - Ilha de S Miguel ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Banco D João de Castro (Canal Terceira - S Miguel) ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Baixa do Sul (Canal do Faial) ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Ponta da Ilha - Ilha do Pico ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Lajes do Pico - Ilha do Pico ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None

NE ATLANTIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Ilhéus da Madalena - Ilha do Pico ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Ponta do Castelo - Ilha de Sta Maria ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Costa das Quatro Ribeiras - Ilha da Terceira ZEC	NE Atlantic	Portugal (Azores)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Formigas Islets and Dollabarat Reef (Canal S Miguel-Sta Maria) Nature Reserve (Seamount)	NE Atlantic	Portugal (Azores)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve & Proposed MPA	None
Iroise Marine National Park	NE Atlantic	France	N		N	Y	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Nature Reserve	None
Harbor Porpoise Sanctuary and SAC, National Park Wadden Sea of Schleswig-	NE Atlantic	Germany	Y	Harbor porpoise	Y	Y	Y	N	N	N	Eligible	Eligible	Further Analysis Necessary	Proposed SAC	None

NE ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Holstein (Sylt Outer Reef)															
Harbor Porpoise Sanctuary and SAC, National Park Wadden Sea of Schleswig-Holstein (Borkum-Riffgrund)	NE Atlantic	Germany	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Proposed SAC	None
Eastern German Bight	NE Atlantic	Germany	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible		None
Schleswig-Holsteinishes Wattenmeer National Park	NE Atlantic	Germany	N		Y	Y	N	Y	N	Y	Not Eligible	Eligible	Not Eligible	National Park & Proposed SAC	II
Irish Whale and Dolphin Sanctuary (Coast to EEZ limit)	NE Atlantic	Ireland	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	National Sanctuary	None
Shannon River Estuary SAC	NE Atlantic	Ireland	N		U	Y	Y	N	U	Y	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Galway Bay SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None

NE ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
North Connemara SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Roaringwater Bay SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Blasket Islands SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Dublin Bay SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Dursey Island SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Old Head of Kinsale SAC	NE Atlantic	Ireland	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Madeiran Marine Mammal Sanctuary	NE Atlantic	Portugal (Maderia)	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	National Sanctuary	None
Ilhas Desertas Natural Reserve and ZEC	NE Atlantic	Portugal (Maderia)	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Ponta de S. Lourenço ZEC	NE Atlantic	Portugal (Maderia)	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Ilhéu da Viúva Natural Reserve and ZEC	NE Atlantic	Portugal (Maderia)	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Proposed SAC	None

NE ATLANTIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Sado Estuary Natural Reserve and Ramsar area	NE Atlantic	Portugal	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Arrábida Natural Park and Marine Natural Reserve	NE Atlantic	Portugal	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Marine Natural Reserve & Proposed SAC	None
Doñana National Park	NE Atlantic	Spain	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park & Proposed SAC	None
Breña y Marismas de Barbate Natural Park	NE Atlantic	Spain	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Park & Proposed SAC	V
Islas Cies and Complex Ons-Ogrove National Park	NE Atlantic	Spain	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Park & Proposed SAC	V
Moray Firth	NE Atlantic	United Kingdom	N		U	U	U	U	U	N	Not Eligible	Unknown	Not Eligible	Proposed SAC	None
Cardigan Bay SAC	NE Atlantic	United Kingdom	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	SAC	None
Lleyn Peninsula and the Sarnau SAC	NE Atlantic	United Kingdom	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed SAC	None

NE ATLANTIC

Area	Geography: Marine Region[1]	Geography: Country	Geography: Outside the Coastal Standoff Distance or Non-OpArea (1)	Biology: Species[2]	Biology: High Density (2a)	Biology: Breeding Calving (2b)	Biology: Foraging Grounds (2b)	Biology: Migration Route (2b)	Biology: Critical Habitat (2b)	Biology: Small, Distinct Population (2c)	Criteria: Criterion 1: Coastal Standoff Distance	Criteria: Criterion 2: Concentration Area 2a, 2b, or 2c	Preliminary Result: Nomination Status	Additional Information: Designation	Additional Information: IUCN Category
Hebridean Marine National Park	NE Atlantic	United Kingdom	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park & Proposed MPA	None
Atlantic Frontier MPA and World Heritage Site	NE Atlantic	United Kingdom	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Proposed Offshore MPA	None
St Kilda Archipelago	NE Atlantic	United Kingdom	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	World Heritage Site & Proposed SAC	None

BALTIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Fehmarnbelt (Fehmarn Belt)	Baltic	Germany	N		N	Y	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Kadetrinne (Kadet Trench)	Baltic	Germany	N		Y	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Proposed SAC	None
Westliche Rönnebank (Western Ronne Bank)	Baltic	Germany	Y	Harbor porpoise	N	N	N	N	N	Y	Eligible	Eligible	Further Analysis Necessary	Proposed SAC	None
Pommersche Bucht mit Oderbank (Pommeranian Bay Odra Bank)	Baltic	Germany	Y	Harbor porpoise	N	N	N	N	N	Y	Eligible	Eligible	Further Analysis Necessary	Proposed SAC	None
Adlerground (Adler Ground)	Baltic	Germany	Y	Harbor porpoise	N	N	N	N	N	Y	Eligible	Eligible	Further Analysis Necessary	SAC	None
Kurshskaya Kosa National Park	Baltic	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Coastal National Park	None

CARIBBEAN

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Pelican Cays Land and Sea Park	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	II
Exuma Cays Land and Sea Park	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	II
Inagua National Park	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	II
Abaco National Park	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	II
Central Andros National Parks	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	None
Little Inagua National Park	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	None
Moriah Harbour Cay National Park	Caribbean	Bahamas	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	None
Port Honduras Marine Reserve	Caribbean	Belize	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine Reserve	IV
Belize Barrier Reef Reserve System World Heritage Site	Caribbean	Belize	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	World Heritage Site	II, III, IV

CARIBBEAN

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Swallow Cay Wildlife Sanctuary	Caribbean	Belize	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Wildlife Sanctuary	IV
Turneffe Atoll MPA and Biosphere Reserve	Caribbean	Belize	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Proposed Biosphere Reserve	None
Tortuguero National Park	Caribbean	Costa Rica	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	II
Gondoca-Manzanillo Wildlife Reserve	Caribbean	Costa Rica	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Wildlife Refuge	None
Seaflower Marine Protected Area	Caribbean	Columbia	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	MPA	None
Cuban National Natural Parks (19 sites)	Caribbean	Cuba	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Proposed National Parks	None
Soufrière/Scotts Head Marine Reserve	Caribbean	Dominica	N		N	N	N	Y	N	N	Not Eligible	Eligible	Not Eligible	Designated Marine Reserve	V
Marine Mammal Sanctuary of the Dominican Republic	Caribbean	Dominican Republic	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Marine Mammal Sanctuary	None

CARIBBEAN

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Silver Bank and Navidad Bank	Caribbean	Dominican Republic	Y	Humpback whale	N	Y	Y	N	N	N	Eligible	Eligible	Eligible		
East National Park	Caribbean	Domincan Republic	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	None
Bayahibe Marine Sanctuary	Caribbean	Domincan Republic	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Sanctuary	None
French West Indies AGOA marine mammal sanctuary	Caribbean	Guadeloupe Martinique	N		Y	Y	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Proposed MPA	None
St-Barthélemy MPA	Caribbean	Guadeloupe	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Nature Reserve	IV
Montego Bay Marine Park	Caribbean	Jamaica	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	II
Miskito Coast Protected Area	Caribbean	Nicaragua	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Reserve	Ia
Soufrière Marine Management Area	Caribbean	St. Lucia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Management Area	VI
Princess Alexandra Marine National Park	Caribbean	Turks and Caicos Islands	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Management Area	VI

CARIBBEAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Mouchoir Bank Marine Sanctuary	Caribbean	Turks and Caicos Islands	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Proposed MPA	None
Gray's Reef National Marine Sanctuary and Biosphere Reserve	Caribbean	United States	N		N	Y	N	Y	N	N	Not Eligible	Eligible	Not Eligible	NMS and Biosphere Reserve	IV
Southeastern Right Whale Seasonal Habitat	Caribbean	United States	Y	North Atlantic right whale	N	Y	N	Y	Y	N	Eligible	Eligible	Eligible	Designated Critical Habitat	None
Florida Keys National Marine Sanctuary	Caribbean	United States	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	NMS	IV
Sistema Arrecifal Veracruzano	Caribbean	Mexico	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	II
Fort Clinch State Park Aquatic Preserve	Caribbean	United States	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	State Park	None
Flower Garden Banks National Marine Sanctuary	Caribbean	United States	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	NMS	None
Caño Guaritico Wildlife Refuge	Caribbean	Venezuela	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Inland Wildlife Refuge	IV
Delta del Orinoco	Caribbean	Venezuela	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Biosphere Reserve	VI

CARIBBEAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	**Marine Region[1]**	**Country**	**Outside the Coastal Standoff Distance or Non-OpArea (1)**	**Species[2]**	**High Density (2a)**	**Breeding Calving (2b)**	**Foraging Grounds (2b)**	**Migration Route (2b)**	**Critical Habitat (2b)**	**Small, Distinct Population (2c)**	**Criterion 1: Coastal Standoff Distance**	**Criterion 2: Concentration Area 2a, 2b, or 2c**	**Nomination Status**	**Designation**	**IUCN Category**
Venezuelan Cetacean Sanctuary	Caribbean	Venezuela	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed Sanctuary	None

WEST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Caving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Canary Islands Cetacean Marine Sanctuary	West Africa	Canary Islands (Spain)	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Proposed Cetacean Sanctuary	None
Chinijo Archipelago Natural Park	West Africa	Canary Islands (Spain)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Natural Park	None
Natural Marine Park of the Whales and Franja Marina Teno Rasca SAC	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Franja Marina Santiago - Valle Gran Rey SAC	West Africa	Canary Islands (Spain)	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	SAC	None
Sebadales de La Graciosa SAC	West Africa	Canary Islands (Spain)	N		N	N	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Marine Reserve SAC	None
Mar de las Calmas SAC	West Africa	Canary Islands (Spain)	N		N	N	N	N	N	U	Not Eligible	Unknown	Not Eligible	Marine Reserve SAC	None
Sebadales de Corralejo SAC	West Africa	Canary Islands (Spain)	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	SAC	None

WEST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Caving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Área Marina de la Isleta SAC	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Franja Marina de Mogán SAC	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Bahía del Confital	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Sebadales de Playa del Inglés	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Franja Marina de Fuencaliente	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Playa de Sotavento de Jandía	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Southeastern Fuerteventura	West Africa	Canary Islands (Spain)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	SAC	None
Cape Verde Humpback Whale MPA	West Africa	Cape Verde	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed MPA	None
Niumi National Park	West Africa	The Gambia	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	National Park	II

WEST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Caving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Tanji Bird Reserve	West Africa	The Gambia	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	National Park	II
Kiang West National Park	West Africa	The Gambia	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	II
Konkoure Estuary MPA	West Africa	Guinea	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	Wetland of International Importance	None
Banc d'Arguin National Park and Biosphere Reserve	West Africa	Mauritania	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	National Park	II
Dakhla National Park	West Africa	Morocco	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	National Park	None
Saloum Delta National Park and Siné-Saloum Biosphere Reserve	West Africa	Senegal	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	National Park	II
De Hoop MPA	West Africa	South Africa	N		N	N	N	N	N	Y	Not Eligible	Eligible	Not Eligible	MPA	IV
Robberg MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Dwesa-Cwebe MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Tsitsikamma MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV

WEST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Caving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Sardinia Bay MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Mkambati MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Hluleka MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Trafalgar MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
St Lucia MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Maputaland MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Helderberg MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Walker Bay Whale Sanctuary	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
West Coast National Park	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	None
Langebaan Lagoon	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Sixteen Mile Beach	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Marcus Island	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV

WEST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Caving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Jutten Island	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Malgas Island	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Cape Peninsula and Castle Rock	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park Proposed MPA	None
Betty's Bay MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
Goukamma MPA	West Africa	South Africa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	MPA	IV
St Helena Biosphere Reserve	West Africa	British Overseas Territory	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed Biosphere	None
Tristan da Cunha Cetacean Sanctuary (Coast to EEZ limit)	West Africa	British Overseas Territory	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Cetacean Sanctuary	None
Inaccessible Island Nature Reserve	West Africa	British Overseas Territory	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	None
Gough Island Wildlife Reserve	West Africa	British Overseas Territory	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	Ia

SOUTH ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area[1]	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Bahía Anegada Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	None
Golfo San José Provincial Marine Park	South Atlantic	Argentina	N		U	Y	U	U	Y	Y	Not Eligible	Unknown	Not Eligible	Marine Park	II
Punta Loma Faunal Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Faunal Reserve	None
Punta Norte Provincial Faunal Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Faunal Reserve	None
Punta Pirámide Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	None
Península Valdés Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	None
Bahía San Antonio Oeste Hemispheric Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Reserve	None
Bahía Laura Provincial Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	IV

SOUTH ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area[1]	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Cabo Blanco Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	IV
Monte Loayza Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	None
Península San Julián and Bahía de San Julián Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Provincial Reserve	IV
Complejo Bahía Oso Marino Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	None
Ría Deseado Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Provincial Reserve	VI
Costa Atlántica de Tierra del Fuego Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	II
Tierra del Fuego National Park and National Strict Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	II

SOUTH ATLANTIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area[1]	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Isla Monte León Provincial Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Provincial Reserve	None
Cabo Virgenes Nature Reserve	South Atlantic	Argentina	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Provincial Reserve	IV
Cabo Orange National Park	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	II
Lago Piratuba Biological Reserve	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Biological Reserve	None
Mamirauá Sustainable Development Reserve	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Development Reserve	None
Amanã Sustainable Development Reserve	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Development Reserve	None
Atol das Rocas Biological Reserve	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Biological Reserve	Ia
Fernando de Noronha National Marine Park	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	II

SOUTH ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area[1]	**Marine Region[1]**	**Country**	**Outside the Coastal Standoff Distance or Non-OpArea (1)**	**Species[2]**	**High Density (2a)**	**Breeding Calving (2b)**	**Foraging Grounds (2b)**	**Migration Route (2b)**	**Critical Habitat (2b)**	**Small, Distinct Population (2c)**	**Criterion 1: Coastal Standoff Distance**	**Criterion 2: Concentration Area 2a, 2b, or 2c**	**Nomination Status**	**Designation**	**IUCN Category**
Abrolhos National Marine Park	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	II
Shelf of the Northern Coast Environmental Protected Area	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Unknown	None
Arraial do Cabo Sustainable Reserve	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Sustainable Reserve	None
Laje de Santos Marine State Park (18 nm offshore, small rocky feature)	South Atlantic	Brazil	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	State Marine Park	II
Tupiniquins Ecological Station	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Ecological Station	Ia
Tupinambás Ecological Station	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Ecological Station	Ia
Ilhabela State Marine Park	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	State Park	II

SOUTH ATLANTIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area[1]	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Ilha Anchieta State Marine Park	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	State Park	II
Anhatomirim Environmental Protection Area	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Environmental Protection Area	None
Right Whale Environmental Protection Area	South Atlantic	Brazil	N		U	U	U	Y	U	Y	Not Eligible	Unknown	Not Eligible	Environmental Protection Area	None
Marine Tucuxi Environmental Protection Area of Paraty Bay	South Atlantic	Brazil	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Environmental Protection Area	None
Falkland Islands Marine Mammal Sanctuary (Coast to EEZ limit)	South Atlantic	United Kingdom	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Marine Mammal Sanctuary	None
Punta Ballena - Bahía de Maldonado - José Ignacio MPA	South Atlantic	Uruguay	N		U	U	U	U	Y	U	Not Eligible	Unknown	Not Eligible	Proposed Biosphere Reserve	None

SOUTH ATLANTIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area[1]	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Cabo Santa María - La Pedrera MPA	South Atlantic	Uruguay	N		U	U	U	U	Y	U	Not Eligible	Unknown	Not Eligible	Proposed Biosphere Reserve	None
Cabo Polonio - Punta del Diablo MPA	South Atlantic	Uruguay	N		U	U	U	U	Y	U	Not Eligible	Unknown	Not Eligible	Proposed Biosphere Reserve	None

INDIAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Sundarbans World Heritage Site	Central Indian Ocean	Bangladesh	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Wildlife Sanctuary	IV
Sangu River	Central Indian Ocean	Bangladesh	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Proposed Sanctuary	None
National Chambal Sanctuary	Central Indian Ocean	India	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Sanctuary	None
Vikramshila Gangetic Dolphin Sanctuary	Central Indian Ocean	India	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Sanctuary	None
Gulf of Mannar Marine National Park	Central Indian Ocean	India	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine National Park	Ib
Eidhigali Kulhi / Koattey Protected Area	Central Indian Ocean	Maldives	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed Designation	None

INDIAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Lampi Island Marine National Park	Central Indian Ocean	Myanmar	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	Ib
Royal Bardia National Park	Central Indian Ocean	Nepal	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	None
Palk Bay and the Gulf of Mannar Marine International Park	Central Indian Ocean	Sri Lanka	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	None

ARABIAN SEAS

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Daymaniyat Islands National Nature Reserve	Arabian Seas	Oman	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Nature Reserve	IV
Bar al Hikman	Arabian Seas	Oman	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed MPA	None
Masirah Island	Arabian Seas	Oman	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed MPA	None
Indus River Dolphin Reserve, or Sind Dolphin Reserve	Arabian Seas	Pakistan	N		U	U	U	U	U	Y	Not Eligible	Unknown	Not Eligible	Reserve	None

EAST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Mohéli Marine Park	East African	Comoros	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	II
Malindi Marine National Park and Reserve	East African	Kenya	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	II
Watamu Marine National Park and Reserve	East African	Kenya	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	II
Mombasa Marine National Park and Reserve	East African	Kenya	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	II
Diani-Chale Marine National Reserve	East African	Kenya	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	VI
Kisite Marine National Park and Mpunguti Reserve	East African	Kenya	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Park	II
Kiunga Marine National Reserve	East African	Kenya	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine National Reserve	VI

EAST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Manannara North Biosphere Reserve, Antafana Islands Marine Park	East African	Madagascar	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	II
Masoala National Park, including Itampolo, Masoala and Tanjona Reserves	East African	Madagascar	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	II, VI
Baie d'Antongil - Sainte Marie Island Humpback Whale Sanctuary	East African	Madagascar	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Proposed MPA	None
Toliara-Nosy Ve Candidate World Heritage Site	East African	Madagascar	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Candidate World Heritage Site	None
Passe en S Reserve (Passe de Longogori)	East African	Mayotte (France)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Strict Fishing Reserve	VI

EAST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Saziley Reserve	East African	Mayotte (France)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Park	II
Bazaruto Archipelago National Park	East African	Mozambique	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	National Park	II
Maputo Bay-Inhaca Island Machangalo Candidate World Heritage Site	East African	Mozambique	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Faunal Reserve	VI
Zambezi River Delta Candidate World Heritage Site	East African	Mozambique	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	NA	None
Réunion Marine Park	East African	La Reunion	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	NA	None
Seychelles Marine Mammal Sanctuary (Coast to EEZ limit)	East African	Seychelles	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Marine Mammal Sanctuary	None
Menai Bay Conservation Area	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Conservation Area	VI

EAST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Misali Island Conservation Area	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Conservation Area	VI
Mnazi Bay-Ruvuma Estuary	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	VI
Mafia Island	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	VI
Dar es Salaam Marine Reserves (Mbudya, Bongoyo, Pangavini, Fungu Yasini)	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Reserves	None
Maziwi Marine Reserve	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Reserves	II
Mnemba Island Marine Conservation Area	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Conservation Area	VI
Chumbe Marine Sanctuary	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Mkwaja Saadani National Park	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

EAST AFRICA

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Pangani MPA	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Tanga Coral Gardens Marine Reserve and Marine Conservation Area (proposed)	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Kipumbwi Marine Conservation Area (proposed)	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Kigombe Marine Conservation Area (proposed)	East African	Tanzania	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

EAST ASIAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Spratly Islands Marine Sanctuary (Proposed)	East Asian	International Disputed	Y		N	N	N	N	N	N	Eligible	Not eligible	Not Eligible	NA	None
Mekong River Ramsar Site	East Asian	Cambodia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Savu Sea Marine National Park (Coast to EEZ limit)	East Asian	Indonesia	N		N	N	Y	N	N	N	Not eligible	Eligible	Not Eligible	Marine Park	None
Area in the Ombai Strait in the Savu Sea Marine National Park	East Asian	Indonesia	Y	Blue whale, sperm whale; fin whale	N	N	Y	Y	N	N	Eligible	Eligible	Eligible	Marine Park	None
Bunaken National Marine Park	East Asian	Indonesia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Wakatobi Marine National Park	East Asian	Indonesia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Cendrawasih Bay Marine National Park	East Asian	Indonesia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		

EAST ASIAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Komodo National Park, Biosphere Reserve and World Heritage Site	East Asian	Indonesia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Semayang Lake National Park	East Asian	Indonesia	N		U	U	U	U	U	Y	Not eligible	Unknown	Not Eligible		
Alor-Solor (Nusa Tenggara) Included within Savu Sea MPA	East Asian	Indonesia	N		N	N	Y	Y	N	N	Not eligible	Eligible	Not Eligible	Proposed MPA	
Bandanaira, Gunungapi, Lucipara, Pulau Manuk, Sangihe Talaud, Taka bone Rate, Pulau Kakabia, Kepulauan Asia, Pulau Mapia, Bali-Lombok Strait	East Asian	Indonesia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		

EAST ASIAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Community Fisheries Conservation Zones (FCZ) of Muang-Khong District	East Asian	Laos	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Johore Marine Park	East Asian	Malaysia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Langkawi Island Marine Park	East Asian	Malaysia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Labuan Island Marine Park	East Asian	Malaysia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
North Borneo Marine Park	East Asian	Malaysia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Lawas Marine Park	East Asian	Malaysia	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Malampaya Sound Protected Land and Seascape	East Asian	Philippines	N		U	U	U	U	U	Y	Not eligible	Unknown	Not Eligible		
Tañon Strait Protected Seascape	East Asian	Philippines	N		N	N	N	Y	N	N	Not eligible	Eligible	Not Eligible	Protected Landscape/ Seascape	V

EAST ASIAN

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Pamilacan Island Marine Mammal Sanctuary	East Asian	Philippines	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Tubbataha National Marine Park	East Asian	Philippines	Y		N	N	N	N	N	N	Eligible	Not eligible	Not Eligible	National Marine Park	II
Batanes Islands Protected Land and Seascape	East Asian	Philippines	N		N	Y	N	Y	N	Y	Not eligible	Eligible	Not Eligible		
Calayan Island Protected Area	East Asian	Philippines	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Sierra Madre Natural Park	East Asian	Philippines	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Turtle Islands Wildlife Sanctuary	East Asian	Philippines	Y		N	N	N	N	N	N	Eligible	Not eligible	Not Eligible		
Siargao Island Protected Land and Seascape	East Asian	Philippines	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Apo Reef Natural Park	East Asian	Philippines	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		
Hon Mun MPA	East Asian	Vietnam	N		U	U	U	U	U	U	Not eligible	Unknown	Not Eligible		

EAST ASIAN

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Offshore Hainan Island*	East Asian	Philippines	N	Western Pacific gray whale	N	Y	N	N	N	Y	Not eligible	Eligible	Not Eligible	None	None
Offshore Babuyan Islands*	East Asian	China	N	Humpback whale	N	Y	N	N	N	Y	Not eligible	Eligible	Not Eligible	None	None

* Although there are data to support that this general area meets Criterion 2, the preliminary analysis did not include any information that indicates that any part of the biologically important area falls outside of the Navy's 12-nm standoff zone.

SOUTH PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
American Samoa Whale and Turtle Sanctuary	South Pacific	American Samoa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Fagatele Bay National Marine Sanctuary	South Pacific	American Samoa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
National Park of American Samoa	South Pacific	American Samoa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Rose Atoll Marine National Monument	South Pacific	American Samoa	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine National Monument	Ia
Cook Islands Whale Sanctuary*	South Pacific	New Zealand	N		N	Y	N	Y	Y	N	Not Eligible	Eligible	Not Eligible		
Parques Marinos de Rapa Nui	South Pacific	Easter Island (Chile)	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Fiji Whale Sanctuary	South Pacific	Fiji	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Whale Sanctuary	None
French Polynesia Marine Mammal Sanctuary	South Pacific	French Polynesia	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine Mammal Sanctuary	None

SOUTH PACIFIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Hawaiian Islands Humpback Whale National Marine Sanctuary (Penguin Bank)	South Pacific	United States	Y	Humpback whale	N	Y	N	N	Y	Y	Eligible	Eligible	Eligible	National Marine Sanctuary	IV
New Caledonia Whale Sanctuary*	South Pacific	New Caledonia (France)	N		N	Y	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Whale Sanctuary	None
Niue Whale Sanctuary	South Pacific	Niue (New Zealand)	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Whale Sanctuary	
Northwestern Hawaiian Islands Marine National Monument*	South Pacific	United States	N		N	Y	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Marine National Monument	II
Area Around Nihoa, Necker, and Lisianski Islands, Gardner Pinnacles & Maro Reef (Northwestern Hawaii)*	South Pacific	United States	N	Humpback whale , short-finned pilot whale, Hawaiian monk seal, pygmy killer whale	N	Y	N	N	Y	N	Not Eligible	Eligible	Not Eligible		
Rock Islands Conservation Area	South Pacific	Palau	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

SOUTH PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Ngeremendu Bay Conservation Area	South Pacific	Palau	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Pacific Remote Islands Mairine National Monument (Palmyra Atoll, Kingman Reef)	South Pacific	United States	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine National Monument	II
Papua New Guinea Whale Sanctuary	South Pacific	Papua New Guinea	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Whale Sanctuary	
Milne Bay MPA	South Pacific	Papua New Guinea	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Samoa Whale, Turtle and Shark Sanctuary	South Pacific	Samoa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Aleipata MPA	South Pacific	Samoa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Safata MPA	South Pacific	Samoa	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Marovo Lagoon World Heritage Area	South Pacific	Solomon Islands	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

SOUTH PACIFIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Arnavon Islands Marine Conservation Area	South Pacific	Solomon Islands	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Marine Conservation Area	IV
Tongan Whale Sanctuary	South Pacific	Tonga	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Whale Sanctuary	None
Ha'apai Marine Conservation Area*	South Pacific	Tonga	N		N	N	N	Y	N	N	Not Eligible	Eligible	Not Eligible		
Funufuti Conservation Area	South Pacific	Tuvalu	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Vanuatu Marine Mammal Sanctuary	South Pacific	Vanuatu	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Whale Sanctuary	None

NORTHEAST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Orca Pass International Marine Stewardship Area	Northeast Pacific	International	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Robson Bight/Michael Bigg Ecological Reserve	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Gwaii Haanas National Marine Conservation Area Reserve	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Race Rocks (Candidate Marine Protected Area)	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Pacific Rim National Park Reserve	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Southern Strait of Georgia National Marine Conservation Area	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Scott Islands Marine Wildlife Area	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

NORTHEAST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Bowie Seamount	Northeast Pacific	Canada	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Proposed Marine Protected Area	None
Gabriola Passage	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Clayoquot Sound Biosphere Reserve	Northeast Pacific	Canada	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Mexican Whale Refuge (Coast to EEZ limit)	Northeast Pacific	Mexico	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible	Whale Refuge	None
El Vizcaino Biosphere Reserve	Northeast Pacific	Mexico	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Revillagigedo Archipelago Biosphere Reserve	Northeast Pacific	Mexico	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Islas Marías Biosphere Reserve	Northeast Pacific	Mexico	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Loreto Bay National Park	Northeast Pacific	Mexico	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

NORTHEAST PACIFIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Upper Gulf of California and Colorado River Delta Biosphere Reserve	Northeast Pacific	Mexico	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Biosphere Reserve	Ia
Bahía Magdalena National Gray Whale Refuge	Northeast Pacific	Mexico	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Monterey Bay Submarine Canyon	Northeast Pacific	United States	Y	Blue whale pacific gray whale Steller sea lion	N	N	Y	Y	N	N	Eligible	Eligible	Eligible		
Cordell Bank Seamount	Northeast Pacific	United States	Y	Humpback whale pacific gray whale pacific white-sided dolphin	N	N	Y	Y	N	N	Eligible	Eligible	Eligible		
Area Southwest of Farrallon Islands	Northeast Pacific	United States	Y	Humpback whale pacific gray whale blue whale pacific white-sided dolphin, Steller sea lion	N	Y	N	Y	N	N	Eligible	Eligible	Eligible		
Southern California Bight: Tanner Bank and Cortez Bank	Northeast Pacific	United States	Y	Pacific gray whale blue whale fin whale Steller sea lion	N	Y	Y	Y	N	N	Eligible	Eligible	Eligible		

NORTHEAST PACIFIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	**Marine Region**[1]	**Country**	**Outside the Coastal Standoff Distance or Non-OpArea (1)**	**Species**[2]	**High Density (2a)**	**Breeding Calving (2b)**	**Foraging Grounds (2b)**	**Migration Route (2b)**	**Critical Habitat (2b)**	**Small, Distinct Population (2c)**	**Criterion 1: Coastal Standoff Distance**	**Criterion 2: Concentration Area 2a, 2b, or 2c**	**Nomination Status**	**Designation**	**IUCN Category**
Olympic Coast NMS: Including the Prairie, Barkley Canyon, and Nitnat Canyon areas	Northeast Pacific	United States	Y	Humpback whale killer whale	N	N	Y	N	N	N	Eligible	Eligible	Eligible		
Glacier Bay National Park and Preserve	Northeast Pacific	United States	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Southeastern Bering Sea Right Whale Critical Habitat (Proposed)	Northeast Pacific	United States	N		N	N	N	N	Y	N	Not Eligible	Eligible	Not Eligible	Whale Critical Habitat	None
San Juan Islands National Wildlife Refuge	Northeast Pacific	United States	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Northwest Straits Management Area	Northeast Pacific	United States	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Gulf of Alaska Steller Sea Lion Critical Habitat	Northeast Pacific	United States	Y	Steller sea lion	Y	Y	N	N	Y	N	Eligible	Eligible	Eligible		

NORTHWEST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Lung Kwu Chau and Sha Chau Marine Park	Northwest Pacific	China	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Xiamen Marine National Park and Conservation Areas	Northwest Pacific	China	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Baiji Natural Reserve (and the Shishou and Tong Ling semi-natural reserves)	Northwest Pacific	China	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Zhujiang (Pearl River) Delta Ecosystem Protected Area	Northwest Pacific	China	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Seto-naikai National Park	Northwest Pacific	Japan	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Finless Porpoise Gathering Area National Natural Monument	Northwest Pacific	Japan	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Botchinskiy Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Commander Islands Biosphere Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

NORTHWEST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Nalychevo Nature Park and Marine Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Far Eastern Marine Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Dzhugdzhurskiy Nature Reserve (Zapovednik)	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Koryakskiy Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Kronotskiy Biosphere Reserve (and Zapovednik)	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
South Kamchatka Sanctuary	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Kurilskiy Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Maliy Kurils Wildlife Refuge	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Lazovskiy Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Sikhote-Alinskiy Biosphere Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

NORTHWEST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Magadanskiy Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Poronayskiy Nature Reserve	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Vostok Bay National Comprehensive Marine Sanctuary	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Piltun and Chayvo Offshore Feeding Grounds	Northwest Pacific	Russia	Y	Western Pacific gray whale	N	N	Y	Y	N	N	Eligible	Eligible	Eligible	Whale Refuge	None
Shantar Archipelago National Park	Northwest Pacific	Russia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

SOUTHEAST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Eastern Tropical Pacific Seascape	Southeast Pacific	International	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Francisco Coloane National Marine Park	Southeast Pacific	Chile	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Caldera MPA	Southeast Pacific	Chile	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Bahía Mansa MPA	Southeast Pacific	Chile	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Humboldt Penguin National Reserve	Southeast Pacific	Chile	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Chiloe National Park	Southeast Pacific	Chile	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Isla Gorgona National Natural Park	Southeast Pacific	Columbia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Ensenada de Utría National Natural Park	Southeast Pacific	Columbia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Malaga Bay MPA	Southeast Pacific	Columbia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

SOUTHEAST PACIFIC

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Cocos Island Marine and Terrestrial Conservation Area	Southeast Pacific	Costa Rica	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Ballena Marine National Park	Southeast Pacific	Costa Rica	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Costa Rica Dome	Southeast Pacific	Costa Rica	Y	Blue whale humpback whale	N	N	Y	Y	N	N	Eligible	Eligible	Eligible		
Galápagos Marine Resources Reserve*	Southeast Pacific	Ecuador	N	Blue whale sperm whale Galapagos sea lion (endemic) Galapagos fur seal (endemic)	N	N	Y	Y	N	N	Not Eligible	Eligible	Not Eligible	Whale Refuge	None
Manglares-Churute Ecological Reserve	Southeast Pacific	Ecuador	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Cuyabeno Faunistic Reserve	Southeast Pacific	Ecuador	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Machalilla National Park	Southeast Pacific	Ecuador	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Cerro Hoya National Park	Southeast Pacific	Panama	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Coiba National Park	Southeast Pacific	Panama	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

SOUTHEAST PACIFIC

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Coiba National ParkSpecial Marine Protection Zone	Southeast Pacific	Panama	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Special Marine Protection Zone	II
Golfo de Chiriquí National Marine Park	Southeast Pacific	Panama	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
El Golfo de Montijo Wetland	Southeast Pacific	Panama	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Paracas National Reserve	Southeast Pacific	Peru	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Pacaya-Samiria National Reserve	Southeast Pacific	Peru	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Peninsula Bayovar MPA	Southeast Pacific	Peru	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

AUSTRALIA—NEW ZEALAND

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	**Marine Region[1]**	**Country**	**Outside the Coastal Standoff Distance or Non-OpArea (1)**	**Species[2]**	**High Density (2a)**	**Breeding Calving (2b)**	**Foraging Grounds (2b)**	**Migration Route (2b)**	**Critical Habitat (2b)**	**Small, Distinct Population (2c)**	**Criterion 1: Coastal Standoff Distance**	**Criterion 2: Concentration Area 2a, 2b, or 2c**	**Nomination Status**	**Designation**	**IUCN Category**
Australian Whale Sanctuary (Coast to EEZ limit)	Australia - New Zealand	Australia	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Whale Sanctuary	None
Great Barrier Reef Marine Park Between 16°E and 21°S	Australia - New Zealand	Australia	Y	Humpback whale dwarf minke whale	N	Y	N	N	N	N	Eligible	Eligible	Eligible	Marine Park	Ia, II, IV, VI
Solitary Islands Marine Reserve and Marine Park	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Coringa-Herald and Lihou Reef National Nature Reserve	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Mermaid Reef Marine National Nature Reserve	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Lord Howe Island Marine Park and World Heritage Area	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Elizabeth and Middleton Reefs Marine Nature Reserve	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Tasmanian Seamounts Marine Reserve	Australia - New Zealand	Australia	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Marine Reserve	Ia, VI

AUSTRALIA—NEW ZEALAND

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Macquarie Island Marine Park and World Heritage Area	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible	Marine Park	Ia, IV
Ningaloo Marine Park	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Bonney Upwelling Blue Whale Feeding critical habitat MPA	Australia - New Zealand	Australia	Y	Blue whale pygmy blue whale New Zealand fur seal southern right whale Australian sea lion	N	N	Y	N	N	N	Eligible	Eligible	Eligible		
Moreton Bay Marine Park	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Hervey Bay Marine Park	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

AUSTRALIA—NEW ZEALAND

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Queensland MPAs: Cairns Marine Park, Trinity Inlet-Marlin Coast Marine Park, Mackay Capricorn Marine Park, Woongarra Marine Park, Townsville Whitsunday Marine Park, Gumoo Woojabuddee Marine Park, Gulf of Carpentaria Marine Park, Torres Strait Indigenous Protected Area	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
New South Wales MPAs: Cape Byron Marine Park, Jervis Bay Marine Park, Port Stephens Marine Park	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

AUSTRALIA—NEW ZEALAND

	GEOGRAPHY			BIOLOGY							CRITERIA		PRELIMINARY RESULT	ADDITIONAL INFORMATION	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Victoria MPAs: Bunurong Marine National Park, Wilsons Promontory Marine National Park, Cape Howe Marine National Park, Churchill Marine National Park, Discovery Bay Marine National Park, Ninety Mile Beach Marine National Park, Point Addis Marine National Park, Point Hicks Marine National Park, Port Phillip Heads Marine National Park, The Twelve Apostles Marine National Park, Yaringa Marine National Park, Merri Marine Sanctuary	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

AUSTRALIA—NEW ZEALAND

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Great Australian Bight Marine National Park	Australia - New Zealand	Australia	Y		N	N	N	N	N	N	Eligible	Not Eligible	Not Eligible	Marine National Park	VI
Head of Bight: Great Australian Bight Marine National Park	Australia - New Zealand	Australia	Y	Southern right whale Australian sea lion	N	Y	N	N	N	N	Eligible	Eligible	Eligible		
Encounter Bay MPA	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Adelaide Dolphin Sanctuary	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

AUSTRALIA—NEW ZEALAND

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Western Australia MPAs: Shoalwater Islands Marine Park, Marmion Marine Park, Jurien Bay Marine Park, Shark Bay Marine Park and World Heritage Area, Rowley Shoals Marine Park, The Capes Marine Park, Monte Bellos/Barrow Island Marine Reserve, Garig Gunak Barlu National Park	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Tasmania MPAs: Governor Island Marine Reserve	Australia - New Zealand	Australia	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
New Zealand Marine Mammal Sanctuary	Australia - New Zealand	New Zealand	N		N	N	N	N	N	N	Not Eligible	Not Eligible	Not Eligible		

AUSTRALIA—NEW ZEALAND

	Geography			Biology							Criteria		Preliminary Result	Additional Information	
Area	Marine Region[1]	Country	Outside the Coastal Standoff Distance or Non-OpArea (1)	Species[2]	High Density (2a)	Breeding Calving (2b)	Foraging Grounds (2b)	Migration Route (2b)	Critical Habitat (2b)	Small, Distinct Population (2c)	Criterion 1: Coastal Standoff Distance	Criterion 2: Concentration Area 2a, 2b, or 2c	Nomination Status	Designation	IUCN Category
Auckland Islands Marine Mammal Sanctuary and Marine Reserve	Australia - New Zealand	New Zealand	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Banks Peninsula Marine Mammal Sanctuary	Australia - New Zealand	New Zealand	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Akaroa Harbour Marine Reserve (Part of Banks Peninsula Reserve)	Australia - New Zealand	New Zealand	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
Doubtful Sound Marine Sanctuary	Australia - New Zealand	New Zealand	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		
West Coast Marine Park	Australia - New Zealand	New Zealand	N		U	U	U	U	U	U	Not Eligible	Unknown	Not Eligible		

APPENDIX D-4: SURTASS LFA MARINE MAMMAL OBIA REVIEWERS (SUBJECT MATTER EXPERTS [SMES]), 2 AUGUST 2010

Atlantic Ocean

Dr. Debra Lynn Palka
NMFS Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543
Phone: (508) 495-2387
E-mail: debra.palka@noaa.gov

Pacific Ocean

Dr. Robert Brownell
NMFS Southwest Fisheries Science Center
3333 North Torrey Pines Court
La Jolla, CA 92037-1022
Phone: (831) 648-5338
E-mail: Robert.Brownell@noaa.gov

Dr. Jay Barlow
NMFS Southwest Fisheries Science Center
3333 North Torrey Pines Court
La Jolla, CA 92037-1022
Phone: (858) 546-7178
E-mail: Jay.Barlow@noaa.gov

Dr. Megan Ferguson
NMFS Alaska Fisheries Science Center
7600 Sand Point Way N.E., Building 4
Seattle, Washington 98115
Phone: 206-526-6274
E-mail: Megan.Ferguson@noaa.gov

.

Mediterranean

Dr. Giuseppe Notarbartolo di Sciara
Tethys Research Institute
Viale G.B. Gadio 2
I 20121 Milano, Italy
E-mail: gn@disciara.net

Indian Ocean / SE Asia

Dr. Thomas Jefferson
3333 North Torrey Pines Court
La Jolla, CA 92037-1022
Phone: (858) 546-7050
E-mail: tom.jefferson@noaa.gov

Robert Pitman
NMFS Southwest Fisheries Science Center
3333 North Torrey Pines Court
La Jolla, CA 92037-1022
Phone: (858) 546-7092
E-mail: robert.pitman@noaa.gov

Offshore Africa and South America

Dr. Howard C. Rosenbaum
Wildlife Conservation Society
2300 Southern Boulevard
Bronx, New York 10460 USA
Phone: (718) 220-5184
Email: hrosenbaum@wcs.org

Australia

No volunteers

APPENDIX D-5: NMFS' LETTER TO NAVY RE: MARINE MAMMAL OFFSHORE BIOLOGICALLY IMPORTANT AREAS (OBIAS) FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR, 16 JUNE 2010

Date: June 16, 2010

To: Branch Head, Undersea Surveillance (N2/N6F21)
Department of the Navy,
Office of the Chief of Naval Operations
2000 Navy Pentagon
Washington, DC 20350

Re: Marine Mammal Offshore Biologically Important Areas (OBIAs) for Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) Sonar.

Thank you for the opportunity to participate as a cooperating agency in the preparation of the Navy's second Draft Supplemental Environmental Impact Statement (DSEIS2) for SURTASS LFA sonar, including the identification of OBIAs for the conservation of marine mammals. The enclosed document titled "*Recommendations for Marine Mammal Offshore Biologically Important Areas (OBIAs) for the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar"* presents 45 suggestions for OBIAs in the Atlantic, Indian and Pacific Oceans and Mediterranean and Caribbean Seas, which NMFS recommends you consider in the development of your alternatives for the DSEIS2.

As you are aware, NMFS and, separately, a panel of Subject Matter Experts (SMEs) compiled information to identify and support the recommended designation of OBIAs based on specific criteria that NMFS laid out in advance. Subsequently, NMFS reviewed each recommendation (i.e., NMFS' own initial recommendations and the SME's contributions) and ranked it based upon the quality of the data to support the designation of the given area based on each of the two criteria.

To ensure that the nominated areas were ranked consistently, NMFS assigned a rank of zero to four (i.e., 0 = lowest, 4 = highest) to qualify the robustness of the supporting documentation for each criteria that the area was nominated. These ranking categories are as follows:

- Rank 0: Not Eligible, not applicable
- Rank 1: Not Eligible, insufficient data
- Rank 2: Eligible for consideration, requires more data
- Rank 3: Eligible for consideration, adequate justification
- Rank 4: Eligible for consideration, strong justification

Of the initial 77 recommendations, 45 received a ranking of 2, 3, or 4 for at least one criterion.

Separate from the ranking of the data that support a criterion, NMFS also assigned a rank for the robustness of the supporting documentation for each proposed boundary. These ranking categories are as follows:

- Rank 0: SME did not provide boundary information.
- Rank 1: Clear justification (qualitative or quantitative) for boundary consideration is not available.
- Rank 2: Proposed boundary inferred from analyses conducted for purposes other than quantifying the boundary.
- Rank 3: Proposed boundary inferred from peer-reviewed analyses.
- Rank 4: Proposed boundary is well documented and/or codified by national law or regulation.

Table 1 (attached) provides an example as to how NMFS defined and described the ranking criteria for evaluating NMFS' and the SME's recommendations.

Several of the SMEs submitted boundaries that appear to include a buffer zone around the identified area of biological importance. Within the time allotted for this process, in some cases, NMFS was unable to amend the size of the boundaries to remove the buffers so that the size of the suggested OBIA comports with the data provided. Where applicable, NMFS has identified these areas with an asterisk and the following statement: "*NMFS: The proposed boundary appears to have a buffer zone that extends beyond the identified area of biological importance.*"

We understand that the Navy will consider many factors in the development of their alternatives and the decisions regarding whether to include each of these suggested areas as proposed OBIAs in their DSEIS2; however, we ask that the Navy include all of the information that NMFS has compiled in the Appendices of the DSEIS2 so that the public has the most complete set of information to comment on and potentially augment.

As we have previously discussed, NMFS plans to solicit additional input from the SMEs regarding habitat ranking for the OBIA recommendations (based on biological importance, not strength of supporting information). Additionally, we anticipate that the public, as well as the SMEs, may bring additional pertinent information to bear during the DSEIS2 public comment period. Last, the Navy has biological expertise as well, and we expect that the information used to support the inclusion/non-inclusion of certain suggested areas as proposed OBIAs in the DSEIS2 will further inform this process. Once the Navy has submitted an MMPA application under section 101(a)(5) of the Marine Mammal Protection Act (MMPA), all of this additional information will be considered in NMFS' decisions regarding what OBIAs to propose pursuant to the MMPA authorization process.

We look forward to our next meeting with the Navy on the identification of OBIAs.

Thank you.

APPENDIX D-6: RECOMMENDATIONS FOR MARINE MAMMAL OFFSHORE BIOLOGICALLY IMPORTANT AREAS (OBIAS) FOR THE SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR, 16 JUNE 2010

Recommendations for Marine Mammal Offshore Biologically Important Areas (OBIAs) for the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

National Marine Fisheries Service
Office of Protected Resources
May 30, 2012

Table 1 – NMFS' Classification Methodology for OBIA Recommendations

Level	Level Description for High Density, Foraging, Breeding/Calving, Migration, or Small Distinct Populations	Level Description Boundary Consideration
0	Information not provided or information presented does not meet NMFS' definition of the corresponding OBIA criteria or the OBIA criteria are not applicable.	SME did not provide boundary information.
1	Clear justification (qualitative or quantitative) for corresponding OBIA criteria is not available; or the SME did not provide sufficient detail to NMFS for criteria evaluation; or for high density specifically, the SME provided strong abundance/presence information, but without the comparative information that supports *high* density.	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.
2	Designation inferred from analyses conducted for purposes other than quantifying the corresponding OBIA criteria. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.	Proposed boundary inferred from analyses conducted for purposes other than quantifying the boundary. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.
3	Designation inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented from a single source or is generally imprecise (e.g., CV => 30%).	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the proposed boundary.
4	Designation inferred from peer-reviewed analyses or surveys specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented is from multiple sources or is generally precise (e.g., CV < 30%).	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973).

Table 2 - List of Recommendations and NMFS' Classification of Supporting Data

Name	High Density	Foraging	Breeding Calving	Migration	Critical Habitat	Small Distinct	Highest Score
Georges Bank	3	4	0	4	0	0	4
Roseway Basin Right Whale Conservation Area	0	4	0	0	0	0	4
Great South Channel	0	3	0	0	4	0	4
The Gully Marine Protected Area	4	3	0	0	0	0	4
Southeastern U.S. Right Whale Seasonal Habitat	0	0	4	0	4	0	4
Silver Bank and Navidad Bank	0	0	4	0	0	0	4
Coastal Waters of Gabon, Congo and Equatorial Guinea	1	1	4	4	0	2	4
Patagonian Shelf Break	0	4	0	0	0	0	4
Southern Right Whale Seasonal Habitat	0	0	4	0	0	0	4
Northern Bay of Bengal and Swatch-of-No-Ground	1	2	2	0	0	4	4
Coastal Waters off Madagascar	1	1	4	1	0	0	4
Madagascar Plateau, Madagascar Ridge, Walters Shoal	1	3	4	3	0	2	4
Central California National Marine Sanctuaries	4	4	0	4	0	0	4
Vaquita Habitat in the Northern Gulf of California	0	0	0	0	0	4	4
Southern California Bight	0	4	0	4	0	0	4
Gulf of Alaska Steller Sea Lion Critical Habitat	0	0	0	0	4	0	4
Okhotsk Sea	0	4	0	2	0	0	4
Area around Ischia Island and Regno di Nettuno Marine Protected Area	1	1	3	0	0	0	3
Area in the Northern Adriatic Sea	1	2	3	0	0	0	3

Table 2 - List of Recommendations and NMFS' Classification of Supporting Data

Name	High Density	Foraging	Breeding Calving	Migration	Critical Habitat	Small Distinct	Highest Score
Northeast Slope in the Ligurian-Corsican-Provençal Basin	0	3	0	0	0	0	3
Harbor Porpoise Take Reduction Management Areas	3	3	0	3	0	0	3
Cape Hatteras Special Research Area	3	3	0	0	0	0	3
Shortland Canyon and Haldimand Canyon	3	3	0	0	0	0	3
Gulf of Thailand	1	0	1	0	0	3	3
Penguin Bank	3	0	3	0	0	0	3
Costa Rica Dome	0	3	0	0	0	0	3
Cross Seamount	0	3	0	0	0	0	3
Great Barrier Reef Between 16°E and 21°S	0	0	3	0	0	0	3
Bonney Upwelling	0	3	0	0	0	0	3
Southwest Mediterranean	1	2	2	0	0	0	2
North Alboran Sea, Gulf of Vera, Southern Almeria	1	2	2	0	0	0	2
Avenzar Bank, Câbliers Bank, and El Mansour Seamount	1	2	2	0	0	0	2
Djibouti Bank, Ville de Djibouti Bank, and Alborán Channel	1	2	2	0	0	0	2
Barcelona Canyon, Tarragona Canyon, Mallorca Chanel, Pituisas Canyon	1	2	2	0	0	0	2
Southern Almería, Seco de los Olivos Seamount, Alborán Island, Águilas Seamount	1	2	2	0	0	0	2
Felibres Hills, Calypso Hills, Spinola Spur, and Montpelier Canyon	1	2	2	0	0	0	2

Table 2 - List of Recommendations and NMFS' Classification of Supporting Data

Name	High Density	Foraging	Breeding Calving	Migration	Critical Habitat	Small Distinct	Highest Score
Marseille Canyon, Cassis Canyon, Felibres Hill, Alabe Hill, Barcelona Canyon	1	2	0	0	0	0	2
Area off of Southwest Greece and Crete, Ptolemy Mountains, Cretan-Rhodes Ridge	1	2	2	0	0	0	2
Northwest of Challenger Bank	0	2	0	1	0	0	2
Sylt Outer Reef	1	0	2	0	0	0	2
Pommeranian Bay, Adler Ground, and Western Ronne Bank	0	0	2	0	0	0	2
Buenos Aires Province Coastal Area	1	2	2	0	0	2	2
Area in the Ombai Strait in the Savu Sea Marine Protected Area	0	2	0	2	0	0	2
Fairweather Grounds, Southeast Alaska	0	2	0	0	0	0	2
Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon	0	2	0	0	0	0	2
Sardinian Seamount, Comino Trough, Sardinia, Corsica Trough	1	0	0	0	0	0	1
Peñiscola Canyon, Valencia Basin, Benidorm Canyon, Alicante Canyon, Águilas Seamount	1	0	0	0	0	0	1
Mediterranean Sea West of 10° E Ligurian Sea to Gibralter Strait	1	0	0	0	0	0	1
Pelagos Cetacean Sanctuary	1	0	0	0	0	0	1
Caprera Canyon, Giglio Ridge, Oblia Terrace – Southeast of Pelagos Sanctuary	1	0	0	0	0	0	1

Table 2 - List of Recommendations and NMFS' Classification of Supporting Data

Name	High Density	Foraging	Breeding Calving	Migration	Critical Habitat	Small Distinct	Highest Score
Area off Eastern Sicily, East of Messina Canyon	1	0	0	0	0	0	1
Area off the Gaza Strip and the Western Coast of Israel	1	0	0	0	0	0	1
Song of the Whale Surveys - Eastern Mediterranean	1	0	0	0	0	0	1
Dogger Bank	1	0	0	0	0	0	1
Continental Slope of the Northern Gulf of Mexico	1	1	0	0	0	0	1
Canary Islands Cetacean Marine Sanctuary	1	0	0	0	0	0	1
Tristan da Cunha Cetacean Sanctuary	1	0	0	0	0	0	1
Komodo National Park, Biosphere Reserve	1	0	0	0	0	0	1
Beaked Whale Habitat in the Coastal Waters off California, Washington, and Oregon	1	0	0	0	0	0	1
Southern Gulf of California	1	0	0	0	0	0	1
Exclusion around Japan and the Ryukyu Islands	1	0	0	0	0	0	1
The Sea of Japan	1	0	0	0	0	0	1
Exclusion in the South China Sea	1	0	0	0	0	0	1
Exclusion for the West Philippine Sea	1	0	0	0	0	0	1
Area around Quarqannah Island	0	0	0	0	0	0	0
Area Malta Island and Malta Plateau	0	0	0	0	0	0	0
Total Exclusion within the Yellow Sea / East China Sea	0	0	0	0	0	0	0
Exclusion around Taiwan	0	0	0	0	0	0	0

Table 2 - List of Recommendations and NMFS' Classification of Supporting Data

Name	High Density	Foraging	Breeding Calving	Migration	Critical Habitat	Small Distinct	Highest Score
Total Exclusion in the Gulf of Tonkin	0	0	0	0	0	0	0
Exclusion around Wake Island	0	0	0	0	0	0	0
Exclusion for the North Philippine Sea	0	0	0	0	0	0	0
Exclusion for the East China Sea	0	0	0	0	0	0	0

IUCN Marine Region 3: Mediterranean Sea

Southwest Mediterranean Sea (South of Sardinia to Alborán Sea - IFAW Survey)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 1*	SME provided a KMZ file. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- One of the areas with highest sperm whale densities in the Mediterranean. Whales feed and breed here. Considering that there is some genetic exchange between Mediterranean and Atlantic sperm whales, the Alborán Sea can be considered a migration corridor between the two regions (Lewis, 2010).
- On the assumption that g(0)=1, standard DISTANCE analysis gives an abundance estimate for the survey block of 561 animals (Lewis, 2010).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

North Alborán Sea, Gulf of Vera, Southern Almeria (Spain)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Short-Beaked Common Dolphin (*Delphinus delphis)* Striped dolphins (*Stenella coeruleoalba*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 2*	SME provided a KMZ file. Area proposed covers coast to 30 nm seaward of the Andalusian Coast. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	Year-round.

Background Provided by SME

- Paper describes mostly short-beaked common dolphins; however this and other studies clearly emphasize importance of area for: a) high densities of a number of odontocete species, which feed and breed there year-round (Cañadas & Hammond, 2008).
- Area covered in map is only the one which was surveyed: critical habitat of described species certain to extend much further to the south, possibly all the way to the Moroccan and Algerian coasts.
- Ana Cañadas and colleagues have published during the past decade or so a large number of papers detailing the importance of the N. Alboran Sea for a number of odontocete species. These include long-finned pilot whales (*Globicephala melas*), Risso's dolphins (*Grampus griseus*), Cuvier's beaked whales (*Ziphius cavirostris*), common bottlenose dolphins (*Tursiops truncates*). (Notarbartolo di Sciara, 2010).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Avenzar Bank, Câbliers Bank, and El Mansour Seamount—MED 09 Surveys (Spain)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Cuvier's beaked whale (*Ziphius cavirostris*) Long-finned pilot whale (*Globicephala melas*) Risso's dolphin (*Grampus griseus*) Common dolphin (*Delphinus delphis*) Striped dolphin (*Stenella coeruleoalba*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 3*	SME provided a KMZ file. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density area for species mentioned.
- Breeding and feeding known to occur in the area for all of them.
- Alborán East: area covered by [Med-09] cruise, where a very large number of sightings were made (in 45 hours of effort: 67 Cuvier's beaked whales, 168 long-finned pilot whales, 89 Risso's dolphins, 304 short-beaked common dolphins, 870 striped dolphins, plus a number of mixed-species groups and unidentified cetaceans) is certainly much smaller than the area actually used by the concerned populations (Anon., 2010).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Djibouti Bank, Ville de Djibouti Bank, and Alborán Channel—MED 09 Surveys (Spain)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Cuvier's beaked whale (*Ziphius cavirostris*) Long-finned pilot whale (*Globicephala melas*) Risso's dolphin (*Grampus griseus*) Common dolphin (*Delphinus delphis*) Striped dolphin (*Stenella coeruleoalba*) Bottlenose dolphin (*Tursiops truncatus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 4*	SME provided a KMZ file.* ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density area for species mentioned.
- Breeding and feeding known to occur in the area for all of them.
- Alborán West: area covered by cruise, where a very large number of sightings were made (in 60 hours of effort: 56 Cuvier's beaked whales, 71 long-finned pilot whales, 38 Risso's dolphins, 222 short-beaked common dolphins, 550 striped dolphins, plus a number of mixed-species groups and unidentified cetaceans) is certainly much smaller than the area actually used by the concerned populations (Anon., 2010; Notarbartolo di Sciara, 2010).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Sardinian Seamount, Comino Trough, Sardinia/Corsica Trough—MED 09 Surveys (Sardinia/Italy)

Potential Criteria:	2A: High Density
Species of Concern:	Fin whale (*Balaenoptera physalus*) Sperm whale (*Physeter macrocephalus*) Cuvier's beaked whale (*Ziphius cavirostris*) Bottlenose dolphin (*Tursiops truncatus*) Common dolphin (*Delphinus delphis*) Striped dolphin (*Stenella coeruleoalba*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 5*	SME provided a KMZ file.* ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Tyrrhenian Sea: area covered by cruise, where a very large number of sightings were made (in 53 hours of effort: 27 fin whales, 24 sperm whales, 12 Cuvier's beaked whales, 4 bottlenose dolphins, 45 short-beaked common dolphins, 366 striped dolphins, plus a number of mixed-species groups and unidentified cetaceans) is certainly much smaller than the area used by the concerned populations (Anon., 2010).
- Breeding and feeding known to occur in the area for all of them.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Barcelona Canyon, Tarragona Canyon, Mallorca Chanel, Pituisas Canyon (Spain and France)

Potential Criteria:	2A: High Density 2B: Critical Habitat 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Bottlenose dolphin (*Tursiops truncatus*) Sperm whale (*Physeter macrocephalus*) Striped dolphin (*Stenella coeruleoalba*) Fin whale (*Balaenoptera physalus*) Risso's dolphin (*Grampus griseusz*) Long-finned pilot whale (*Globicephala melas*) Common dolphin (*Delphinus delphis*) Unidentified beaked whale
Proposed Boundary Consideration: *Basis: Notobartolo di SciaraNumbers 6 and 7*	SME provided a KMZ file*. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance*.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Area contains critical habitat of the species (i.e., *Tursiops*) which feeds and breeds there (Forcada, Gazo, Aguilar, Gonzalvo, & Fernández-Contreras, 2004; Notarbartolo di Sciara, 2010).
- Breeding and feeding known to occur in the area for at least all odontocetes.
- Large number of sightings of different species made during two summer cruises in 2003 and 2004 testify importance of Balearic waters for cetacean ecology and biodiversity (Notarbartolo di Sciara, 2010; Rendell, Cañadas, & Mundy, 2005).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

Peñiscola Canyon, Valencia Basin, Benidorm Canyon, Alicante Canyon, Águilas Seamount (Spain)

Potential Criteria:	2A: High Density
Species of Concern:	Fin whale (*Balaenoptera physalus*) Sperm whale (*Physeter macrocephalus*) Cuvier's beaked whale (*Ziphius cavirostris*) Bottlenose dolphin (*Tursiops truncatus*) Common dolphin (*Delphinus delphis*) Striped dolphin (*Stenella coeruleoalba*) Risso's dolphin (*Grampus griseus*) Long-finned pilot whale (*Globicephala melas*) Unidentified beaked whale
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 8*	SME provided a KMZ file*. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density area for species mentioned.
- Population estimates performed with aerial and vessel surveys demonstrated the high values of the study area for striped dolphins (mean abundance 15,778), bottlenose dolphins (1,333) and Risso's dolphins (493). (Gómez de Segura, Crespo, Pedraza, Hammond, & Raga, 2006; Notarbartolo di Sciara, 2010).

Number of Supporting Documents

Peer-Reviewed Article(s)	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Southern Almería, Seco de los Olivos Seamount, Alborán Island, Águilas Seamount (Spain)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*) Cuvier's beaked whale (*Ziphius cavirostris*) Bottlenose dolphin (*Tursiops truncatus*) Common dolphin (*Delphinus delphis*) Striped dolphin (*Stenella coeruleoalba*) Risso's dolphin (*Grampus griseus*) Long-finned pilot whale (*Globicephala melas*) Unidentified beaked whale
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 9*	SME provided a KMZ file*. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density area for species mentioned.
- Breeding and feeding known to occur in the area for all of them.
- "The results identified areas that are important for a number of cetacean species, thus illustrating the potential for MPAs to improve cetacean conservation generally in the Alborán Sea, a region of great importance for supporting biodiversity and ecological processes in the wider Mediterranean Sea (Cañadas, Sagarminaga, De Stephanis, Urquiola, & Hammond, 2005)."

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Felibres Hills, Calypso Hills, Spinola Spur, and Montpelier Canyon (France, Italy, Monaco)

Potential Criteria:	2B: Critical Habitat 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Striped dolphin (*Stenella coeruleoalba*) Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Numbers 10 and 12*	SME provided a KMZ file*. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Area (established as a cetacean sanctuary (i.e., Pelagos) contains critical habitat for a number of cetacean species, in particular the two listed here (striped dolphin and fin whale), which are known to feed and breed in the area .
- In a recent aerial survey, unpublished at present, fin whale numbers seen in 2009 are smaller than in previous years, but still substantive. Whales likely to have moved wider and ranging beyond Sanctuary waters.
- High density, feeding and breeding area.
- This area coincides with distribution detected during 1992 survey, described in Forcada J., Notarbartolo di Sciara G., Fabbri F. 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. (Forcada, Notarbartolo di Sciara, & Fabbri, 1995).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

1.1

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Mediterranean Sea West of 10° E – Ligurian Sea to Gibralter Strait (France, Italy, Monaco)

Potential Criteria:	2A: High Density
Species of Concern:	Striped dolphin (*Stenella coeruleoalba*) Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 11*	SME provided a KMZ file*. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Study indicates locations of distributional "hot spots" for both species in a large portion of the west Mediterranean.
- See also: Forcada J., Aguilar A., Hammond P.S., Pastor X., Aguilar R. 1994. Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. Marine Mammal Science 10(2):137-150 (Forcada, Aguilar, Hammond, Pastor, & Aguilar, 2006).
- This area coincides with distribution detected during 1992 survey, described in Forcada J., Notarbartolo di Sciara G., Fabbri F. 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. Mammalia 59(1):127-140.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Marseille Canyon, Cassis Canyon, Felibres Hill, Alabe Hill, Barcelona Canyon (France, Italy)

Potential Criteria:	2A: High Density 2B: Foraging Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 13*	SME provided a KMZ file*. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density, feeding area.
- Area stops at Lat 39° 35′ however there is just a small distance to cover to merge into area No. 1 (i.e., the Southwest Mediterranean - South of Sardinia to Alboran Sea - IFAW Survey recommendation (Anon., 2010)) so we should presume the two are contiguous .

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	0	0	0	0
Status	Not Eligible	Eligible	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Pelagos Cetacean Sanctuary (France, Italy, Monaco)

Potential Criteria:	2A: High Density
Species of Concern:	Striped dolphin (*Stenella coeruleoalba*) Sperm whale (*Physeter macrocephalus*) Fin whale (*Balaenoptera physalus*) Long-finned pilot whale (*Globicephala melas*) Risso's Dolphin (*Grampus griseus*) Cuvier's beaked whale (*Ziphius cavirostris*) Bottlenose dolphin (*Tursiops truncatus*) Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Numbers 14 and 15*	SME provided a KMZ file.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High densities. High density confirmed also during winter.
- A total of 131 cetacean sightings of were made: striped dolphins (n=114), common bottlenose dolphins (7), fin whales (1), sperm whales (1), Cuvier's beaked whales (1) and unidentified small dolphins (7). Uncorrected striped dolphin population size was estimated to be 19,578 (% CV=19.2; 95% C.I.=12,318 – 27,039), with a density of 0.2218 individuals km-1 (%CV=19.23; 95% C.I.=0.1395-0.3063) (S. Panigada, Burt, Lauriano, Pierantonio, & Donovan, 2009).
- Panigada and Azzelino's (2009) report to the Italian Ministry of the environment, in Italian contains a summary of almost two decades of data, with spatial modeling to describe habitat for several species.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973).

Caprera Canyon, Giglio Ridge, Oblia Terrace – Southeast of Pelagos Sanctuary (Italy)

Potential Criteria:	2A: High Density
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 16*	SME provided a KMZ file.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High densities.
- Detected hitherto unsuspected high densities of fin whales (but also striped dolphin and common dolphin) outside of boundaries of Pelagos Sanctuary, to the southeast (Arcangeli et al., 2009).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	0	1

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Area around Ischia Island and Regno di Nettuno Marine Protected Area (Italy)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 17*	SME provided a KMZ file. *Note that many areas (Napoli Canyon, Ponza-Salerno Terrace) are within 12 nm of island coastlines.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- One of the few remaining strongholds for the species in the Mediterranean, outside of the Alborán Sea.
- An MPA (i.e., Ischia – Regno di Nettuno MPA) was established by the Italian Government in large part to protect cetaceans (these also include sperm whales, frequenting the Cuma Canyon north of the island of Ischia).
- 46 Recognizable individuals have been catalogued, 19 of these re-sighted in different years, suggesting significant levels of site fidelity. Breeding activities are often observed, and calves are always present in one or more of the group sub-units. Sighted groups are relatively large (mean=65.5, SD=23.94, n=41, range 35–100 individuals) and often observed in association with striped dolphins (*Stenella coeruleoalba*), particularly during surface feeding targeting shoaling prey (Mussi, Miragliuolo, & Bearzi, 2002).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	1	3	0	0	0
Status	Not Eligible	Not Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Insufficient Detail	Adequate Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973).

Area off Eastern Sicily, East of Messina Canyon (Sicily, Italy)

Potential Criteria:	2A: High Density
Species of Concern:	Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 20*	SME provided a KMZ file. *Note that many areas are within 12 nm of island coastlines except for a small portion.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High densities.
- "...marine biologists from the University of Pavia piggy-backed a sea mammal–monitoring experiment on [an] array [of four sensors off Sicily to see whether background noise is low enough to allow for acoustic detection of neutrinos]. The ensuing log, which is still being analyzed by both biologists and physicists, indicates hundreds of sperm-whale transits per year over an area of about 1,000 square kilometers" (Holden, 2007).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	0	1

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Area around Quarqannah Island (Tunisia)

Potential Criteria:	2B: Critical habitat
Species of Concern:	Bottlenose dolphin (*Tursiops truncatus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 21*	SME provided a KMZ file. *Note that many areas are within 12 nm of coastline.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Presence of critical habitat.
- "La densité du Grand dauphin a été estimée à 0,19 animaux/km², avec un coefficient de variation de 33%. L'effectif estimé pour l'ensemble de la zone étudiée est de 3977 dauphins, avec un intervalle de confiance relativement large, de 1982 à 7584 animals."
- **Translation from Abstract:** This campaign, ASPIS 2003, concerned the zone of the 15 MN of Kélibia to Zarzis, in the east and the south of the country. The density of the common bottlenose dolphin was 0.19 per km^2 with a CV of 33%. The valued strength for the whole of the studied zone is 3,977 dolphins, with a relatively large confidence interval, of 1,982 to 7,584 animals. The relative abundance of the bottlenose dolphin was 0.1383 individuals per km^2. The species was however abundant in the Monastirs-Chebba and the Gabes Gulf zones. In the zone of the Cap Bon, the relative abundance was relatively weak compared to the other zones (Ben Naceur et al., 2004).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	N/A	N/A	N/A	N/A	N/A	N/A
Assessment	N/A	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Area Malta Island and Malta Plateau (Malta)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding/Calving Area
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 23*	SME provided a KMZ file. *Note that many areas are within 12 nm of coastline.* ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Vella's (2005) preliminary study, detected important presence of species and recommends further research/conservation effort.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	0	1

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	Not Eligible	Not Eligible	Not Eligible	N/A	N/A	N/A
Assessment	Information not provided.	Information not provided.	Information not provided.	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Area in the Northern Adriatic Sea (Italy, Greece, Slovenia)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding/Calving Area
Species of Concern:	Bottlenose dolphin (*Tursiops truncatus*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Numbers 24 and 25*	SME provided a KMZ file*. *Note that many areas are within 12 nm of coastline.* ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Moderate density area; *Tursiops* is the only cetacean sighted.
- "…a total of 156 sightings between 1988 and 2007. Encounter rates ranged between 0.42 and 1.67 groups/100 km of effort (Bearzi et al., 2009).
- High density, breeding/calving area, foraging grounds (i.e., off the Slovenian coast).
- "…A total of 120 sightings ...101 dolphins identified" between 2002 and 2008. High rate of site fidelity. Offspring present in 53.3% of groups. Annual mark-recapture estimate 0.069 dolphins/km^2 (Genov, Kotnjek, Lesjak, Hace, & Fortuna, 2008).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	3	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Adequate Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Area off of Southwest Greece and Crete (Ptolemy Mountains, Cretan-Rhodes Ridge) (Greece)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding/Calving Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*) Cuvier's beaked whale (*Ziphius cavirostris*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 30*	SME provided a KMZ file*. *Note that some areas are within 12 nm of coastline.* ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density, breeding/calving area, foraging grounds.
- Frantzis and colleagues have collected vast amounts of additional data during yearly cruises, which however remain unpublished. Data include information on another deep-diving species *Ziphius cavirostris*, which also apparently has important habitat in the area (Frantzis et al., 1999).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	1	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	0
Status	Not Eligible	Eligible	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	Requires more Justification	Requires more Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Area off the Gaza Strip and the Western Coast of Israel (Palestine, Israel)

Potential Criteria:	2A: High Density
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: Notobartolo di Sciara Number 35*	SME provided a KMZ file. *Note that some areas are within 12 nm of coastline.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Hitherto unsuspected presence in large groups.
- Several sightings of large groups in recent years, contrasting with previous absence of the species from the area in the authors' collective experience (Scheninin, Kerem, & Goffman, 2010).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	1	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Northeast Slope in the Ligurian-Corsican-Provençal Basin

Potential Criterion:	2B: Foraging Area
Species of Concern:	Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: Location inferred from Azzellino et al. (2008).	8°35'23.085"E, 43°57'14.637"N 9°6'36.592"E, 43°56'30.726"N 9°6'21.955"E, 43°26'45.04"N 8°35'37.721"E, 43°26'59.677"N *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	July through August

Background

- The total size of the fin whale population in the Mediterranean is unknown. However, one study estimates that approximately 3500 individuals range in a portion of the western basin. High whale densities, comparable to those found in rich oceanic habitats, were found in well-defined areas of high productivity. Most whales concentrate in the Ligurian-Corsican-Provençal Basin; however, neither their movement patterns throughout the region nor their seasonal cycle are clear (Notarbartolo-Di-Sciara, Zanardelli, Jahoda, Panigada, & Airoldi, 2003).
- During the summer months, the species is known to concentrate in high numbers in the Corso-Ligurian Basin, described as one of the principal feeding grounds for fin whales in the Mediterranean Sea (Notarbartolo-Di-Sciara, et al., 2003)
- One nine-year study surveyed a total of 73,046 km and reported 540 sightings of fin whales in the Ligurian Sea. Water depth was the most significant variable in describing fin whale distribution, with more than 90% of sightings occurring in waters deeper than 2,000m (S Panigada et al., 2005).
- One study sought to correlate marine mammal presence in the Ligurian Sea with physical and biological parameters collected during NATO's SACLANT Undersea Research Centre's sea trials, called Sirena. The data suggested that large (sperm and fin) whales were predominately found in the deeper portion of the basin (D' Amico et al., 2003).
- In the western Ligurian Sea, many submarine canyons at the boundary between neritic and oceanic domains create the conditions for the accumulation of migratory micronektonic species in the continental slope waters. One study suggests that the periodic pattern of concentration of pelagic zooplankton near the bottom above the slope may provide an abundant food source for organisms living in the slope area, and it could also be the reason for the occasional presence of fin whales over the upper slope (Azzellino, Gaspari, Airoldi, & Nani, 2008)
- Most of the fin whale sightings occurred along the 2000-m depth contour. Also, Fin whales showed also a periodic east-to west pattern in their movements during the July–August period. Such a pattern suggests once more a relationship with the counter-clockwise circulation of the Liguro-Provenc- al-Catalan Current (Azzellino, et al., 2008).
- Azzellino et al. (2008) noted that bottlenose dolphin, Risso's dolphin, sperm whale and Cuvier's beaked whale were all found associated with well-defined depth and slope gradients showing very clear preferences for specific physical habitats, respectively, the shelf-edge, the upper slope and the lower slope.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	3	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

IUCN Marine Region 4: Northwest Atlantic Ocean

Harbor Porpoise Take Reduction Management Areas (United States)

Potential Criteria:	2A: High Density 2B: Migration Route 2B: Foraging Area
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)

Proposed Boundary Consideration:

MID-COAST MANAGEMENT AREA

Point	N. lat.	W. long.
MC1	42°30.0′	70°50.1′ (MA shoreline).
MC2	42°30.0′	70°15.0′
MC3	42°40.0′	70°15.0′
MC4	42°40.0′	70°00.0′
MC5	43°00.0′	70°00.0′
MC6	43°00.0′	69°30.0′
MC7	43°30.0′	69°30.0′
MC8	43°30.0′	69°00.0′
MC9	44°17.8′	69°00.0′ (ME shoreline).

STELLWAGEN BANK MANAGEMENT AREA

Point	N. lat.	W. long.
SB1	42°30.0′	70°30.0′
SB2	42°30.0′	70°15.0′
SB3	42°15.0′	70°15.0′
SB4	42°15.0′	70°30.0′
SB1	42°30.0′	70°30.0′

SOUTHERN NEW ENGLAND MANAGEMENT AREA

Point	N. lat.	W. long.
SNE1	Western boundary as specified [1]	
SNE2	40°00.0′	72°30.0′
SNE3	40°00.0′	69°30.0′
SNE4	42°15.0′	69°30.0′
SNE5	42°15.0′	70°00.0′
SNE6	41°58.3′	70°00.0′ (MA shoreline).

[1] Bounded on the west by a line running from the Rhode Island shoreline at 41°18.2′ N. lat. and 71°51.5′ W. long. (Watch Hill, RI), southwesterly through Fishers Island, NY, to Race Point, Fishers Island, NY; and from Race Point, Fishers Island, NY; southeasterly to the intersection of the 3-nautical mile line east of Montauk Point; southwesterly along the 3-nautical mile line to the intersection of

OFFSHORE MANAGEMENT AREA

Point	N. lat.	W. long.
OFS1	42°50.0′	69°30.0′

OFFSHORE MANAGEMENT AREA—Continued

Point	N. lat.	W. long.
OFS2	43°10.0′	69°10.0′
OFS3	43°10.0′	67°40.0′
OFS4	43°05.8′	67°40.0′ (EEZ boundary).
OFS5	42°53.1′	67°44.5′ (EEZ boundary).
OFS6	42°47.3′	67°40.0′ (EEZ boundary).
OFS7	42°10.0′	67°40.0′
OFS8	42°10.0′	69°30.0′
OFS1	42°50.0′	69°30.0′

MUDHOLE NORTH MANAGEMENT AREA

Point	N. lat.	W. long.
MN1	40°28.1′	74°00.0′ (NJ shoreline).
MN2	40°30.0′	74°00.0′
MN3	40°30.0′	73°20.0′
MN4	40°05.0′	73°20.0′
MN5	40°05.0′	74°02.0′ (NJ shoreline).

MUDHOLE SOUTH MANAGEMENT AREA

Point	N. lat.	W. long.
MS1	40°05.0′	73°31.0′
MS2	40°05.0′	73°00.0′

MUDHOLE SOUTH MANAGEMENT AREA—Continued

Point	N. lat.	W. long.
MS3	39°51.0′	73°00.0′
MS4	39°51.0′	73°31.0′
MS1	40°05.0′	73°31.0′

Basis: U.S. Government These areas are designated in the Harbor porpoise take reduction plan (75 FR 7402; 19 February 2010).

Proposed Temporal Consideration:	Regions outside of 12-nmi from the coast within the following areas: Mid-Coast Management Area: September 15 through May 31 Stellwagen Bank Management Area: November 1 through May 31 Southern New England Management Area: December 1 through May 31 Offshore Management Area: November 1 through May 31 Mudhole North: January 1 through April 30 Mudhole South: January 1 through April 30

Background Provided by SME

- The Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena*) stock annually migrate through U.S. Atlantic waters from North Carolina in the winter to the Gulf of Maine and Bay of Fundy in the summer (Palka, Read, Westgate, & Johnston, 1996). They are in the northern Gulf of Maine and lower Bay of Fundy, Canada region during July and begin to migrate out during September. During September to December and April to June, they are seen in the lower Gulf of Maine and off the Atlantic coast of Nova Scotia near Halifax, although not in the numbers observed in the Bay of Fundy. During December to March, some of the population is presumed to be offshore of the US mid-Atlantic, from North Carolina to Massachusetts, as indicated by beach strandings (Haley & Read, 1993) and several sighting surveys (Northridge, 1996; Palka, 1995; Read, 1999; Winn, 1982). Although a few strandings have been found in Florida, the typical southerly boundary is Cape Hatteras, North Carolina (Palka, et al., 1996).
- The Gulf of Maine/Bay of Fundy harbor porpoise stock is considered a strategic stock because human-related mortalities exceed the potential biological removal (PBR) level (Waring, Josephson, Fairfield-Walsh, & Maze-Foley, 2009).
- Harbor porpoises are small sized, so they are unable to carry large energy stores (Koopman, 1998). Thus, their patterns of movement are likely to be strongly related to the distribution of their prey (Johnston, Westgate, & Read, 2005). Their primary prey are juvenile Atlantic herring *Clupea harengus harengus* though they also feed on silver hake *Merluccius bilinearis*, hake *Urophycis* spp. and pearlsides *Maurolicus weitzmani* (Gannon, Craddock, & Read, 1998).
- Because during the harbor porpoise's annual migrations they have consistently been found to inhabit certain regions in high to intermediate density levels where their prey are commonly found and where gillnet fishing commonly occurs, management actions have been developed to reduce the bycatch of harbor porpoises during specific times in specific management areas (75 FR 7383-7402; 19 February 2010). These times and areas (detailed above in the Proposed Temporal Consideration section) are clearly important habitat for this species and should receive appropriate protection. Management actions include restricting gillnet fishing or require gillnets to use pingers.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	3	1	0	0	4	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	3	3	0	3	0	0
Status	Eligible	Eligible	N/A	Eligible	N/A	N/A
Assessment	Adequate Justification	Adequate Justification	N/A	Adequate Justification	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Cape Hatteras Special Research Area (United States)

Potential Criterion:	2A: High Density 2B: Foraging Area
Species of Concern:	Pilot whale spp. (*Globicephala* spp.)
Proposed Boundary Consideration:	An area bounded by the following coordinates: 75 º W, 36º 25'N 74 º W, 36º 25'N 74 º W, 35 º N 75 º W, 35 º N
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- Mixing of shelf, slope and Gulf Stream water over the continental shelf edge of the Middle Atlantic Bight near Cape Hatteras, North Carolina results in upwelling and Gulf Stream meanders (Churchill, Levine, Connors, & Cornillon, 1993)
- (Böhm, Hopkins, Pietrafesa, & Churchill, 2006; Churchill, et al., 1993). This creates a highly productive region which allows temperate and tropical marine species to flourish; species ranging from larval fish (Hare et al., 2002) to cetaceans (DON, 2007b; Garrison et al., 2003; Waring, et al., 2009).
- The Cape Hatteras Special Research Area, an area off Cape Hatteras within the above productive region, has a high density of pilot whales and high bycatch rates of pilot whales in the pelagic long line fishery (74 FR 23349-23358; May 19, 2009).
- Inside this Research Area, pelagic long line fishers are required to carry an observer on board, if requested, and to participate in focused research on pilot whale interactions with the pelagic longline fishery.
- Sightings of pilot whales (*Globicephala sp*.) in the western North Atlantic occur primarily near the continental shelf break ranging from Florida to the Nova Scotian Shelf (Mullin & Fulling, 2003). The long-finned pilot whale (*Globicephala melaena*) is distributed from North Carolina to North Africa (and the Mediterranean) and north to Iceland, Greenland and the Barents Sea (Abend, 1993; Abend & Smith, 1999; Buckland, Anderson, Burnham, & Laake, 1993; Leatherwood, Caldwell, Winn, Schevill, & Caldwell, 1976; Sergeant, 1962). Long-finned pilot whales and short-finned pilot whales (*Globicephala macrorhynchus*) overlap spatially along the mid-Atlantic shelf break between Cape Hatteras, North Carolina and New Jersey (Garrison, Martinez, & Maze-Foley, (in review); Payne & Heinemann, 1993). In addition, short-finned pilot whales are documented along the continental shelf and continental slope in the northern Gulf of Mexico (Hansen, Mullin, Jefferson, & Scott, 1996; Mullin & Fulling, 2003; Mullin & Hoggard, 2000), and they have also been seen in the wider Caribbean.
- Pilot whales are bycaught in the U.S. Atlantic pelagic longline, mid-Atlantic midwater trawl and the mid-Atlantic bottom trawl fisheries (Waring, et al., 2009).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
6	1	0	0	1	6	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	3	3	0	0	0	0
Status	Eligible	Eligible	N/A	N/A	N/A	N/A
Assessment	Adequate Justification	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Georges Bank (United States)

Potential Criterion:	2A: High Density 2B: Foraging Area 2B: Migration Route
Species of Concern:	North Atlantic Right whale (*Eubalaena glacialis*) Beaked whales (*Mesoplodon* spp. and *Ziphius* spp.)
Proposed Boundary Consideration:	An area bounded by the following coordinates: 40º 00’ N, 72º 30’ W 39º 20’ N, 71º 54’ W 39º 30’ N, 71º 25’ W 39º 45’ N, 69º 00’ W 40º 26’ N, 66º 43’ W 41º 45’ N, 65º 26’ W 42º 20’ N, 66º 06’ W 42º 18’ N, 67º 23’ W ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically designated area of biological importance.*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- Georges Bank is a region very rich with marine life, ranging from plankton to marine mammals (Link et al., 2008; Steele et al., 2007) and is among the most diverse, productive, and trophically complex marine temperate areas in the world (Link, et al., 2008; Overholtz & Link, 2007).
- The northern edge of Georges Bank is a relative shallow, cool region where the Georges Bank anti-cyclonic frontal circulation system deposits abundant amounts of copepods, such as *Calanus* (Durbin et al., 2003). As a result of this abundant food, the northern edge of Georges Bank is a foraging area for many cetaceans including endangered whales, such as right whales (*Eubalaena glacialis*), humpback whales (*Megaptera novaeangliae*), sei whales (*Balaenoptera borealis*), and fin whales (*Balaenoptera physalus*), and a variety of small cetaceans, such as pilot whales (*Globicephala spp.*), white-sided dolphins (*Lagenorhynchus acutus*), common dolphins (*Delphinus delphis*), and Risso’s dolphins (*Grampus griseus*) (DON, 2007a; Pace & Merrick, 2008; Palka, 2006; Rossman, 2009; Selzer & Payne, 1988; Vigness-Raposa, Kenney, Gonzalez, & August, 2009; Waring, et al., 2009; Winn, 1982)
- The southern edge of Georges Bank is a different habitat with its warmer shelf-slope front, many deep canyons (e.g. Hydrographer and Oceanographer canyons), warm intrusions of the Gulf Stream, and steep shelf edge (Mooers et al. 1979). This habitat also has high densities of cetaceans, though some of the species are different from the northern edge of Georges Bank. Species commonly found foraging on the southern edge of Georges Bank include beaked whales (Mesoplodon spp. and Ziphius spp.), fin whales, sperm whales (*Physeter macrocephalus*), pilot whales, spotted dolphins (*Stenella attenuata*), striped dolphins (*Stenella coeruleoalba*), offshore bottlenose dolphins (*Tursiops truncatus*), Risso’s dolphins, and common dolphins (DON, 2007a, 2007b; Hamazaki, 2002; Palka, 2006; Selzer & Payne, 1988; Waring, et al., 2009).
- In addition, the cetacean density is even larger because some species migrate through Georges Bank and do not reside for long time periods on George Bank. Examples of these species are harbor porpoises (*Phocoena phocoena*), minke whales (*Balaenoptera acutorostrata*), and killer whales (*Orcinus orca*) (Hamazaki, 2002; Palka, Orphanides, & Warden, 2009).

- The species composition in the northern and southern edges of Georges Bank differs from season to season; however, in total there are high densities of foraging cetaceans during all parts of the year, where the winter has the lowest densities (DON, 2007a; Winn, 1982).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	0	0	0	0	8	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	3	4	0	4	0	0
Status	Eligible	Eligible	N/A	Eligible	N/A	N/A
Assessment	Adequate Justification	Strong Justification	N/A	Strong Justification	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Northwest of Challenger Bank (Bermuda)

Potential Criteria:	2B: Migration Route 2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Stone et al. (1987)	The area around 65°19'11.214"W, 32°12'16.23"N *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	March and April

Background

- Historical accounts show that humpback whales have frequented Bermuda waters, which are located half-way between wintering and summering grounds in the western North Atlantic, since the early 17th century (Stone, Katona, & Tucker, 1987). Stone et al. (1987) suggested that humpback whales from the North Atlantic feed briefly and opportunistically at Bermuda (32°20'N) while migrating (Danilewicz, Tavares, Moreno, Ott, & Trigo, 2009).
- Humpback whales were common in Bermudian coastal waters during the late winter and spring (March-May); sperm whales, in offshore waters probably throughout much of the year (Reeves, Mckenzie, & Smith, 2006)
- Humpbacks utilize Bermuda as a mid-ocean habitat through which all members of the western North Atlantic population migrate during spring (Stone, et al., 1987).
- Humpbacks returning to their northern feeding grounds may take more westerly routes that in many cases pass close to Bermuda where as suggested by Stone et al. (1987), they may linger and feed (Clapham & Mattila, 1990).
- Stone et al. (1987) suggest that the presence of humpbacks at Bermuda, a way-point during the springtime northward migration, may be attributed to increased food availability, providing the first opportunity to feed after the wintering ground fast (Baraff, Clapham, Mattila, & Bowman, 1991).
- There is also evidence suggesting that humpback whales feed at Bermuda on deep water scattering layers during their stop-over (Stone, et al., 1987).
- It seems likely that humpbacks returning to their northern feeding grounds may take more westerly routes that in many cases pass close to Bermuda where, as suggested by Stone et al. (1987), they may linger and feed (Clapham & Mattila, 1990).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
5	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	2	0	1	0	0
Status	N/A	Eligible	N/A	Not Eligible	N/A	N/A
Assessment	N/A	Requires More Data	N/A	Insufficient Detail	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

Roseway Basin Right Whale Conservation Area (Canada)

Potential Criterion:	2B: Foraging Grounds
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: Canadian Government.	An area bounded by the following coordinates: NW 43° 05'N, 65° 40'W NE 43° 05'N, 65° 03'W SW 42° 45'N, 65° 40'W SE 42° 45'N, 65° 03'W
Proposed Seasonal Consideration:	*Canadian Restriction is June through December.*

Background

- In 2008, Transport Canada implemented the Roseway Basin Area to be Avoided (ATBA) following its adoption by the International Maritime Organization (IMO). The measure is seasonal and recommended for all vessels ≥ 300 gross tonnage from June through December. The aim of this ATBA is to protect the endangered North Atlantic right whale from ship strikes and to enhance maritime safety (IMO, 2007).
- From 1999 to 2001, Baumgartner et al. (2003) conducted surveys in Roseway Basin to investigate the physical and biological oceanographic factors associated with North Atlantic right whale occurrence. They noted that right whales in these regions fed on *Calanus finmarchicus*.
- Spatial variability in right whale occurrence was associated with water depth and the depth of the bottom mixed layer. *C. finmarchicus* CS aggregated over the deepest water depths in both regions, and within these areas, right whales occurred where the bottom mixed layer forced discrete layers of *C. finmarchicus* to occur shallower in the water column (allowing more efficient foraging) (Baumgartner, et al., 2003).
- Baumgartner et al. (2003) concluded that annual increases in right whale occurrence appeared to be associated with decreases in sea surface temperature (SST) in both regions; however, they any further observation merits based on the short duration of the three-year study.
- Baumgartner et al. (2003) concluded that spatial variability in right whale occurrence was associated with water depth and the depth of the bottom mixed layer, within the Bay of Fundy and Roseway Basins. Copepods (*Calanus finmarchicus*) aggregated over the deepest water depths in these areas. Within these areas, right whales occurred where the bottom mixed layer forced discrete layers of *C. finmarchicus* to occur shallower in the water column, which allows more efficient foraging.
- The spatial and interannual variability in occurrences observed for right whales might be associated with the SST gradient, a proxy for ocean fronts (Baumgartner, et al., 2003).
- The summer feeding areas are in waters near Nova Scotia and the principal spring feeding ground (April-June) is in the GSC (Kenney & Wishner, 1995).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	4	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Strong Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Great South Channel (United States)

Potential Criteria:	2B: Critical Habitat 2B: Foraging Area
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: U.S. Government.	It is bounded by the following coordinates: 42°30′00.0″ N, 069°45′00.0″ W 41°40′00.0″ N, 069°45′00.0″ W 41°00′00.0″ N, 069°05′00.0″ W 42°09′00.0″ N, 067°08′24.0″ W 42°30′00.0″ N, 067°27′00.0″ W 42°30′00.0″ N, 069°45′00.0″ W *This area is within designated critical habitat.*
Proposed Seasonal Consideration:	*Ship Strike Rule is April 1 to July 31.*

Background

- The Great South Channel (GSC) area lies east of Cape Cod, Massachusetts, U.S.A. between Nantucket Shoals on the west and Georges Bank on the east. Right whales are the world's most endangered large whale species, and the GSC is the principal feeding ground of the western North Atlantic population (Kenney & Wishner, 1995).
- The South Channel Ocean Productivity Experiment (SCOPEX), a multidisciplinary study of a whale-zooplankton predator-prey system in the southwestern Gulf of Maine, confirmed the co-occurrence of right whales with high density *Calanus finmarchicus* patches. Also, the whales fed on patches with higher proportions of larger lifestages of *C. finmarchius* (Kenney & Wishner, 1995).
- The summer feeding areas are in waters near Nova Scotia and the principal spring feeding ground (April-June) is in the GSC (Kenney & Wishner, 1995).
- Right whales were only rarely observed in the GSC during the fall and winter seasons. Most sightings occurred in April, May, and June, with a large peak in sighting frequency in May (Kenney, Winn, & Macaulay, 1995).
- In the Great South Channel Seasonal Management Area, NOAA has proposed an April through July requirement that all vessels over 300 gross tons travel no faster than 10 knots. To physically separate whales and vessels, NOAA has also considered designating the Great South Channel critical habitat area as an International Maritime Organization-approved Area To Be Avoided (ATBA). NMFS proposed seasonal restriction of the April through July based on the number of greatest sighting densities found in the southwest corner of the GSC Critical Habitat (Merrick & Cole, 2007).
- NMFS designated this area as critical habitat and an important feeding area for the North Atlantic right whale in 1994 (NMFS, 1994).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migratio n Route	Critical Habitat	Small Distinct Population
Rank	0	3	0	0	4	0
Status	N/A	Eligible	N/A	N/A	Eligible	N/A
Assessment	N/A	Adequate Justification	N/A	N/A	Strong Justification	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

The Gully Marine Protected Area (Canada)

Potential Criteria:	2A: High Density 2B: Foraging Grounds
Species of Concern:	Northern bottlenose whales (*Hyperoodon ampullatus*)
Proposed Boundary Consideration: Basis: Canadian Government	An area bounded by the following coordinates: 44°13′ N, 59°06′ W to 43°47′ N, 58°35′W; 43°35′ N, 58°35′ W to 43°35′ N, 59°08′ W to 44°06′ N, 59°20′ W
Proposed Seasonal Consideration:	Year Round

Background

- The Gully, a submarine canyon off eastern Canada, was nominated as a pilot Marine Protected Area (MPA) in 1998, largely to safeguard the vulnerable population of northern bottlenose whales (Hooker, Whitehead, & Gowans, 2002).
- Northern bottlenose whales are consistently found through the year in the Gully (Whitehead, Gowans, Faucher, & McCarrey, 1997).
- A small, apparently isolated, and endangered population of approximately 130 northern bottlenose whales is found on the Scotian Slope south of Nova Scotia, Canada (Wimmer & Whitehead, 2004).
- A ship survey along the 1,000 m depth contour in 2001 showed northern bottlenose whales only in the Gully, Shortland Canyon, and Haldimand Canyon. Studies in 2002 reconfirmed the presence of the whales in the other canyons, although densities were about 50% lower than in the Gully (Wimmer & Whitehead, 2004)
- Hooker et al. (2002) estimated the energy consumption of bottlenose whales in The Gully and suggested that there must be a substantial spatial subsidy in the underlying food web of the submarine canyon to support the bottlenose whales using the Gully. Studies of this species' diet elsewhere in the North Atlantic Ocean have suggested specialization on the deep-sea squid, Gonatus fabricii (Hooker, Iverson, Ostrom, & Smith, 2001).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	4	3	0	0	0	0
Status	Eligible	Eligible	N/A	N/A	N/A	N/A
Assessment	Strong Justification	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

Shortland Canyon and Haldimand Canyon (Canada)

Potential Criteria:	2A: High Density 2B: Foraging Grounds
Species of Concern:	Northern bottlenose whales (*Hyperoodon ampullatus*)
Proposed Boundary Consideration: Location inferred from Wimmer and Whitehead (2004)	An area bounded by the following coordinates: 58°38'16.385"W, 44°11'56.984"N 57°54'5.541"W, 44°31'42.32"N 57°42'35.89"W, 44°8'43.019"N 58°29'39.147"W, 43°50'23.889"N
Proposed Seasonal Consideration:	Year Round

Background

- On the Scotian Shelf, northern bottlenose whales have been sighted most often in the deep waters of three underwater canyons (the Gully, Shortland Canyon, and Haldimand Canyon) along the shelf edge. They are thought to be year-round residents but winter distribution is not understood (DFO, 2007)
- The carrying capacity (the maximum number of individuals that a given environment can support) of northern bottlenose whales on the Scotian Shelf is unknown. The density of whales is higher in the Gully than in the other two canyons. This could indicate that there is room for population expansion in Shortland and Haldimand canyons. However a large canyon such as the Gully can have proportionately higher productivity due to its oceanographic and bathymetric (ocean depths) characteristics suggesting that it would be able to support higher densities of whales than smaller canyons (DFO, 2007).
- Haldimand and Shortland canyons are clearly important habitat for this species, and should receive appropriate protection. Research in 2002 confirmed that northern bottlenose whales regularly use Shortland and Haldimand canyons (Wimmer & Whitehead, 2004).
- Northern bottlenose whales were encountered in Shortland and Haldimand canyons at a rate about half that in The Gully, which suggests about half the density. Also, the whales seem to prefer waters between about 800 and 1500 m deep within all three canyons (Wimmer & Whitehead, 2004).
- Although there have been several sightings of northern bottlenose whales in other areas on and surrounding the Scotian Slope, the only areas in which we know they can be reliably found are the Gully and Shortland and Haldimand canyons (Wimmer & Whitehead, 2004) .
- Northern bottlenose whales do move between the three canyons. The function of this movement can be considered from the perspective of optimal foraging on dispersed patches of prey. As the Gully (the richer patch) fills with more northern bottlenose whales, individuals would likely do better in terms of individual net gain to use other, albeit poorer, areas with fewer competitors (Haldimand and Shortland canyons and other areas (Wimmer & Whitehead, 2004).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	3	3	0	0	0	0
Status	Eligible	Eligible	N/A	N/A	N/A	N/A
Assessment	Adequate Justification	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

IUCN Marine Region 5: Northeast Atlantic Ocean

Dogger Bank (OSPAR International)

Potential Criterion:	2A: High Density
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	None submitted.
Proposed Seasonal Consideration:	None submitted.

Background

- In 2002 and 2003, Germany's Federal Agency for Nature Conservation (BfN) conducted aerial surveys in the German EEZ and 12 nm zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. The BfN found that the densities estimated for this site were fairly high, indicating an important area for porpoises. Also, Dogger Bank was the only area where sightings of other species could be observed (white-beaked dolphin and minke whale) (Gilles, Herr, Lehnert, Scheidat, & Siebert, 2008).
- Other studies (Siebert et al., 2006) have collected data on the occurrence of harbour porpoises in German waters from 1988 to 2002 from dedicated aerial surveys, incidental sightings and strandings. In the article, Siebert et al. notes that aerial surveys conducted in 1995 and 1996 revealed a mean abundance of 4288 (in 1995) and 7356 harbour porpoises (in 1996) in the German North Sea study area. Further, they describe reports of 791 incidental sightings of harbour porpoise pods in German and partly Danish coastal waters of the North and Baltic Seas from 1988 to 2002.
- Siebert et al. (2006) also found that 996 harbour porpoise strandings along the German North Sea coast in the period 1990 to 2001. Only 17 animals were identified as by-catch.
- Siebert et al. (2006) noted that their observational data demonstrated a strong seasonality of harbour porpoise occurrence off the German coast with highest numbers during the summer months.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Sylt Outer Reef (Germany)

Potential Criteria:	2A: High Density 2B: Calving Grounds
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	None submitted.
Proposed Seasonal Consideration:	None submitted.

Background

- In 2002 and 2003, Germany's Federal Agency for Nature Conservation (BfN) conducted aerial surveys in the German EEZ and 12 nm zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. The BfN found that the densities estimated for this site were fairly high, indicating an important area for porpoises.
- Giles et al. (2008) noted that the highest density was estimated for Sylt Outer Reef (2002: 2.7 individuals/km^2; 2003: 3.7 individuals/km^2).
- Important habitats for harbour porpoises were detected west of the islands of Sylt and Amrum in the North Sea and around the Schlei estuary, in waters west of Fehmarn and the Fischland-Darss area in the Baltic Sea (Siebert, et al., 2006).
- In the BfN evaluation of sites in the North Sea, only the Sylt Outer Reef was delineated for porpoises using the criteria of Article 4.1 Habitats Directive. There, three selection criteria were positively validated: (1) continuous or regular presence, (2) good population density, and (3) a high ratio of mother-calf pairs (60%) (Gilles, et al., 2008).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	3	0	0	0
Status	Not Eligible	N/A	Eligible	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	Adequate Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

IUCN Marine Region 6: Baltic Sea

Pommeranian Bay, Adler Ground, and Western Ronne Bank (Germany)

Potential Criterion:	2B: Breeding Area
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	None submitted.
Proposed Seasonal Consideration:	Spring - Fall

Background

- The harbor porpoise is the only resident cetacean species in the German Baltic Sea (Scheidat, Gilles, Kock, & Siebert, 2008).
- One study (Verfuß et al., 2007) indicated regular presence of harbor porpoises within the Baltic Sea and noted that the porpoise usage patterns of the area indicated geographical and seasonal variation.
- The larger numbers of harbor porpoise detections in spring to autumn compared with winter suggests that the German Baltic Sea is an important breeding and mating area for these animals (Verfuß, et al., 2007).
- A recent Danish effort (http://www2.dmu.dk/Pub/FR657.pdf) to designate and identify areas of high harbor porpoise density has collected all relevant data on movements and density of the harbor porpoises in Danish and adjacent waters.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	2	0	0	0
Status	N/A	N/A	Eligible	N/A	N/A	N/A
Assessment	N/A	N/A	Requires More Data	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

IUCN Marine Region 7: Caribbean

Continental Slope of the Northern Gulf of Mexico (United States)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Critical Habitat
Species of Concern:	Sperm whale, several cetacean species
Proposed Boundary Consideration: *Basis: T. Jefferson*	Between 200 and 1,000 meter depth contours. **NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited (Sparks, 1997) and (O'Hern & Biggs, 2009) for support.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	1	0	0	0	0
Status	Not Eligible	Not Eligible	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	Insufficient Detail	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Southeastern U.S. Right Whale Seasonal Habitat (United States)

Potential Criteria:	2B: Calving Area 2B: Designated Critical Habitat
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: U.S. Government	The coastal waters between 31°15' N and 30°15' N from the coast out 15 nautical miles; and the coastal waters between 30°15' N and 28°00' N from the coast out 5 nautical miles. *This area is within designated critical habitat.*
Proposed Seasonal Consideration:	November through March

Background

- NMFS has designated critical habitat for the NARW in coastal waters of the southeastern United States (SEUS) (NMFS, 1994). This area is the only known calving ground for NARW off the SEUS in the winter (Kraus, Hamilton, Kenney, Knowlton, & Slay, 2001).
- The NARW calving season extends from late November through early March with an observed peak in January. The presence of females with calves was primarily limited to the coastal waters between 27°30'N and 32°00'N latitudes (NMFS, 1994).
- Based on the number of calves and females with calves in the SEUS since 1980, NMFS considers the SEUS as the primary calving area for the population (NMFS, 1994).
- Keller et al. (2006) found that SST likely plays an important role in the distribution of right whales in the southeastern, winter habitat. Warm Gulf Stream waters, generally found south and east of delineated critical habitat, represent a thermal limit for right whales and play an important role in their distribution within the calving grounds (Keller et al., 2006).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	4	0	4	0
Status	N/A	N/A	Eligible	N/A	Eligible	N/A
Assessment	N/A	N/A	Strong Justification	N/A	Strong Justification	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Silver Bank and Navidad Bank (Dominican Republic)

Potential Criteria:	2B: Breeding Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration:	An area bounded by the following coordinates: 70°1'44.244"W, 20°54'55.121"N 69°39'45.454"W, 20°55'36.078"N 68°46'39.063"W, 20°17'6.149"N 68°31'13.453"W, 19°48'1.415"N 69°3'18.394"W, 19°55'40.124"N 70°2'8.817"W, 20°16'17.001"N *This area is within a nationally-designated marine mammal sanctuary*.
Proposed Seasonal Consideration:	December through April

Background

- One survey conducted between 14 February and 19 March 1984 reported 317 whales were individually identified from photographs of ventral fluke patterns. Analysis of matches suggests that whales from the various high-latitude feeding stocks mix randomly on Silver Bank. Overall, the number of whales, calves, and surface-active groups observed during this study confirms the apparently singular importance of Silver Bank to the breeding ecology of western North Atlantic humpback whales (Mattila, Clapham, Katona, & Stone, 1989).
- Fast moving groups containing three or more adult humpback whales are found in the winter on Silver Bank in the West Indies. Many of these groups (Mattila, et al., 1989) have a definite structure: a central Nuclear Animal, with or without a calf, is surrounded by escorts who compete, sometimes violently, for proximity to the Nuclear Animal (Tyack & Whitehead, 1982).
- The humpback whales which winter in the West Indies are principally found over banks which are at latitudes between 10° and 22° N, have substantial areas of flat bottom between 15 and 60 m deep, and lie less than 30 km from the North Atlantic 2000-m contour. The surface sea temperatures in these areas are between 24 and 28° C (Whitehead & Moore, 1982).
- The major concentrations of the humpbacks, which feed little in winter, are on Silver and Navidad banks. On Silver Bank the humpback and humpback song densities peak in the centre of the Bank. Mothers with calves are generally found in areas of calm water, and singers are found over areas with a flat bottom, where they meander slowly (Whitehead & Moore, 1982).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	4	0	0	0
Status	N/A	N/A	Eligible	N/A	N/A	N/A
Assessment	N/A	N/A	Strong Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

IUCN Marine Region 8: West Africa

Canary Islands Cetacean Marine Sanctuary (Canary Islands)

Potential Criteria:	2A: High Density 2B: Critical Habitat
Species of Concern:	Short-finned Pilot Whale (*Globicephala macrorhynchus*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	*This area is a proposed nationally-designated marine mammal sanctuary.* The proposed boundary for the sanctuary could encompass: either all or portion of national waters to the limit of the EEZ of the Canary Islands, or possibly the waters between the islands, with or without the main whale watch areas off southwest Tenerife and La Gomera. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Canary Islands represent a major area of concentration for the short-finned pilot whale (*Globicephala macrorhynchus*).
- This population is resident and is under significant stress from ship strikes and poorly-regulated whale-watching activities (Heimlich-Boran, 1993).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Tristan da Cunha Cetacean Sanctuary (British Overseas Territory)

Potential Criteria:	2A: High Density 2B: Critical Habitat
Species of Concern:	Tasman beaked whale (*Tasmacetus shepherdi*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	*This area is a nationally-designated marine mammal sanctuary.* SME did not submit a spatial file.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- This subantarctic island has recently been found to contain a relatively high concentration of Shepherd's beaked whale (*Tasmactus shepherdi*), a beaked whale species that is considered rare and presumably highly-susceptible to impacts from naval sonar (Best, Glass, Ryan, & Dalebout, 2009).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

Coastal Waters of Gabon, Congo and Equatorial Guinea (West Africa)

Potential Criteria:	2A: High Density (*TJ*, *HR*) 2B: Breeding / Calving (*TJ*, *HR*) 2B: Foraging Grounds (*HR*) 2B: Migratory Route (*HR*) 2B: Critical Habitat (*TJ*, *HR*) 2C: Small, Distinct Population (*HR*)
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) (*TJ*, *HR*) Blue Whale (*Balaenoptera musculus*) (*HR*) Sperm Whale (*Physeter macrocephalus*) (*HR*) Beaked Whales (Ziphiidae) (*HR*) Bottlenose Dolphins (*Tursiops truncates*) (*HR*) Atlantic Humpback Dolphins (*Sousa teuszii*) (*HR*) Melon-headed Whales (*Peponocephala electra*) (*HR*)
Proposed Boundary Consideration: *Basis: T. Jefferson, H. Rosenbaum. Published literature, IWC reports and Wildlife Conservation Society unpublished data*	Territorial sea to 20 nm offshore. (*TJ*) Coasts of Gabon, Congo, and Equatorial Guinea to 40 nm. (*HR*) ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	Year-round (*HR*)

Background Provided by SME

- Well documented breeding habitat and migratory corridor for humpback whales, with particularly good documentation of dense aggregations in coastal waters of Gabon, particularly areas around Port Gentil, and the coastal shelf north and south to Luanda and northwards to Bioko (Findlay, 2001; Rosenbaum & Collins, 2006; Townsend, 1935; Walsh, Fay, Gulick, & Sounguet, 2000) and (Collins et al., 2008; Rosenbaum et al., 2009; Strindberg, Ersts, Collins, Sounguet, & Rosenbaum, In Press).
- Documented presence of the rare and likely endangered Atlantic Humpback dolphin in coastal waters of Gabon and Congo. The global population is small, and their range heavily fragmented. Gabon and Congo may host the healthiest habitat and populations remaining (low hundreds). (Collins, Ngouessono, & Rosenbaum, 2004; Van Waerebeek et al., 2004).
- Presence of sperm whales and beaked whales (Best, 2007; Townsend, 1935; Weir, 2006b, 2007).
- High biodiversity documented in the Port Gentil region due to the convergence of habitat suitable for both inshore, shallow water, and offshore, deep water species (Rosenbaum & Collins, 2006; Weir, 2006a) Findlay et al. 2006; Best 2007).
- Blue whales recorded on multiple occasions in the inshore waters of Northern Angola during dedicated study in 2008 (WCS unpublished data). Whaling catch record also suggests blue whales form a typical component of the cetacean species assemblage of the area (Best, 2007; Branch et al., 2007).
- Humpback whales (*Megaptera novaeangliae*) use the waters offshore of Gabon as a major breeding area in the Southern Hemisphere winter. There is concern about the impacts of extensive oil exploration and extraction has on the population, which has been studied in detail for several years (Rosenbaum & Collins, 2006).

- **[New Data - TJ]** Although their current status in waters of Congo and Equatorial Guinea are unknown, the coastal waters of Gabon are inhabited by an apparently small and localized population of Atlantic humpback dolphins (*Sousa teuszii*), which is listed by the IUCN as Vulnerable to extinction. Several sightings of these animals have been made there in recent years and preliminary evidence suggests that all populations of this species are small and fragmented (Collins, et al., 2004; Van Waerebeek, et al., 2004). In addition, these dolphins are highly vulnerable to impacts from oil exploration and extraction, which occurs along much of the West Africa coast.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
11	2	0	0	0	4	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	1	4	4	0	2
Status	Not Eligible	Not Eligible	Eligible	Eligible	Not Eligible	Eligible
Assessment	Insufficient Detail	Insufficient Detail	Strong Justification	Strong Justification	Does not qualify.	Requires More Data

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

IUCN Marine Region 9: South Atlantic Ocean

Buenos Aires Province Coastal Area (Argentina)

Potential Criterion:	2A: High Density 2B: Breeding / Calving 2B: Foraging Area 2C: Small, Distinct Population
Species of Concern:	Franciscana dolphin (*Pontoporia blainvillei*), Burmeister's Porpoise (*Phocoena spinipinnis*)
Proposed Boundary Consideration: *Location inferred from H. Rosenbaum*	The coastal waters of the Buenos Aires Province, from the coast out 10 nautical miles, between 35°00'S and 38°57'S. The coastal waters of the Buenos Aires Province, from the coast out 50 nautical miles, between 38°57'S and 40°37'S, to cover the island systems in the area. The coastal waters of the Buenos Aires Province, from the coast out 10 nautical miles, between 40°37'S and 42°00'S. *This area includes 12 nationally and/or internationally (UNESCO) designated marine protected areas (MPAs)*
Proposed Temporal Consideration:	Year-Round

Background Provided by SME

- The Franciscana dolphin is endemic to the Southwestern Atlantic Ocean, from Northern Brazil to Northern Argentina, and has been recognized as the most endangered cetacean in the region (Bordino et al., 2002; Secchi, Danilewicz, & Ott, 2003).
- This species is listed as Vulnerable by the IUCN and in Appendix II of CITES. The Burmeister's porpoise is endemic to the coasts of South America, from Southern Brazil to Northern Peru. This species is listed as conservation dependent-Data Deficient by the IUCN and in Appendix II of CITES. The coastal area of the Buenos Aires represents the southern limit of the Franciscana dolphin distribution range, and approaches the northern distribution range limit of Burmeister's porpoises.
- Density estimations for Franciscanas in the Buenos Aires area range between 0.37 and 0.48 ind/km^2 in the Buenos Aires area, which translates to an estimated abundance of approximately 30,000 individuals for this area (Bordino, Albareda, & Fidalgo, 2004; Crespo, Pedraza, Grandi, Dans, & Garaffo, 2004; Crespo, Pedraza, Grandi, Dans, & Garaffo, 2010) .
- Recent genetic data shows clear evidence of population structure of Franciscanas in Argentina, within the Buenos Aires Area (Lázaro, Lessa, & Hamilton, 2004; Mendez, Rosenbaum, & Bordino, 2008). Specifically, Mendez and colleagues provided evidence of at least three distinct populations in this area: one in northern Buenos Aires in the Samborombón area, at least one in eastern Buenos Aires between 36°30' deg. S and 38°00' deg. S., and at least another isolated population in southern Buenos Aires between 38°00' deg. S. and the species' distribution limit at 42°00' deg. S. (Mendez, et al., 2008; Mendez, Rosenbaum, Yackulic, Subramaniam, & Bordino, 2010). This genetic evidence is strongly supported by satellite tracking data for the species in northern and southern Buenos Aires (Bordino & Wells, 2005; Bordino, Wells, & Stamper, 2008).
- Based on environmental data and studies of fish community structure and abundance (Lasta, 1995; Lasta & Acha, 1996), coupled with the genetic evidence of *Franciscana* population structure in

Buenos Aires, Mendez et al. (2008) suggested that northern Buenos Aires could be a feeding area and calving ground for these dolphins.

- Genetic evidence suggests the existence of at least three isolated populations of Burmeister's porpoises along their distribution range: one population in coastal Peru, a second one in southern Chile, and a third one in Southern Argentina (Rosa et al., 2005). Because the Argentinean samples were collected in the Tierra del Fuego Province, over 2000 km of linear coastal distance from Buenos Aires, it is likely that future studies including specimens in this area uncover further population structure in Argentina.
- The Buenos Aires coastal area includes the following designated MPAs: Bahía de Samborombón (RAMSAR), Bahía San Blas-Isla Gama (National), Caleta de los Loros (National), Campos del Tuyú (National), Complejo Islote Lobos (National), Costero del Sur (National) ,Parque Costero del Sur (UNESCO), Dunas Atlántico Sur Mar Chiquita (National), Islas Embudo, Bermeja y Trinidad (National), Mar Chiquito (UNESCO), Punta Bermeja (National), and Rincon de Ajo (National).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	3	0	0	1	0	1

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	2
Status	Not Eligible	Eligible	Eligible	N/A	N/A	Eligible
Assessment	Insufficient Detail	Requires More Data	Requires More Data	N/A	N/A	Requires More Data

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

Patagonian Shelf Break (Argentina)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Southern elephant seal (*Mirounga leonina*)
Proposed Boundary Consideration: *Location inferred from Campagna et al. (1995, 1998, 1999, 2006) and Falabella et al. (2009). H. Rosenbaum*	Relevant areas are located between the isobaths of 200 and 2000 meters and the following latitudes: 1) 35°00'S and 39°00'S 2) 56°30'S and 58°30'S 3) 40°40'S and 42°30'S 2) 46°00'S and 48°50'S
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The breeding aggregation of southern elephant seal at Peninsula Valdes is estimated to number some 50,000 individuals one year old or older. It is the only colony for the species that grew during about three decades and is today stable.
- Contrary to all other colonies of southern elephant seals, Peninsula Valdes is continental and is located in temperate waters rather than Antarctic of subantarctic waters (Campagna & Lewis, 1992).
- During foraging seasons (up to 7 month at sea), elephant seals combine exceptionally deep diving (up to 1500 m) with long-distance traveling, covering millions of square kilometers.
- The shelf break is an oceanic front exploited throughout the year by elephant seals. In summer (January – March) there is an intense use of the slope from the Rio de la Plata to the south of the San Jorge Gulf. In autumn, the main foraging areas are distributed to the south of the slope and around the Malvinas Islands (Falabella, Campagna, & Croxall, 2009).
- The shelf break front is a narrow transition region between subpolar and shelf waters that shows a moderate sea surface temperature front and chlorophyll-a maxima in summer resulting from upwelling created by the Malvinas Current interaction with the bottom topography (Romero, Piola, Charo, & Garcia, 2006; Saraceno, Provost, & Piola, 2005).
- During the foraging season, adults disperse widely, over millions of square kilometers. Females migrate longer distances than males, to the Argentine Basin. Males apparently prefer the edge of the continental shelf, which is much closer and more predictable in terms of productivity than the Basin. Juveniles behave as adults in terms of the extent of their migrations, although they show seasonal differences. While adults breed on land in the spring, juveniles are at sea, and while adult females are at sea after giving birth, juveniles molt on land see (Campagna, Fedak, & McConnell, 1999; Campagna, Le Boeuf, Blackwell, Crocker, & Quintana, 1995; Campagna et al., 2007; Campagna, Piola, Rosa Marin, Lewis, & Fernández, 2006; Campagna, Quintana, Le Boeuf, Blackwell, & Crocker, 1998; Campagna, Rivas, & Marin, 2000).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
9	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	4	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Strong Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Southern Right Whale Seasonal Habitat (Argentina)

Potential Criteria:	2B: Calving Area 2B: Designated Critical Habitat
Species of Concern:	South Atlantic right whale (*Eubalena australis*)
Proposed Boundary Consideration: *Basis: H. Rosenbaum*	The coastal waters between 42°00'S and 43°00'S from the coast out 15 nautical miles including the enclosed bays of Golfo Nuevo, Golfo San Jose and San Matias *This area is contains designated calving habitat.*
Proposed Temporal Consideration:	May through December

Background Provided by SME

- The coastal waters surrounding Peninsula Valdes off the coast of Argentina contain one of the main calving areas for this species (Paine ref.).
- The southern right whale calving season extends from late May through late December with an observed peak in September. The presence of females with calves was primarily limited to the coastal waters between 42°00' S and 42°45'S latitudes (Paine et. Al, ref).
- Based on the number of females with calves in this area since 1970, this is considered one of the primary calving areas for the southern right whale population (Paine ref; Best ref).
- Although parts of Golfo Nuevo and all of Golfo San Jose have protected area status, southern right whales also range outside these bays throughout the season into Golfo San Matias and the Atlantic Ocean adjoining peninsula Valdes to 15nm from shore and further.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	4	0	0	0
Status	N/A	N/A	Eligible	N/A	N/A	N/A
Assessment	N/A	N/A	Strong Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

IUCN Marine Region 10: Central Indian Ocean

Northern Bay of Bengal and Swatch-of-No-Ground (India)

Potential Criterion:	2A: High Density 2B: Breeding Calving 2B: Foraging Area 2C: Small, Distinct Population
Species of Concern:	Irrawaddy dolphin (*Orcaella brevirostris)* Finless porpoise (*Neophocaena phocaenoides)* Indo-Pacific humpback dolphin (*Sousa chinensis)* Indo-Pacific bottlenose dolphin (*Tursiops aduncus)* Bryde's whale (small form) (*Balaenoptera edeni)* Pantropical spotted dolphin (*Stenella attenuate)* Spinner dolphin (*S. longirostris)*
Proposed Boundary Consideration: Location inferred from Smith *et al*. (2008) and Mansur *et al.* (unpublished ms submitted to *Marine Mammal Science*) in Bangladesh waters and inferred from similar habitat in Indian waters.	Area is inclusive of the Swatch-of-No-Ground Submarine Canyon and adjacent coastal waters, Bangladesh and northeastern India. Polygon extending along the margins of the Sundarbans mangrove forest from a point in the east at 22º30'N, 91º40'E to a point in the west at 21º26'N, 87º41'E, following the Bangladesh coast south to 20º30'N, 92º30'E and to an offshore point at 20º30'N, 87º41'E, inclusive of the Swatch-of-No-Ground (SoNG) submarine canyon and St. Martin's Island. *This area lies adjacent to three UNESCO World Heritage sites in the Sundarbans and includes a proposed international Marine Protected Area for cetaceans in the SoNG (Bangladesh Cetacean Diversity Project, 2008)*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The coastal and deep-sea waters of Bangladesh have recently been identified as a global 'hotspot' of cetacean abundance and diversity (Smith, Ahmed, Mowgli, & Strindberg, 2008).
- Coastal waters are influenced by discharge from the third-largest river system in the world, the Ganges/Brahmaputra/Meghna (GBM), which supplies about 133 x 10^9mol yr^{-1} to the Bay of Bengal that is more than 1.5% of the total riverine input to the world's oceans (Sarin, Krishnaswami, Dilli, Somayajulu, & Moore, 1989) and a seasonally reversing, wind-driven, basin-scale gyre (Somayajulu, Murty, & Sarma, 2003). These conditions combine to produce a highly stratified and productive sea-surface layer that supports relatively large populations of Irrawaddy dolphins, finless porpoises, and Indo-Pacific humpback dolphins (Smith, et al., 2008). The first two species are Red Listed by the IUCN as 'vulnerable' and the third as 'near threatened.'
- A distance analysis of Irrawaddy dolphin and finless porpoise sightings made during a survey conducted in the winter season of 2004 resulted in abundance estimates of 5,383 (CV=39.5) and 1,382 (CV=54.8%) individuals, respectively (Smith, et al., 2008). This is the largest documented population of Irrawaddy dolphins by more than an order of magnitude. Its large size can almost certainly be explained by the extensive freshwater influence of the GBM system. The population estimate for finless porpoises also compares favorably to other marine areas where the species has been surveyed - e.g., Ariake Sound and Tachibana Bay (Yoshida, Shirakihara, Kishino, &

Shirakihara, 1997) and Hong Kong and adjacent waters (Jefferson, Hung, Law, Torey, & Tregenza, 2002). Although an insufficient number of Indo-Pacific humpback dolphin groups were observed during the 2004 survey to estimate abundance (*n*=6), the relatively large size of some groups (>50 individuals) probably indicates a significant population.

- During the 2004 survey mentioned above all three species were found much farther offshore compared to other areas of their distribution (>30 nm for Irrawaddy dolphin, >36 nm for finless porpoise, and >19 nm for Indo-Pacific humpback dolphins) even though the survey was conducted in the winter when freshwater discharge was at its lowest. Habitat selection models for Irrawaddy dolphins indicate that the species would almost certainly be found even farther offshore with increasing freshwater flow during the monsoon season (Smith, et al., 2008).
- The Swatch-of-No-Ground (SoNG) is a 900+ meter deep submarine canyon that incises approximately 65 nm inside the continental shelf in a northeast direction to within 20 nm of the rim of the Sundarbans mangrove forest. The canyon has relatively steep walls (12-15°), ranges from about 40 km wide at its mouth to about 6 km wide at its head, and carries sediments that sustain the world's largest submarine fan (Michels, Suckow, Breitzke, Kudrass, & Kottke, 2003; Subrahmanyam, Krishna, Ramana, & Murthy, 2008). According to a mark-resight analysis under Pollock's robust design of 907 individuals photo-identified during the winter seasons of 2005-2007, a population of about 1,800 Indo-Pacific bottlenose dolphins was estimated to occur in a 2,455 km^2 area at the head of the SoNG (Mansur *et al.* in review). This makes it one of the largest populations assessed of the species. The probability of animals transitioning from an observable state in season 1 to an unobservable state in season 2 was 15.2% or less which may indicate that the actual size of the population is higher than the estimate of 1,800 individuals (Mansur *et al.* in review).
- During the photo-identification study of Indo-Pacific bottlenose dolphins mentioned above eight sightings were made of pantropical spotted dolphins (mean group size = 137, range 20-350) in the far offshore fringes of the study area in waters >100 m deep (Brian D. Smith and Rubaiyat Mansur, unpublished). A single pantropical spotted dolphin group (~800 individuals) was also detected during the 2004 survey of coastal cetaceans at the far offshore and high salinity extreme of survey coverage (Smith, et al., 2008),which only touched the margin of the species' preferred habitat in warm, stratified, pelagic waters see (Perrin & Hohn, 1994). This implies that significant numbers of the species may also occur farther offshore in un-surveyed waters where stratification remains high due to the basin-scale current gyre in the Bay of Bengal (Smith, et al., 2008). During the same the photo-identification study, 14 sightings were made of spinner dolphins (mean group size = 85.0, SD=74.2, range = 2-200) in waters at the outer fringes of the study area >120 m deep (Brian D. Smith and Rubaiyat Mansur, unpublished).
- During 2005-2008, 114 sightings were made of Bryde's whales (mean groups size = 2.3, SD=2.0, range=1-15) in similar habitat as Indo-Pacific bottlenose dolphins at the head of the SoNG (Brian D. Smith and Rubaiyat Mansur, unpublished). A total of 15 individuals were identified from photographs of their dorsal fin, of which six were re-identified during all three seasons (Mahabub, 2008). MtDNA control region data from 38 skin samples collected from these whales indicated that these animals were closely aligned with the "small form" of Bryde's whales (Matt Leslie, unpublished). Bryde's whales are not known to undergo long-range seasonal migrations and the high, predictable productivity in the SoNG may support a resident population of this species. The common occurrence of calves may also indicate that the area is important for breeding
- Although there are no empirical data on the abundance of cetaceans inhabiting the coastal or deep-sea waters on the Indian side of the border of the proposed Offshore Biologically Important Area, similar high densities of cetaceans may be inferred from the existence of similar habitat including freshwater discharge from the Sundarbans and Hooghly River and at western edge of the SoNG.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	0	0	0	1	2	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	2	0	0	4
Status	Not Eligible	Eligible	Eligible	N/A	N/A	Eligible
Assessment	Insufficient Detail	Requires More Data	Requires More Data	N/A	N/A	Strong Justification

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

IUCN Marine Region 12: East Africa

Coastal Waters off Madagascar (Madagascar)

Potential Criteria:	2A: High Density 2B: Breeding and Calving Grounds 2B: Foraging Grounds 2B: Migratory Route 2B: Critical Habitat
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Blue whale (*Balaenoptera musculus*) Sperm whale (*Physeter macrocephalus*) Beaked whales (family Ziphiidae) Bottlenose dolphins (*Tursiops aduncus, T. 166runcates*) Indo-Pacific Humpback dolphin (*Sousa chinensis*) Melon-headed whale (*Peponocephala electra*)
Proposed Boundary Consideration: *Basis: H. Rosenbaum. Published literature, IWC reports and Wildlife Conservation Society unpublished data.*	All coasts of Madagascar out to 50 nm. **NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- Well documented breeding habitat for humpback whales, with particularly good documentation of dense aggregations in the northeast (Antongil Bay, Isle Ste. Marie), the southeast (Ft. Dauphin), southwest regions (Toliara/Anakao), the Comoros Archipelago off the northeast coast, and suggestions of distribution throughout the entire region (Cerchio, Andrianarivelo, Razafindrakoto, Mendez, & Rosenbaum, 2009; Cerchio et al., 2009; Ersts & Rosenbaum, 2003; Rosenbaum, et al., 2009; Rosenbaum, Walsh, Razafindrakoto, Vely, & Desalle, 1997).
- Presence of sperm whales and beaked whales documented in waters off shelf in the northeast, southwest and northwest regions (Kiszka et al., 2009; Townsend, 1935). Likely foraging grounds in these deep waters.
- Sensitive populations of coastal dolphins, including impacted populations of humpback dolphins, bottlenose dolphins and spinner dolphins off the west coast (Cerchio, Andrianarivelo, et al., 2009). Clearly foraging and breeding habitat for all these non-migratory species.
- High biodiversity documented in the southwest region with 13 different cetacean species due to the close proximity of foraging habitat suitable for both inshore, shallow water species and offshore, deep water species (Cerchio, Andrianarivelo, et al., 2009).
- Documented mass stranding of melon-headed whales off the northeast coast associated with oil and gas exploration activities and the introduction of noise into the regional waters.
- Likely migratory routes for blue whales in the offshore waters off both the east coast and west coast (Mozambique Channel) (Branch, et al., 2007).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
5	3	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	2	4	3	0	0
Status	Not Eligible	Eligible	Eligible	Eligible	N/A	N/A
Assessment	Insufficient Detail	Requires More Data	Strong Justification	Adequate Justification	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Madagascar Plateau / Madagascar Ridge / Walters Shoal (Madagascar)

Potential Criteria:	2A: High Density 2B: Foraging Grounds 2B: Migratory Route 2C: Small Distinct Population
Species of Concern:	Pygmy Blue Whale (*Balaenoptera musculus brevicauda*) Humpback Whale (*Megaptera novaeangliae*) Brydes Whale (*Balaenoptera edeni*)
Proposed Boundary Consideration: Location inferred from Best et al. (2003), Branch et al. (2007)	Approximately 25ºS to 40ºS and 40ºE to 55ºE ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- Historic concentrations of catch records of blue whales, likely pygmy blue whale sub-species (Branch, et al., 2007).
- Currently, best documented congregation and feeding area for a pygmy blue whale population in the Indian Ocean, with abundance estimated by line transect distance-sampling at 424 individuals (CV = 0.42) (Best et al., 2003).
- Population identity is likely one of three suspected populations of pygmy blue whales in the Indian Ocean, characterized acoustically by stereotyped "Madagascar" call type (Branch, et al., 2007; McDonald, Mesnick, & Hildebrand, 2006), and restricted to the larger southwest Indian Ocean region (though range extent is currently unknown).
- Documented feeding area and migratory route / stopping area for southwest Indian Ocean population of Humpback whales, Breeding Stock C (Best et al., 1998).
- Documented concentrations of Bryde's whales, they are believed to represent a stock/population/subspecies distinct from two coastal African populations (Best, 2001).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
5	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	3	4	3	0	2
Status	Not Eligible	Eligible	Eligible	Eligible	N/A	Eligible
Assessment	Insufficient Detail	Adequate Justification	Strong Justification	Adequate Justification	N/A	Requires More Data

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

IUCN Marine Region 13: East Asia

Gulf of Thailand (Thailand, Malaysia, Cambodia)

Potential Criteria:	2A: High Density 2B: Breeding / Calving 2B: Critical Habitat 2C: Small Distinct Population
Species of Concern:	Indo-Pacific humpback dolphin (*Sousa chinensis*) Irrawaddy dolphin (*Orcaella brevirostris*) Finless porpoise (*Neophocaena phocaenoides)*
Proposed Boundary Consideration: *Basis: T. Jefferson*	SME did not submit a spatial file. **NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Gulf of Thailand is an area of concentration for three species of coastal small cetaceans that are threatened by human activities: the Indo-Pacific humpback dolphin, Irrawaddy dolphin, and finless porpoise.
- These populations are under stress from serious habitat alteration and unregulated captures for live-display (Beasley, Davidson, Somany, & Ath, 2002; Mahakunlayanakul, 1996).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	1	1	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	1	0	0	3
Status	Not Eligible	N/A	Not Eligible	N/A	N/A	Eligible
Assessment	Insufficient Detail	N/A	Insufficient Detail	N/A	N/A	Adequate Justification

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

Komodo National Park, Biosphere Reserve (Indonesia)

Potential Criteria:	2A: High Density
Species of Concern:	Omura's whale (*Balaenoptera omurai*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	SME did not submit a spatial file. *Note that some areas are within 12 nm of coastline.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The waters around Komodo Island have been found to contain significant numbers of Omura's whales (*Balaenoptera omurai*). This is a newly-recognized species of baleen whale, which has been subjected to whaling operations by Japan, and currently is of unknown status (Kahn, 2001; Kahn, Wawandono, & Subijanto, 2001).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	2	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

Area in the Ombai Strait in the Savu Sea Marine Protected Area (Indonesia)

Potential Criteria:	2B: Migration Route 2B: Feeding Grounds
Species of Concern:	Blue Whale (*Balaenoptera musculus*) Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: Location inferred from Pet Soede (2002)	124°19'2.12"E, 8°40'3.814"S 125°0'5.731"E, 8°32'35.885"S 124°49'57.827"E, 8°46'59.748"S 124°26'46.047"E, 8°57'55.645"S *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	June through September

Background

- The Indonesian Marine Affairs and Fisheries Minister Freddy Numberi announced the designation of the Savu Sea National Marine Park—a blue whale hotspot, in May 2009.
- There is little species information on this area. However, The Nature Conservancy has sponsored the Solor-Alor Visual and Acoustic Cetacean Survey & Research Program in this area since 2001. Their studies consider the southeastern cape of Alor and the entrance of Ombai Strait, is considered to be a wide and important migratory corridor between Alor and East Timor (Pet-Soede, 2002).
- Initial comparisons between blue whale sightings south of Alor (Savu Sea) and north of Komodo (Flores Sea) suggests that blue whales enter and exit Indonesian Seas through different routes and corridors; perhaps initially migrating east towards Ombai Strait, between E. Alor and Timor, and then move into the Banda Sea (Pet-Soede, 2002).
- The small passages between the Solor-Alor Islands in the Savu Sea are considered feeding grounds and corridors for cetacean migration (Mustika, 2006).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	1	1	1

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	2	0	2	0	0
Status	N/A	Eligible	N/A	Eligible	N/A	N/A
Assessment	N/A	Requires More Data	N/A	Requires More Data	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

IUCN Marine Region 15: Northeast Pacific

Beaked Whale Habitat in the Coastal Waters off California, Washington, and Oregon (United States)

Potential Criteria:	2A: High Density 2B: Critical Habitat
Species of Concern:	Beaked whales (*Ziphiidae*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	Bathymetry: Between 550 and 2,000 meter depth contours. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited MacLeod and Mitchell (2005) for support.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	Not Eligible	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	Does not qualify.	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Central California National Marine Sanctuaries (United States)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Migration Route
Species of Concern:	Blue whale (*Balaenoptera musculus*) Humpback whale (*Megaptera novaeangliae*) Dall's porpoise (*Phocoenoides dalli*) Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) Northern right whale dolphin (*Lissodelphis borealis*) Risso's dolphin (*Grampus griseus*) Eastern gray whale (*Eschrichtius robustus*) Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Location inferred from Forney (2007)	Single stratum boundary created from the Cordell Bank, Gulf of the Farallones, and Monterey Bay legal boundaries.
Proposed Temporal Consideration:	Blue and humpback whale feeding in this area is largely limited to June-November. Gray whales migrate through this area December-May but are likely to be greater than 12 miles from shore only when crossing Monterey Bay. All other species are year-round residents.

Background Provided by SME

- During the summer and fall of 2005, the Southwest Fisheries Science Center conducted a shipboard line-transect survey of marine mammals in the waters off California, Oregon, and Washington out to 300 nm, with fine-scale survey effort in four National Marine Sanctuaries (NMSs), namely the Olympic Coast, Cordell Bank, Gulf of the Farallones, and Monterey Bay NMSs (Forney, 2007). Geographically-stratified line-transect analyses were used to derive density and abundance estimates for three strata with coarse survey coverage (southern California, central and northern California combined, and Oregon and Washington combined) and three strata with fine-scale survey coverage (the Olympic Coast slope, Olympic Coast NMS, and the three central California NMSs combined). Based on the stratified line-transect analyses, the densities in the central California NMS stratum were the highest among all geographic strata for five cetacean species, Dall's porpoise, northern right whale dolphins, Risso's dolphins, humpback whales, and blue whales. Furthermore, the density of Pacific white-sided dolphins in the central California NMS stratum was the second highest among all strata.
- Each fall, gray whales migrate south along the coast of North America from Alaska to Baja California, in Mexico, most of them starting in November or December (Rugh, Shelden, & Schulman-Janiger, 2001). Gray whale northbound migration generally begins in mid-February and continues through May with cows and newborn calves migrating northward primarily between March and June along the U.S. West Coast (Carretta et al., 2008). Gray whales are greater than 12 nm from shore when they migrate across the mouth of Monterey Bay.
- In the Monterey Bay, blue whales feed on dense euphausiid aggregations between 150 and 200 m on the edge of the Monterey Bay Submarine Canyon. (Croll et al., 2005). Blue whale feeding is also particularly common from the Cordell Bank shoreward to Bodega Bay (Barlow & Forney, 2007) and at the southern extent of the Monterey Bay National Marine Sanctuary (Barlow & Forney, 2007).
- Humpback whale feeding is particularly concentrated with the Cordell Bank, Gulf of the Farallon and Monterey Bay National Marine Sanctuaries (Barlow & Forney, 2007; Forney, 2007).

- The cyclic annual migration of the northeastern Pacific blue whale population is associated with feeding at mid- to high-latitudes throughout the highly productive summer and fall, followed by a southbound migration to tropical regions to give birth and mate in the winter and spring. Primary production off southern California typically peaks in the spring allowing particular euphausiid species to grow to maturity by summer, coinciding with the arrival of blue whales (Burtenshaw et al., 2004).
- Cordell Bank is located about 80 kilometers (50 miles) northwest of San Francisco and 32 kilometers west of the Point Reyes lighthouse. It is approximately 7 kilometers wide and 15 kilometers long and sits on the edge of the continental shelf. The bank is located on the edge of an underwater peninsula and is surrounded by deep water on three sides. Within 11 kilometers of its western edge, the seafloor drops to 1,829 meters at the sanctuary's western boundary (NMS, 2009a).
- Vertical entrapment and/or forcing of prey near the surface likely plays a role in predator aggregation over Cordell Bank. Also, Cordell Bank is shallower than the diurnal depth range of many zooplankton species, especially euphausiids and could vertically trap these prey species in shallow regions within the diving depth of many predators (Yen, Sydeman, & Hyrenbach, 2004)
- Northern fur seals and California sea lions are seasonally abundant in the Cordell Bank NMS, coming here to forage during the fall through the spring.
- Since 1982 Steller sea lion southernmost breeding colonies are within the Monterey Bay and Gulf of the Farallones National Marine Sanctuaries at Año Nuevo Island and the Farallon Islands, respectively. Females and juveniles Steller sea lions stay within the Gulf year-round, while males migrate north and offshore during the non-breeding season from the end of August through May (NMS, 2009c).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
7	0	0	0	2	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	4	4	0	4	0	0
Status	Eligible	Eligible	N/A	Eligible	N/A	N/A
Assessment	Strong Justification	Strong Justification	N/A	Strong Justification	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Vaquita Habitat in the Northern Gulf of California (Mexico)

Potential Criteria:	2C: Small, Distinct Population with Limited Distribution
Species of Concern:	vaquita (*Phocoena sinus*)
Proposed Boundary Consideration: Location inferred from PACE recovery plan	All of the waters in the Gulf of California located north of the line defined by the following coordinates: 114°42'00"W, 30°36'00"N 113°33'00"W, 31°18'54"N
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The vaquita (also known as the Gulf of California harbor porpoise) is listed as Critically Endangered by the IUCN and as Endangered by both the Mexican Official Standard NOM-059 and the U.S. Endangered Species Act.
- A 2007 abundance estimate suggested that only about 150 individuals remained in the population (Jaramillo-Legorreta et al., 2007), and recent acoustic surveys indicate that the population is currently declining rapidly (Jaramillo-Legorreta & Rojas-Bracho, 2008).
- The range of the vaquita population is very small, limited to the northern Gulf of California (Jaramillo-Legorreta, Rojas-Bracho, & Gerrodette, 1999).
- Vaquitas are occasionally found more than 12 nm from shore.
- The primary and ongoing threat to the vaquita is mortality resulting from bycatch in commercial and artisanal gillnet fisheries for shrimp and fish (CIRVA, 1997, 1999, 2004; Rojas-Bracho & Taylor, 1999).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	3	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	4
Status	N/A	N/A	N/A	N/A	N/A	Eligible
Assessment	N/A	N/A	N/A	N/A	N/A	Strong Justification

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Southern Gulf of California (Mexico)

Potential Criteria:	2A: High Density
Species of Concern:	Cuvier's beaked whale (*Ziphius cavirostris*) Blainville's beaked whale(*Mesoplodon densirostris*) Peruvian beaked whale (*Mesoplodon peruvianus*) Sperm whales (*Physeter macrocephalus*) Coastal spotted dolphin (*Stenella attenuate graffmani*) Long-beaked common dolphin (*Delphinus delphis*) Bottlenose dolphins (*Tursiops truncatus*) Risso's dolphin (*Grampus griseus*) Short-finned pilot whale (*Globicephala macrorhynchus*) Dwarf sperm whale (*Kogia sima*) Bryde's whale (*Balaenoptera edeni*) Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: Location inferred from references cetacean and oceanographic cited in Background material	All of the waters in the southern Gulf of California between 22.88 ^{o}N and 30^{o}N ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically designated area of biological importance.*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The southern Gulf of California is an area of particularly high population density for Cuvier's and *Mesoplodon* beaked whales, sperm whales, Bryde's whales, fin whales, coastal spotted dolphins, long-beaked common dolphins, bottlenose dolphins, Risso's dolphins, short-finned pilot whales, and dwarf sperm whales, based on two different analytical methods, geographically stratified line-transect analyses (Ferguson & Barlow, 2001, 2003) and cetacean-habitat models (Ferguson, Barlow, Fiedler, Reilly, & Gerrodette, 2006; Ferguson, Barlow, Reilly, & Gerrodette, 2006). Data for both analyses were based on cetacean sighting data from shipboard line-transect surveys conducted by the Southwest Fisheries Science Center that were designed to study the distribution and abundance of cetaceans.
- The Gulf of California is a narrow sea, with considerable habitat diversity from the northern to the southern end of the Gulf. The Midriff Islands, located between 28^o-30^o N, separate the shallow (approximately 120 m) northern Gulf from the deep (approximately 2000 m) basin of the southern Gulf (Gutiérrez, Marinone, & Parés-Sierra, 2004).
- Basin-wide eddies that reliably form between the Midriff Islands and the mouth of the Gulf enhances productivity in this region of the Gulf (Pegau, Boss, & Martínez, 2002).
- The northern Gulf (north of approximately 29^o N) is characterized by a large-scale, seasonally-reversing gyre (Beier & Ripa, 1999; Carrillo & Palacios-Hernandez, 2002). Collectively, this oceanographic evidence supports placing the boundary between ecosystems in the southern and northern Gulf at approximately 30^{o}N.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Southern California Bight (United States)

Potential Criteria:	2B: Foraging Area 2B: Migration Route
Species of Concern:	Pacific gray whale (*Eschrichtius robustus*) Blue whale (*Balaenoptera musculus*) Short-beaked common dolphin (*Delphinus delphis*) Long-beaked common dolphin (*Delphinus capensis*) Risso's dolphins (*Grampus griseus*)
Proposed Boundary Consideration: Location inferred from Barlow et al. (2009)	120.5°W, 34.5°N to120.5°W, 32°N to 118.605°W, 31.1318°N to 117.8253°W, 32.6269°N to 117.4637°W, 32.5895°N to 117.121°W, 32.507°N
Proposed Temporal Consideration:	Jun through Nov for blue whales, Dec through May for gray whales, year-round for all other species

Background Provided by SME

- The Southern California Bight is a high-density feeding area for a wide variety of cetacean species. The most abundant species is the short-beaked common dolphin, *Delphinus delphis*. The boundaries of this area are taken approximately as the area where *D. delphis* density is estimated to be over 1 animal per km-2 (Barlow et al., 2009). High density areas for other species listed above fall within this zone.
- The waters around the Channel Islands within the Southern California Bight have particularly high densities of Risso's dolphins (Barlow et al. 2009) and long-beaked common dolphins (Barlow & Forney, 2007).
- For blue whales, feeding was noted at a significant fraction of blue whale sightings over the shelf (out to 3.5 km beyond the 200 m isobath) in three areas: around Santa Rosa and San Miguel Islands, north of San Nicolas Island, and along the mainland coast from Pt. Conception north (Fiedler et al., 1998)
- The results of the Whale Habitat and Prey Studies (WHAPS) show that blue whales aggregated near the Channel Islands during the summer, where they feed on dense patches of krill associated with the island shelf. Krill were most abundant along the shelf on the north and west sides of San Miguel Island and the north side of Santa Rosa Island (Fiedler, et al., 1998).
- Blue whales feed off the California coast from roughly June through November, and move southward to waters off Mexico in winter and spring (Calambokidis et al., 1990).
- A study on visual and acoustic encounter rates for blue whales in the SAB reported elevated detection rates of in the Cortez Bank and Butterfly Bank subregions, as the dynamic bathymetry in those regions may concentrate high densities of euphausiids (Oleson, Calambokidis, Barlow, & Hildebrand, 2007). Oleson et al. also notes that the similarity in the visual and acoustic encounter rates in the Cortez Bank and Butterfly Bank subregions suggests that these areas may represent portions of the Bight important to both feeding and traveling whales.
- Each fall, gray whales migrate south along the coast of North America from Alaska to Baja California, in Mexico, most of them starting in November or December (Rugh, et al., 2001). Gray whale northbound migration generally begins in mid-February and continues through May with cows and newborn calves migrating northward primarily between March and June along the U.S. West Coast (Carretta, et al., 2008). Although some gray whales follow the coast in Southern California, many or most are greater than 12 nm from shore when they migrate across the Southern California Bight.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
9	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	4	0	4	0	0
Status	N/A	Eligible	N/A	Eligible	N/A	N/A
Assessment	N/A	Strong Justification	N/A	Strong Justification	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

Fairweather Grounds, Southeast Alaska (United States)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Bounded by 58° 10'N and 58° 30'N, 137° 30'W, and 139° 10'W
Proposed Temporal Consideration:	June through September

Background Provided by SME

- The Fairweather Grounds, located offshore of Mount Fairweather in the Gulf of Alaska, is an offshore bump in the continental shelf waters off Southeast Alaska, rising to within 50 m of the surface. This bathymetric relief provides an area of concentration for fish and zooplankton food sources for humpback whales.
- The bank is more than 12 nm offshore.
- The Fairweather Grounds has long been recognized as a rich whaling ground (Davidson 1869, Coast Pilot of Alaska, US Govt. Printing Office, Washington D.C.). In that report, the area was described as being from Pamploma Reef eastward to the shores off of Mount Fairweather.
- A recent NOAA survey in 2004 found dense groups of humpback whales feeding in the same area, between 58° 10'N and 58°30'N and between 137°30'W and 139° 10'W, with super-groups of 16, 20, and 25 whales (J. Barlow, pers. comm).
- Local fishermen from Sitka often report seeing whales in the Fairweather Grounds (J. Straley, pers. comm.).
- Most of the Fairweather Grounds is more than 12 nm from shore and thus would be considered an offshore biologically important area for feeding humpback whales.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	2	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	2	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Requires More Data	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon (Washington)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Killer whale (*Orcinus orca*)
Proposed Boundary Consideration: Location inferred from Calambokidis et al. (2004)	125°58'38.786"W, 48°30'1.995"N to 125°38'52.052"W, 48°16'55.605"N to 125°17'10.935"W, 48°23'7.353"N to 125°16'42.339"W, 48°12'38.241"N to 125°31'14.517"W, 47°58'20.361"N to 126°6'16.322"W, 47°58'20.361"N to 126°25'48.758"W, 48°9'46.665"N *and existing OBIA boundary as defined in the 2007 Rule.*
Proposed Seasonal Consideration:	June through September

Background

- A CSCAPE survey reported that humpback whale sightings were concentrated in the northern part of the study area between Juan de Fuca Canyon and the outer edge of the continental shelf, an area known as "the Prairie" (Fig. 2). A small area east of the mouth of Barkley Canyon and north of the Nitnat Canyon where the water depth was 125−145 m had a high density of sightings in all years (Calambokidis, Steiger, Ellifrit, Troutman, & Bowlby, 2004). http://www.cascadiaresearch.org/reports/Fish-bul-OCSwEratum.pdf
- NOAA Technical Memorandum 406 estimated that the abundance of humpback whales within the combined three OC strata during 2005 (208, CV=0.28) was about twice the observed abundance during 1995-2000 (range of abundance estimates: 85 - 125, CVs ~0.32), but lower than the peak year of 2002 with 562 (CV=0.21) humpback whales.
- NOAA Technical Memorandum 406 reports that humpback whales were observed largely in the same areas of the OCNMS as during previous years and noted that regions within and to the north (Canadian waters) and west (slope waters) of the OCNMS were likely important foraging regions for West Coast humpback whales.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	2	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Requires More Data	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Gulf of Alaska Steller Sea Lion Critical Habitat (Alaska)

Potential Criterion:	2B: Designated Critical Habitat
Species of Concern:	Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Basis: U.S. Government	Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144°W longitude. 145°43'7.708"W, 60°17'41.42"N to 143°37'31.682"W, 59°38'59.715"N to 146°26'15.838"W, 59°6'38.618"N to 147°34'46.397"W, 59°30'6.865"N to 150°15'53.824"W, 58°57'45.767"N to 151°45'20.388"W, 57°8'1.26"N to 155°30'50.98"W, 55°26'1.094"N to 159°22'19.342"W, 54°24'29.203"N to 162°43'58.85"W, 53°54'32.736"N to 163°23'18.616"W, 54°12'18.436"N to 172°57'38.806"W, 51°40'49.533"N to 179°25'44.364"W, 50°49'26.613"N to 179°39'3.639"W, 51°6'34.253"N to 163°49'34.33"W, 54°21'56.96"N to 157°56'22.112"W, 56°20'3.869"N to 153°11'13.812"W, 58°25'39.894"N to 148°41'53.223"W, 59°49'8.687"N to 148°2'52.488"W, 59°38'59.715"N
Proposed Seasonal Consideration:	Year-Round

Background

- NMFS has designated critical habitat for the Steller sea lion in certain areas and waters of Alaska. Steller sea lions are dependent on these areas and features for its continued existence and any Federal action that may affect these areas or features is subject to the consultation requirements of section 7 of the ESA 58 (58 Federal Register 45269-45285, August 27, 1993).
- Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in State- and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is east of 144°W longitude. Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144°W longitude.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	4	0
Status	N/A	N/A	N/A	N/A	Eligible	N/A
Assessment	N/A	N/A	N/A	N/A	Strong Justification	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Piltun and Chayvo Offshore Feeding Grounds (Russia)

Potential Criteria:	2B: Migration Route 2B: Foraging Area
Species of Concern:	Western Pacific gray whale (*Eschrichtius robustus*)
Proposed Boundary Consideration: Location inferred from IWC and Tyurneva (2006)	143°33'26.5"E, 53°30'42.938"N to 143°40'42.039"E, 53°34'13.683"N to 143°48'39.728"E, 52°41'4.409"N to 143°51'56.423"E, 52°1'44.066"N to 143°24'32.613"E, 52°2'54.314"N to 143°40'13.94"E, 52°38'43.912"N to 143°33'26.5", 53°30'42.938"N
Proposed Seasonal Consideration:	June through November

Background

- The critically endangered western gray whale spends the summer-fall open water period feeding off northeast Sakhalin Island (Rutenko, Borisov, Gritsenko, & Jenkerson, 2007). A previously unknown gray whale feeding area (the Offshore feeding area) was discovered south and offshore from the nearshore Piltun feeding area. The Offshore area has subsequently been shown to be used by feeding gray whales during several years when no anthropogenic activity occurred near the Piltun feeding area (S. Johnson et al., 2007).
- Results of a 2001-2003 aerial survey of the area indicated that gray whales occurred in predominantly two areas, (1) adjacent to Piltun Bay, and (2) offshore from Chayvo Bay (offshore feeding areas). In the Piltun feeding area, the majority of whales were observed in waters shallower than 20 m and were distributed from several hundred meters to similar to 5 km from the shoreline. In the offshore feeding area during all years, the distribution of gray whales extended from southwest to northeast in waters 30-65 m in depth. Fluctuations in the number of whales observed within the Piltun and offshore feeding areas and few sightings outside of these two areas indicate that gray whales move between the Piltun and offshore feeding areas during their summer-fall feeding season. Seasonal shifts in the distribution and abundance of gray whales between and within both the Piltun and offshore feeding areas are thought, in part, to be a response to seasonal changes in the distribution and abundance of prey (Meier et al., 2007).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	3	0	1	0	0
Status	N/A	Eligible	N/A	Not Eligible	N/A	N/A
Assessment	N/A	Adequate Justification	N/A	Insufficient Detail	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

IUCN Marine Region 16: Northwest Pacific

Okhotsk Sea (Russia)

Potential Criteria:	2B: Foraging Area 2B: Migration Route
Species of Concern:	Fin whale (*Balaenoptera physalus*) Minke whale (*Balaenoptera acutorostrata*) North Pacific Humpback whale (*Megaptera novaeangliae*) Western Pacific Right whale (*Eubalaena japonica*) Okhotsk Sea bowhead whale (*Balaena mysticetus*) Baird's beaked whale (*Berardius bairdii*) Dall's porpoise (*Phocoenoides dalli*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	SME did not submit a spatial file. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- A separate population of bowhead whales is restricted to the Okhotsk Sea. During the late spring and early summer these whales concentrate in Shelikhov Bay in the northeastern Okhotsk Sea and then are found from May to October in the Shantar region of the northwestern Okhotsk Sea. However, little is known about their winter distribution, but these whales do not leave the Okhotsk Sea. These concentrations are found within the 12 nm of the coast. The population is estimated in the low hundreds, but this is not based on any quantitative analysis.
- The western population of right whales summers and feeds in the Okhotsk Sea mainly off southern Sakhalin Island and the western side of the Kamchatka Peninsula. The population was depleted during 19th century whaling and again by Soviet whaling in the 1960s. Based on summer sightings during a Japanese-Russian surveys in the Okhotsk Sea in Miyashita and Kato (1998) derived a population estimate of 922 whales (95% CI 404-2,108) using line transect analysis.
- Fin whales seem to be abundant in the central offshore part of the Okhotsk Sea based on recent Japanese surveys, but no abundance estimate has been calculated (Miyashita, 2004).
- A joint Japanese-Russian surveys in the summers of 1989 and 1990 yielded an abundance estimate for western North Pacific minke whales of 25,049 (CV 0.316), but most of these whales (19,209; CV 0.339) were found in the Okhotsk Sea (Buckland, Cattanach, & Miyashita, 1992). The Okhotsk Sea has been surveyed again in 2003 (Miyashita, 2004), but no updated abundance estimate has been derived.
- The main summer feeding grounds for the western North Pacific humpback whales are the waters off easternmost Russian, including the western Bering Sea, the Okhotsk Sea, south to the Sanriku coast of Honshu, Japan (Rice, 1998) [plus any new SPLASH data population estimate of ca. 1,000 whales]).
- Three species of beaked whales (*Z. cavirostris*, *B. bairdii*, and *M. steinegeri*) are known from the waters of the Russian Far East (Tomilin, 1967). The first stranding of a Cuvier's beaked whale was in 1882 from Bering Island, Commander Islands and this specimen is the holotype of *Ziphius grebnitzkii* (Stejneger 1883). Most of the strandings for these species are from the Commander Islands where Cuvier's beaked whale is the most frequently found (Tomilin, 1967).
- Dall's porpoise are recognized as two different color type: the dalli-type and the truei-type. Based on 2003 survey data the population estimates for dalli-type and truei-type porpoises are 173,638 and

178,157, respectively (GOJ, 2007). The true-type breed in the central part of the Okhotsk Sea in summer.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
7	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	4	0	2	0	0
Status	N/A	Eligible	N/A	Eligible	N/A	N/A
Assessment	N/A	Strong Justification	N/A	Requires More Data	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

Exclusion around Japan and the Ryukyu Islands (Japan)

Potential Criteria:	SME did not submit criteria. (NMFS West Coast) 2A: High Density (TJ) 2B: Critical Habitat (TJ)
Species of Concern:	At least 39 species of cetaceans, including eight species of baleen whales, seven species of beaked whales are known from Japanese waters. Beaked whales (*Ziphiidae*) (TJ)
Proposed Boundary Consideration: *Basis: NMFS West Coast or T. Jefferson*	Exclusion around the main Japanese Islands and Ryukyu Islands, extending 100 km (54 nm) seaward of the 12 nm border along the Pacific side (eastern coastline of Japan) and extending 100 km on both sides of the Ryukyu Islands (Okinawa, Kerama, Miiyako, Yaeyama, Kume, Iriomote, and Ishigaki). Bathymetry: between 550 and 2,000 meter depth contours. (TJ) **NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Japanese Archipelago is the world's seventh largest island. The waters around the Japanese Islands have a large diversity of cetaceans because of a distant cool-temperate and warm-temperate fauna to the north and to the south, respectively. The cold water along the northern half of Japan is from the Oyashio Current which supports the Oyashio Large Marine Ecosystem (OLME). The OLME is one of the most productive ecosystems in the North Pacific Ocean (Minoda, 1989). Along the southern half of Japan warmer waters are found from the Kuroshio Current which supports the Kuroshio Large Marine Ecosystem and extends south to its origin off the Philippines.
- At least 39 species of cetaceans are found within these two large marine ecosystems in the Japanese EEZ, including many ecologically and genetically distinct populations. (e.g., (Fujino, 1960; Hayano, 2004, 2007; Ichihara, 1957b; Kasuya & Miyashita, 1988, 1997; Kasuya, Miyashita, & Kasamatsu, 1988; Kasuya & Tai, 1993; Kato, 1992; Miyazaki & Amano, 1994; Miyazaki & Nakayama, 1989; Wada, 1988).
- Eight species of baleen whales (fin whales, sei whales, minke whales, Bryde's whales, Omura's whales, humpback whales, gray whales and North Pacific right whales) are known from Japanese waters.
- In the western North Pacific, there are at least two distinct populations of minke whale. The "J stock" which appears to be an autumn-breeding population that occurs in the Yellow Sea, East China Sea and Sea of Japan. They also occur at least seasonally in the coastal waters along the Pacific coast of Japan with limited penetration into the Okhotsk Sea in summer; The other population is the "O-stock" which breeds in winter like most baleen whales, and occurs in summer in the northwestern Pacific including the northeastern coasts of Japan, and in the Okhotsk Sea, but the "J stock" with a with conception peak in the fall (Kato, 1992; Omura & Sakiura, 1956). J stock whales are found out to at least 50 nm from the Pacific coast of Japan. The population is considered delepted because of past commercial whaling and current bycatch in both Korean and Japanese waters.
- Seven species of beaked whales (*I. pacificus*, *B. bairdii*, *Z. cavirostris*, *M. carlhubbsi*, *M. densirostris*, *M. ginkodens*, *M. stejnegeri*) are known from Japanese waters. Longman's beaked whale was not

recorded until July 2002 at Sendai-shi, Kyushu (Yamada). Three of these species (*B. bairdii*, *M. carlhubbsi*, and *M. stejnegeri*) are restriched to the cold waters of the Oyashio Current and the others are found in the warm Kuroshio Current to the south of 35 N. Cuvier's beaked whales are found in all waters around Japan and six mass strandings (with three or more individuals) of these whales occurred in Sagami Bay and Suruga Bay between 1963 and 1990 (Brownell, Yamada, Mead, & Van Helden, 2004).

- Baird's beaked whales are found off the slope of the eastern coast of Japan to about 35 N. Vessel surveys were conducted between 1983 and 1991 and in 1992. These surveys produced Overall abundance estimates of 4,220 and 5,029, respectively (Miyashita, 1986; Miyashita & Kato, 1993). No abundance estimates are available for any of the other species of beaked whales in Japanese waters and little is known about these actual distributions except from stranded animals.
- Miyashita (1993) estimated population size of the northern form of the short-finned pilot whales in the cold water Oyashio Current off the NE coast of Japan, based on summer surveys in 1982 through 1988 was 4,239 (CV=0.61).
- Dall's porpoise are found only in the North Pacific and two forms are found in the west. These are the dalli-type found along the east side of Japan north of 35 N. and the truei-type known from northern Japan and southern half of the Okhotsk Sea. Based on 2003, abundance estimates for the dalli-type and truei-type were 173,638 and 178,157, respectively (GOJ, 2007). During the winter the truei-type are found in the Oyashio Current offshore from Choshi, Japan to Hokkiado, Japan but in the summer they move to the central Okhotsk Sea. The dalli-type spend the winter in the northern part of the Sea of Japan north of the Shimane Pref. and breed in the Okhotsk Sea.
- Miyashita (1993) estimated the population size of the northern form of the short-finned pilot whales in the cold water Oyashio Current off the NE coast of Japan, based on summer surveys in 1982 through 1988, was 4,239 (CV=0.61).
- Dall's porpoise are found only in the North Pacific and two forms are found in Japanese waters. These are the dalli-type found along the east side of Japan north of 35° N. and the truei-type known from northern Japan and the southern half of the Okhotsk Sea. Based on surveys in 2003, abundance estimates for the dalli-type and truei-type were 173,638 and 178,157, respectively (GOJ, 2007). During the winter the truei-type are found in the Oyashio Current offshore from Choshi, Japan to Hokkaido, Japan but in the summer they move to the central Okhotsk Sea. The dalli-type spends the winter in the northern part of the Sea of Japan (north of the Shimane Pref.) and breed in the Okhotsk Sea.
- Other small cetaceans found in the Oyashio Current include: short-beaked dolphins, striped dolphins, common bottlenose dolphins, Risso's dolphins, northern right whale dolphins, Pacific white-sided dolphins, false killer whales, and killer whales.
- Small cetaceans in the Kuroshio Current in Japanese waters south of 34° N are the tropical and warm-temperate species found worldwide in these types of waters. Some of the more abundant small cetaceans here include: striped dolphins, spotted dolphins, common bottlenose dolphins, Risso's dolphins, southern short-finned pilot whales, and false killer whales. These species are well studied off Japan because they are taken by the Japanese drive fishery. Based on Japanese sightings surveys from 1983 to 1991 in the waters off Japan, population estimates were made for these six species (Miyashita, 1993). These are summarized below:
- Striped dolphins were found in August and September in three geographic concentrations in waters between 25°N - 41°N and 135°E to 180°. The total population estimate for this area was 570,000 (CV=0.18).
- Spotted dolphins were found in August and September and most were concentrated north of 30°. The area surveyed was between 25ºN-38ºN and west of 180º. The total population estimate for the area was 438,000 (CV=0.17).
- Common bottlenose dolphins were found in August and September in waters between 30ºN - 42ºN and west to 160ºE. The total population estimate for the area was 168,000 (CV=0.26).

- Risso's dolphins were found in three concentrations in waters south of 40ºN and west of 180º but their southern boundary was not determined during the surveys. The total abundance estimate was 838,000 (CV=0.17).
- The population size for southern form of short-finned pilot whales was estimated at 53,000 (CV=0.22) during the months of August and September in coastal and offshore waters west to 165ºE and between 25ºN - 36ºN.
- False killer whales were found in generally the same area as the short-finned pilot whales but their northern limit was more southern at 39ºN. The total abundance estimate was 16,000 (CV=0.26).
- Other small cetaceans found in the Kuroshio Current include the following: long-beaked common dolphins, pygmy killer whale, Fraser's dolphins, killer whales, melon-headed whales, spinner dolphins and rough-toothed dolphins.
- The melon-headed whales is known from nine mass stranding events in Japanese waters south of 36° N between 1982 and 2006 (Brownell, Yamada, Mead, & Allen, 2006).
- Also, the Indo-Pacific bottlenose dolphin is found in small seven discontinuous, isolated populations, within the main Japanese islands and offshore islands, in the Kuroshio Current. These populations are: (1) in the Bungo Channel, Amakusa (Shirakihara, Shirakihara, Tomonaga, & Takatsuki, 2002) (2) Kagoshima Bay (Nanbu, Hirose, Kubo, Kishiro, & Shinomiya, 2006) (3) in the Sea of Japan, around Noto-jima (Mori, 2005) (Mori and Yoshioka 2009), (4) Mikura Island and (6) Ogasawara Islands (Mori *et al*. 2005). Mikura and Ogasawara are about 200 km and about 1,000 km, respectively, southeast of Tokyo. The seventh population is in the waters around the Amami Islands which are part of the Ryukyu Islands chain (Miyazaki and Nakayama 1989). Most of these Indo-Pacific bottlenose dolphins, like in other populations throughout their range, are year-around residents (Mori and Yoshioka 2009).
- Eight species of pinnipeds (Kurile harbor seal, larga seal, ringed seal, ribbon seal, bearded seal, and northern fur seal) including one endangered one (Steller sea lion) and one extinct species (Japanese sea lion) are known from northern Japanese waters, mainly in the southern Okhotsk Sea off the northern coast on Hokkaido.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	3	0	0	0	8	3

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	Not Eligible	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	Does not qualify.	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

The Sea of Japan (Japan)

Potential Criteria:	SME did not submit criteria. (NMFS West Coast) 2A: High Density (TJ)
Species of Concern:	Finless porpoise (*Neophocaena phocaenoides*) (NMFS West Coast) Beaked whales (*Ziphiidae*) (TJ)
Proposed Boundary Consideration: *Basis: NMFS West Coast or T. Jefferson*	Total exclusion within the Sea of Japan, extending seaward of the 12 nm borders of the Korean Peninsula and Japan Bathymetry: between 550 and 2,000 meter depth contours. (TJ) ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The cetaceans, including both baleen whales and small cetaceans, found in the Sea of Japan approximately north from the southern end of the Korean Peninsula are the same as those found in the Oyashio Large Marine Ecosystem and the cetaceans to the south of the Korean Peninsula are the same as those found in the Kuroshio Large Marine Ecosystem.
- Finless porpoise are found outside the 12 nm zone of the Sea of Japan because of the shallow nature of this region. Anon. (2005) reported that "In the offshore waters (33°00′ to 37°30′N, 122°00′ to 126°00′E), two sighting surveys were conducted using the R/V Tamgu-3 in 2001 and 2004." Anon. (2005) also says that "Park reported the stock status in the Korean waters based on the abundance estimate. 2 shipboard surveys for finless porpoise were made in each offshore and inshore of the west coast of Korea. The first surveys in offshore and inshore were carried out in each 2001 and 2003 estimated an abundance of 58,650 animals in offshore and 1,571 porpoises in inshore. In 2004, it was estimated that current abundance was 21,532 animals in offshore and 5,464 porpoises in inshore."

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Total Exclusion within the Yellow Sea / East China Sea (China, North Korea, South Korea)

Potential Criteria:	SME did not submit criteria.
Species of Concern:	Gray whale (*Eschrichtius robustus*) Minke whale (*Balaenoptera acutorostrata*) Fin whale (*Balaenoptera physalus*) Humpback whale (*Megaptera novaeangliae*) Omura's whale (*Balaenoptera omurai*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Total exclusion within the Yellow Sea and East China Sea (China) extending seaward of the 12 nm borders of the Korean Peninsula, China and Japan. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Yellow Sea Large Marine Ecosystem is a semi-enclosed Sea bordered by three countries: China, North Korea and South Korea. The southern Yellow Sea is adjacent to the East China Sea Large Marine Ecosystem which is also a semi-enclosed body of water bordered by China, South Korean and Japan. The southern limit of the East China Sea connects to the Taiwan Strait. The warm Tsushima Current, a branch of the Kuroshio Current, is a major influence in the ECS ecosystem.
- The main baleen whales known to occur in the inshore waters are: gray whales, minke whales, fin whales and humpback whales (Zhou, 2004). In addition, Omura's whales should also be present in the coastal and offshore regions of the ECS but not the Yellow Sea (Yamada, 2009).
- A resident population of fin whales, depleted from past commercial whaling operations, is found in both the Yellow Sea and the East China Sea (Fujino, 1960). Ichihara (1957a) reported differences in the general shapes of fin whales between the western Aleutian Islands and the northern part of the East China Sea.
- Three species of beaked whales (Baird's beaked whales, Blainville's beaked whales, and gingko-toothed beaked whales) are recorded from Chinese waters (P. Wang, 1999; Zhou, 2004). No abundance estimates are available for any of these species in Chinese waters and little is known about their actual distribution except from stranded animals.

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	5	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	N/A	N/A	N/A	N/A	N/A	N/A
Assessment	N/A	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion around Taiwan (China)

Potential Criteria:	SME did not submit criteria.
Species of Concern:	SME did not submit any species information.
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Exclusion around Taiwan, extending 100 km (54 nm) seaward of the 12 nm border along the Pacific side (eastern coastline of Taiwan). ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Historically, the humpback whale was the most important baleen whale in Taiwanese waters, but the population was greatly depleted by commercial whalers during the first half of the 20th century.
- Additional baleen whales include minke whales, Bryde's whales and Omura's whales, but gray whales have not been confirmed from Taiwanese waters. All of the small cetaceans listed above from the Kuroshio Large Marine Ecosystem are also found in the same current off the east coast of Taiwan (J. Wang & Yang, 2007) and southward to the Philippines (Dolar, Perrin, Taylor, Kooyman, & Alava, 2006).
- Deep water is found close to shore off the eastern and southern coast of Taiwan. Population estimates are not available for these waters, but small cetaceans are abundant and form the core of the local whale-watching operations along the east coast of Taiwan. Also the same species within distant regions of the Kuroshio Large Marine Ecosystem are different populations and therefore must be assessed and managed separately (Perrin, Dolar, Amano, & Hayano, 2003).
- One of these species, the pygmy killer whale is known from six mass stranding events from the southwestern region of the island between 1995 and 2005 and an additional three near mass stranding events (Brownell et al., 2009).
- Additional MSEs in Taiwan are known for melon-headed whales, rough-toothed dolphins, and short-finned pilot whales (J. Wang and Yang, 2007).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	N/A	N/A	N/A	N/A	N/A	N/A
Assessment	N/A	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion in the South China Sea (China)

Potential Criteria:	SME did not submit criteria. (NMFS West Coast) 2A: High Density (TJ)
Species of Concern:	Misc. Species (TJ)
Proposed Boundary Consideration: *Basis: NMFS West Coast or T. Jefferson*	Bathymetry: 100 km seaward of the shallow water area (NMFS West Coast) Continental shelf. (TJ) ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The main character of the South China Sea Large Marine Ecosystem (SCS) is its tropical climate. The countries bordering the SCS are: Vietnam, China, Taiwan, the Philippines, Malaysia, Thailand, Indonesia and Cambodia.
- The SCS is divided into two major areas: (1) a coastal region less them 200 m from the coast out to about 100 km and (2) a deep water region to the east of the shallow water area.
- The cetaceans found in the shallow waters are not well known and mainly consist of Indo-Pacific bottlenose dolphins, common bottlenose dolphins, Pacific humpbacked dolphins and finless porpoise.
- The offshore cetacean fauna are the same species found in the Kuroshio Large Marine Ecosystem. The main baleen whales known to occur in the offshore waters of the SCS are Bryde's whales and some humpback whales in the northeastern most SCS.
- Within the coastal region the following species have been recorded: gray whales, minke whale, fin whales and humpback whales (Zhou, 2004). In addition, Omura's whales should also be present in the coastal and offshore regions of the SCS (Yamada, 2009).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	2	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Total Exclusion in the Gulf of Tonkin (Vietnam)

Potential Criteria:	None submitted.
Species of Concern:	Indo-Pacific humpback dolphin (*Sousa chinensis*) Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) Finless porpoise (*Neophocaena phocaenoides*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Seaward of the 12 nm borders of Vietnam and China ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- This region is the northwest arm of the South China Sea and is bounded by China to the north and east (Hainan Island) and northern Vietnam to the west. Its size is about 500 km long and 250 km wide with waters only to 70 m deep.
- The Vietnam cetacean fauna is poorly known except for coastal small cetaceans like Indo-Pacific humpback dolphin, Indo-Pacific bottlenose dolphin and finless porpoise (Smith et al., 1995).
- Other species of small cetaceans from the Kuroshio Large Marine Ecosystem are reported from Vietnam but the locations and densities are unknown. Most records from Vietnam are whales that likely stranded near the 'Whale Temples" where their bones were deposited (Smith, et al., 1995).
- The area outside the 2 nm EEZ could be an important wintering region for some of the critically endangered western gray whales and western North Pacific humpback whales (Zhou, 2004).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	2	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	N/A	N/A	N/A	N/A	N/A	N/A
Assessment	No Data	No Data	No Data	No Data	No Data	No Data

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion around Wake Island (United States)

Potential Criteria:	None submitted.
Species of Concern:	None submitted.
Proposed Boundary Consideration: *Basis: NMFS West Coast*	An area extending 100 km seaward of the 12 nm EEZ. **NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Wake Island is the most northern of the Marshall Island chain. It is part of Wake Atoll, which consists of three fringing islands, Wake, Wilkes, and Peale, with a total land area of 6.5 km^2.
- The cetacean fauna in the waters around Wake is poorly known and only three species have been recorded (Brownell and Ralls, 2008). No abundance estimates are available for any of these species.
- Two Cuvier's beaked whales stranded live on Wake Island in January and February 1977 (PIRO Stranding database). Blue whales have been recorded near Wake (McDonald, et al., 2006; Stafford, Nieukirk, and Fox, 2001; Watkins et al., 2000), as have fin whales (Northrop, Cummings, and Thompson, 1967). Stafford *et al*. (2001) believed that some of the calls they reported near Wake were the Eastern Type, but it is now clear that the blue whale song type around Wake is exclusively the Western Type (M. McDonald, pers. comm.).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	1	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	N/A	N/A	N/A	N/A	N/A	N/A
Assessment	No Data	No Data	No Data	No Data	No Data	No Data

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion for the North Philippine Sea (Philippines)

Potential Criteria:	2A: High Density
Species of Concern:	Misc. species
Proposed Boundary Consideration: *Basis: T. Jefferson*	Bathymetry: to the 1,000 meter depth contour. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited Dolar (1999) and Dolar et al. (2006).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	1	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	No Data	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion for the West Philippine Sea (Philippines)

Potential Criteria:	2A: High Density
Species of Concern:	Misc. species
Proposed Boundary Consideration: *Basis: T. Jefferson*	Bathymetry: to the 1,000 meter depth contour. **NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited Dolar (1999) and Dolar et al. (2006).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	1	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion for the East China Sea (China)

Potential Criteria:	2A: High Density
Species of Concern:	Baleen whales (*Mysticeti*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	The continental shelf. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited (Zhou, Leatherwood, and Jefferson, 1995) and (Zhou, 2002).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	1	0	0	0	0	0
Status	Not Eligible	N/A	N/A	N/A	N/A	N/A
Assessment	Insufficient Detail	N/A	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

IUCN Marine Region 17: Southeast Pacific

Penguin Bank (Hawaii)

Potential Criteria:	2A: High Density 2B: Breeding Area
Species of Concern:	Humpback whales (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Mobley (2001)	157°30'58.217"W, 21°10'2.179"N to 157°30'22.367"W, 21°9'46.815"N to 157°31'0.778"W, 21°6'39.882"N to 157°30'30.049"W, 21°2'51.976"N to 157°29'28.591"W, 20°59'52.725"N to 157°27'35.919"W, 20°58'5.174"N to 157°30'58.217"W, 20°55'49.456"N to 157°42'42.418"W, 20°50'44.729"N to 157°44'45.333"W, 20°51'2.654"N to 157°46'4.716"W, 20°53'56.784"N to 157°45'33.987"W, 20°56'32.988"N to 157°43'10.586"W, 21°1'27.472"N to 157°39'27.802"W, 21°5'20.499"N to 157°30'58.217"W, 21°10'2.179" *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	January through April

Background

- The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawai'i. The sanctuary, which lies within the shallow (less than 600 feet), warm waters surrounding the main Hawaiian Islands, constitutes one of the world's most important humpback whale habitats (http://hawaiihumpbackwhale.noaa.gov/about/welcome.html)
- With the exception of a portion of Penguin Banks, the Hawaiian Islands Humpback Whale National Marine Sanctuary is located within 12 nautical miles (nm) of the islands. Penguin Bank is a shallow area of known humpback whale concentration (Mate, Gisiner, and Mobley, 1998).
- The primary period of humpback whale presence in Hawaiian waters is January through April, with peak abundance occurring earlier near the island of Hawai'i than the other islands (Gabriele, Rickards, Yin, and Frankel, 2003). Their report identified the highest whale densities near Keahole Point and just north of Kawaihae Harbor, and lower densities near the resorts along the shore south of Kawaihae (Gabriele, et al., 2003).
- The main Hawaiian Islands (MHI) are the primary winter reproductive area for the majority of North Pacific humpback whales. Identification photographs of individual whales, including 63 females sighted in at least 2 different years and with at least 1 calf, were collected from waters off the islands of Maui and Hawaii between 1977 and 1994 (Craig and Herman, 2000).
- Calves formed a significantly larger proportion of the population off Maui than off the Big Island. The overall proportion of calves to all whales identified (crude birth rate) was 0.099 off Maui and 0.061 off the Big Island (Craig and Herman, 2000).
- Aerial surveys conducted in Hawaiian waters during the winter months (Jan-Apr) of 1976-80 showed humpbacks to be most prevalent in coastal regions and shallow banks where the expanse of water less than 100-fathoms (183 m) was more extensive. Greatest densities of adult humpbacks and calf pods were found in the "four island region" (FIR) consisting of Maui, Molokai, Kahoolawe and Lanai, as well as Penguin Bank (Mobley et al., 2001).
- Mobley, Bauer and Herman (1999) confirmed the earlier preference of both adult humpbacks and calf pods for the FIR and Penguin Bank regions, but also showed a substantial increase of adult humpbacks in the Kauai/Niihau region (Mobley, et al., 2001).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	3	0	3	0	0	0
Status	Eligible	N/A	Eligible	N/A	N/A	N/A
Assessment	Adequate Justification	N/A	Adequate Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

Cross Seamount (United States)

Potential Criteria:	2B: Foraging Area
Species of Concern:	Cuvier's beaked whales (*Ziphius cavirostris*) Blainville's beaked whales (*Mesoplodon densirostris*)
Proposed Boundary Consideration:	18° 36′ N, 158° 26′ W 18° 36′ N, 158° 6′ W 18° 50′ N, 158° 26′ W 18° 50′ N, 158° 6′ W
Proposed Temporal Consideration:	Year-round, but particularly at night.

Background Provided by NMFS

- Cross Seamount is located at 18° 41′ N and 158° 18′ W in the central Pacific Ocean. The summit is approximately 5 by 7 km across and ranges in depth between 450 and 350 m.
- Johnston et al. (2008) conducted passive acoustic monitoring at Cross Seamount between 26 April 2005 and 19 November 2005 using a high-frequency acoustic recording package to detect odontocete echolocation sweeps. Visual examination of scrolling spectrograms from these data discovered that the most frequently detected cetacean signals were echolocation sweeps similar to those produced by Cuvier's beaked whales or Blainville's beaked whales. Almost all detections occurred during the night.
- Acoustic backscatter data indicate higher densities of organisms over the seamount and at its flanks relative to those in ambient water and show a prominent diel cycle due to vertical migratory behavior of sound scattering organisms.
- Feeding buzzes that were not frequency modulated were also occasionally associated with the echolocation signals described in the article, somewhat resembling those known to be associated with Cuvier's and Blainville's beaked whale echolocation sounds (Johnson et al. 2004).
- Highest densities over the plateau were observed during the night-time, with a prominent SSL in the upper 200 m and dense patches of aggregations near the seafloor of the seamount. Trawl surveys of SSL layers in this region revealed squid and fishes, which are potential prey items for beaked whales.
- Their acoustic monitoring reveals that beaked whales foraged at Cross Seamount during most nights. The detection range (based on seafloor reflections) for these signals appears to be less than 5 km, thus detected animals were at the seamount summit. Few beaked whale detections occurred during daylight hours, and several hypotheses may explain this pattern. It is possible that the whales were not present at Cross during the day or that the whales were present in the area but not echolocating. It is also possible that the whales were present, but diving past the summit of the seamount before echolocating at depth.
- It is possible that dense concentrations of prey at Cross may reduce diving demands for beaked whales, allowing them to spend greater time foraging at depth. In this case, the presence of the seamount summit may facilitate prey capture by providing a barrier against which whales concentrate prey. The author further hypothesizes that this may stem from the enhancement of local productivity by ‘seamount effects’, providing predictable patches of prey in an otherwise dilute and oligotrophic environment (Johnston, et al., 2008).
- Johnson et al. (2004) attached acoustic tags to four beaked whales (two *Mesoplodon densirostris* and two *Ziphius cavirostris*) and recorded high–frequency clicks during deep dives. The tagged whales only clicked at depths below 200 m, down to a maximum depth of 1267 m. Both species produced a large number of short, directional, ultrasonic clicks with no significant energy below 20 kHz. The tags recorded echoes from prey items; to the author’s knowledge, a first for any animal echolocating in the wild. They conclude that these echoes provide the first direct evidence on how free-ranging

toothed whales use echolocation in foraging. The strength of these echoes suggests that the source level of *Mesoplodon* clicks is in the range of 200–220 dB re 1 µPa at 1 m.

- The mesopelagic community over the summit contains two species that appear to be found in higher abundance over the summit as opposed to away and may be considered as seamount-associated species. These are a cranchiid squid, *Liocranchia reinhardti*, and a myctophid fish, *Benthosema fibulatum*. This seamount is known to impact the mesopelagic micronekton community and tuna community, but the mechanisms behind these impacts are largely unknown at this time (De Forest and Drazen, 2009).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	3	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the proposed boundary. Boundary surrounds the location of a core biological area of importance.

Costa Rica Dome (Costa Rica, Panama)

Potential Criteria:	2B: Foraging Area 2B: Wintering Ground
Species of Concern:	Blue whale (*Balaenoptera musculus*) Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration:	Existing boundary as defined in the 2007 Final Rule.
Proposed Seasonal Consideration:	Year-Round

Background

- The distribution of blue whales, in the eastern tropical Pacific (ETP) was analyzed from 211 sightings of 355 whales recorded during research vessel sighting surveys or by biologists aboard fishing vessels. Over 90% of the sightings were made in just two areas: along Baja California, and in the vicinity of the Costa Rica Dome. All sightings occurred in relatively cool, upwelling-modified waters. The Costa Rica Dome area was occupied year round, suggesting either a resident population, or that both northern and southern hemisphere whales visit with temporal overlap (Reilly and Thayer, 1990).
- Research conducted in the 1990s reported that some humpback whales from the North Pacific were also using Costa Rican waters as a wintering ground (Acevedo-Gutiérrez and Smultea, 1995).
- With blue whales, the greatest unknown is whether their year-round residency on the Costa Rica Dome is indicative of a distinct, non-migratory population segment or whether some individuals may choose not to migrate every year (Calambokidis, et al., 1990).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	1	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	3	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

IUCN Marine Region 18: Australia – New Zealand

Great Barrier Reef Between 16°E and 21°S (Australia)

Potential Criterion:	2B: Breeding Ground
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Dwarf Minke whale (*Balaenoptera acutorostrata*)
Proposed Boundary Consideration: Location inferred from Arnold (1997)	145°38'46.988"E, 16°1'49.75"S to 146°20'56.18"E, 15°52'12.917"S to 146°59'23.514"E, 17°28'21.251"S to 151°39'40.427"E, 20°16'13.65"S to 150°30'53.849"E, 20°58'22.843"S to 146°49'46.681"E, 18°51'10.893"S to 145°38'46.988"E, 16°1'49.75"S
Proposed Seasonal Consideration:	May through September

Background

- Of particular concern in the Marine Park is a population of dwarf minke whales occurring off northern Queensland, most often seen in the Ribbon Reefs area in June and July although present in the Park from about May to October (GBRMP, 2000).
- An IWC compilation of 181 sightings from the central and northern Great Barrier Reef indicated that dwarf minke whales were regularly seen between Cairns (16°55' S) and Yonge Reef (14° 36' S). Sightings occurred from May to September, with 79.5% of sightings in June and July. Observations suggest, however, that groups of animals may occur in open water on the continental shelf, inshore of the reefs where most whales have been reported. Records of stranded animals 3 m or less in length indicate calving can occur at about 24E-38E S in Australia. There were four reports of cow-calf pairs on the northern Great Barrier Reef, between 15°-16°S, but more information is needed to assess the extent to which the area is a calving/nursery ground (Arnold, 1997).
- Humpback whales which migrate along the east Australian coast comprise part of the Area V (130° E - 170° W) stock. Sheltered water within the Great Barrier Reef between latitudes 16°-21° S appear to be an important breeding ground for the east Australian humpback whale stock (Paterson and Paterson, 1984).
- The humpback whales present in the marine park generally spend the summer feeding in the nutrient-rich waters of Antarctica, migrate northwards in the autumn, and winter in warm-water breeding areas, including the waters off the coast of Queensland. Humpbacks are usually present in the Marine Park from June to October. Of particular concern in the Marine Park are possible adverse effects on pregnant females and cows with young calves. Lactating females typically migrate north before pregnant females, and cows with newborn calves tend to be last to leave the breeding areas to return south to the feeding grounds. Thus, cows who are pregnant or who have young (dependent) calves are present in the Marine Park throughout the season (GBRMP, 2000).

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	0	3	0	0	0
Status	N/A	N/A	Eligible	N/A	N/A	N/A
Assessment	N/A	N/A	Adequate Justification	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Bonney Upwelling **(Australia)**

Potential Criterion:	2B: Foraging Area
Species of Concern:	Blue whale (*Balaenoptera musculus*) Pygmy blue whale (*B. m. brevicauda*) New Zealand fur seal (*Arctocephalus forsteri*) Southern right whale (*Eubalaena australis*) Australian sea lion (*Neophoca cinera*)
Proposed Boundary Consideration: Location inferred from Gill (2002)	139°31'17.703"E, 37°12'20.036"S to 139°42'42.508"E, 37°37'33.815"S to 140°22'57.345"E, 38°10'36.144"S to 141°33'50.342"E, 38°44'50.558"S to 141°11'0.733"E, 39°7'4.125"S to 139°10'52.263"E, 37°28'33.179"S
Proposed Seasonal Consideration:	November through May

Background

- The Bonney Upwelling (formerly the Blue Whale aggregation) is characterized by classical upwelling plumes regularly observed along the Bonney Coast (Robe, South Australia to Portland, Victoria).
- To assess how seasonal changes in ocean productivity influenced foraging behavior, one study fitted18 lactating New Zealand fur seals with satellite transmitters and time-depth recorders (TDRs). Using temperature and depth data from TDRs, they used the presence of thermoclines as a surrogate measure of upwelling activity in continental- shelf waters. The study concluded that lactating New Zealand fur seals shift their foraging location from continental-shelf to oceanic waters in response to a seasonal decline in productivity over the continental shelf, attributed to the cessation of the Bonney upwelling (Baylis, Page, and Goldsworthy, 2008).
- A localized aggregation of blue whales, which may be pygmy blue whales, occurs in southern Australian coastal waters (between 139°45' E-143°E) during summer and autumn (December-May), where they feed on coastal krill (*Nyctiphanes australis*), a species which often forms surface swarms. While the abundance of blue whales using this area is unknown, up to 32 blue whales have been sighted in individual aerial surveys. Krill appear to aggregate in response to enhanced productivity resulting from the summer-autumn wind-forced Bonney Coast upwelling along the continental shelf. During the upwelling's quiescent (winter-spring) period, blue whales appear to be absent from the region. Krill surface swarms have been associated with 48% of 261 blue whale sightings since 1998, with direct evidence of feeding observed in 36% of all sightings. Mean blue whale group size was 1.55 (SD = 0.839), with all size classes represented including claves. This seasonally predictable upwelling system is evidently a regular feeding ground for blue whales (Gill, 2002).
- http://bluewhalestudy.com/home.html

Number of Supporting Documents

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	1	0	0	0

NMFS' Classification Scores for Supporting Documents

	High Density	Foraging Area	Breeding / Calving Area	Migration Route	Critical Habitat	Small Distinct Population
Rank	0	3	0	0	0	0
Status	N/A	Eligible	N/A	N/A	N/A	N/A
Assessment	N/A	Adequate Justification	N/A	N/A	N/A	N/A

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Works Cited

Abend, A. (1993). *Distribution and diet of long-finned pilot whales as determined from stable carbon and nitrogen ratio isotope tracers.* University of Massachusetts, Amherst, MA.

Abend, A., & Smith, T. (1999). Review of Distribution of the Long-finned Pilot Whale (Globicephala melas) in the North Atlantic and Mediterranean.

Acevedo-Gutiérrez, A., & Smultea, M. (1995). First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of Northern and Southern hemisphere populations. *Marine Mammal Science., 11*(4), 554-560.

Anon. (2005). *Report of the Workshop on Finless Porpoises in theWestern North Pacific. (Available from IWC, The Red House, 135 Station Road, Impington, Cambridge C24 9NP, UK.).*

Anon. (2010). *Progress report on the Med09 cruise. ACCOBAMS, 6th Meeting of the Scientific Committee, Casablanca, 11-13 January 2010. Document SC6-Inf 06. 21 p.*

Arcangeli, A., Muzi, E., Tepsich, P., Carcassi, S., Castelli, A., Crosti, R., et al. (2009). *Large-scale cetacean monitoring from passenger ferries in Italy: networking summer 2008 surveys. Proceedings of the 23rd Conference of the European Cetacean Society, Istanbul. 6 p.*

Arnold, P. (1997). *Occurrence of dwarf minke whales (Balaenoptera acutorostrata) on the northern Great Barrier Reef, Australia*.

Azzellino, A., Gaspari, S., Airoldi, S., & Nani, B. (2008). Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep-Sea Research Part I: Oceanographic Research Papers, 55*(3), 296-323.

Baraff, L., Clapham, P., Mattila, D., & Bowman, R. (1991). Feeding behavior of a humpback whale in low-latitude waters. *Marine Mammal Science, 7*(2), 197-202.

Barlow, J., & Forney, K. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *FISHERY BULLETIN-NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 105*(4), 509.

Baumgartner, M., Cole, T., Clapham, P., & Mate, B. (2003). North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. *Marine Ecology Progress Series, 264*, 137-154.

Baylis, A., Page, B., & Goldsworthy, S. (2008). Effect of seasonal changes in upwelling activity on the foraging locations of a wide-ranging central-place forager, the New Zealand fur seal. *Canadian Journal of Zoology, 86*(8), 774-789.

Bearzi, G., Costa, M., Politi, E., Agazzi, S., Pierantonio, N., Tonini, D., et al. (2009). Cetacean records and encounter rates in the Northern Adriatic Sea during the years 1988-2007. *Annales, 19*(2), 145-150.

Beasley, I., Davidson, P., Somany, P., & Ath, L. (2002). *Abundance, distribution and conservation management of marine mammals in Cambodia's coastal waters. Unpublished report.*

Beier, E., & Ripa, P. (1999). Seasonal gyres in the northern Gulf of California. *Journal of Physical Oceanography, 29*(2), 305-311.

Ben Naceur, L., Gannier, A., Bradai, M. N., Drouot, V., Bourreau, S., Laran, S., et al. (2004). Recensement du grand dauphin Tursiops truncatus dans les eaux tunisiennes. *Bull. Inst. Natn. Scien. Tech. Mer de Salammbô, 31*.

Best, P. (2001). Distribution and population separation of Bryde's whale Balaenoptera edeni off southern Africa. *Marine Ecology Progress Series, 220*, 277-289.

Best, P. (2007). *Whales and dolphins of the southern African subregion*: Cambridge University Press.

Best, P., Findlay, K., Sekiguchi, K., Peddemors, V., Rakotonirina, B., Rossouw, A., et al. (1998). Winter distribution and possible migration routes of humpback whales Megaptera novaeangliae in the southwest Indian Ocean. *MEPS, 162*, 287-299.

Best, P., Glass, J., Ryan, P., & Dalebout, M. (2009). Cetacean records from Tristan da Cunha, South Atlantic. *Journal of the Marine Biological Association of the UK, 89*(Special Issue 05), 1023-1032.

Best, P., Rademeyer, R., Burton, C., Ljungblad, D., Sekiguchi, K., Shimada, H., et al. (2003). The abundance of blue whales on the Madagascar Plateau, December 1996. *Journal of Cetacean Research and Management, 5*(3), 253-260.

Bordino, P., Albareda, D., & Fidalgo, G. (2004). *Abundance estimation of Franciscana dolphin Pontoporia blainvillei from boat surveys in Buenos Aires, Argentina. International Whaling Commission, Cambridge, UK, Scientific Committee Document SC/56/SM13.*

Bordino, P., Kraus, S., Albareda, D., Fazio, A., Palmerio, A., Mendez, M., et al. (2002). Reducing incidental mortality of Franciscana dolphin *Pontoporia blainvillei* with acoustic warning devices attached to fishing nets. *Marine Mammal Science, 18*(4), 833-842.

Bordino, P., & Wells, R. (2005). *Radiotracking of Franciscana Dolphins (Pontoporia Blainvillei) in Bahia Samborombon, Buenos Aires, Argentina.* Paper presented at the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, California (USA), 12-16 Dec 2005.

Bordino, P., Wells, R., & Stamper, M. (2008). *Satellite tracking of Franciscana Dolphins Pontoporia blainvillei in Argentina: preliminary information on ranging, diving and social patterns. Paper SC/53/IA32 presented to the IWC Scientific Committee, (unpublished)*.

Branch, T., Stafford, K., Palacios, D., Allison, C., Bannister, J., Burton, C., et al. (2007). Past and present distribution, densities and movements of blue whales Balaenoptera musculus in the Southern Hemisphere and northern Indian Ocean. *Mammal Review, 37*(2), 116-175.

Brownell, R., & Ralls, K. (2008). Cetacean records from U. S. Commonwealth and Territories in the Pacific Ocean. PSRG-2008-15.

Brownell, R., Yamada, T., Mead, J., & Allen, B. (2006). *Mass strandings of melon-headed whales, Peponocephala electra: a worldwide review. SC/58/SM 8, 12 pp. (Available from IWC, The Red House, 135 Station Road, Impington, Cambridge C24 9NP, UK.)*.

Brownell, R., Yamada, T., Mead, J., & Van Helden, A. (2004). Mass strandings of Cuvier's beaked whales in Japan: US Naval acoustic link. *Unpublished paper SC/56/ E, 37*.

Brownell, R., Yao, C., Lee, C., Wang, M., Yang, W., & Chou, L. (2009). Worldwide review of pygmy killer whales, Feresa attenuata, Mass Strandings Reveals Taiwan Hot Spot. *SC/61/SM1*, *20 pp. (Available from IWC, The Red House, 135 Station Road, Impington, Cambridge C24 9NP, UK.)*.

Buckland, S., Anderson, D., Burnham, K., & Laake, J. (1993). *Distance sampling: Estimating abundance of biological populations*: Chapman & Hall London.

Buckland, S., Cattanach, K., & Miyashita, T. (1992). *Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys*.

Burtenshaw, J. C., Oleson, E. M., Hildebrand, J. A., McDonald, M. A., Andrew, R. K., Howe, B. M., et al. (2004). Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. *Deep Sea Research (Part II, Topical Studies in Oceanography), 51*(10-11), 967-986.

Böhm, E., Hopkins, T. S., Pietrafesa, L. J., & Churchill, J. H. Continental slope sea level and flow variability induced by lateral movements of the Gulf Stream in the Middle Atlantic Bight. *Progress In Oceanography, 70*(2-4), 196-212.

Böhm, E., Hopkins, T. S., Pietrafesa, L. J., & Churchill, J. H. (2006). Continental slope sea level and flow variability induced by lateral movements of the Gulf Stream in the Middle Atlantic Bight. *Progress In Oceanography, 70*(2-4), 196-212.

Calambokidis, J., Steiger, G., Cubbage, J., Balcomb, K., Ewald, C., Kruse, S., et al. (1990). *Sightings and movements of blue whales off central California 1986-88 from photo-identification of individuals*.

Calambokidis, J., Steiger, G., Ellifrit, D., Troutman, B., & Bowlby, C. (2004). Distribution and abundance of humpback whales(Megaptera novaeangliae) and other marine mammals off the northern Washington coast. *Fishery Bulletin, 102*(4), 563-580.

Campagna, C., Fedak, M., & McConnell, B. (1999). Post-breeding distribution and diving behavior of adult male southern elephant seals from Patagonia. *Journal of Mammalogy, 80*(4), 1341-1352.

Campagna, C., Le Boeuf, B., Blackwell, S., Crocker, D., & Quintana, F. (1995). Diving behaviour and foraging location of female southern elephant seals from Patagonia. *Journal of Zoology, 236*(1), 55-71.

Campagna, C., & Lewis, M. (1992). Growth and distribution of a southern elephant seal colony. *Marine Mammal Science, 8*(4), 387-396.

Campagna, C., Piola, A., Marin, M., Lewis, M., Zajaczkovski, U., & Fernández, T. (2007). Deep divers in shallow seas: Southern elephant seals on the Patagonian shelf. *Deep Sea Research Part I: Oceanographic Research Papers, 54*(10), 1792-1814.

Campagna, C., Piola, A., Rosa Marin, M., Lewis, M., & Fernández, T. (2006). Southern elephant seal trajectories, fronts and eddies in the Brazil/Malvinas Confluence. *Deep-Sea Research Part I, 53*(12), 1907-1924.

Campagna, C., Quintana, F., Le Boeuf, B., Blackwell, S., & Crocker, D. (1998). Diving behaviour and foraging ecology of female southern elephant seals from Patagonia. *Aquatic Mammals, 24*, 1-12.

Campagna, C., Rivas, A., & Marin, M. (2000). Temperature and depth profiles recorded during dives of elephant seals reflect distinct ocean environments. *Journal of Marine Systems, 24*(3-4), 299-312.

Carretta, J. V., Forney, K. A., Lowry, M. S., Barlow, J., Baker, J., Hanson, B., et al. (2008). *U.S. Pacific Marine Mammal Stock Assessments: 2008* (Report No. NOAA-TM-NMFS-SWFSC-434).

Carrillo, L., & Palacios-Hernandez, E. (2002). Seasonal evolution of the geostrophic circulation in the northern Gulf of California. *Estuarine, Coastal and Shelf Science, 54*(2), 157-173.

Cañadas, A., & Hammond, P. (2008). Abundance and habitat preferences of the short-beaked common dolphin Delphinus delphis in the southwestern Mediterranean: implications for conservation. *Endangered Species Research, 4*(3), 309.

Cañadas, A., Sagarminaga, R., De Stephanis, R., Urquiola, E., & Hammond, P. (2005). Habitat preference modelling as a conservation tool: proposals for marine protected areas for cetaceans in southern Spanish waters. *Aquatic Conservation: Marine and Freshwater Ecosystems, 15*(5), 495-521.

Cerchio, S., Andrianarivelo, N., Razafindrakoto, Y., Mendez, M., & Rosenbaum, H. (2009). *Coastal dolphin hunting in the southwest of Madagascar: status of populations, human impacts and conservation actions. In: Paper SC/61/SM15 presented to the IWC Scientific Committee, May 2009. 9pp.*

Cerchio, S., Ersts, P., Pomilla, C., Loo, J., Razafindrakoto, Y., Leslie, M., et al. (2009). *Updated estimates of abundance for humpback whale breeding stock C3 off Madagascar, 2000-2006. In: Paper SC/61/SH7 presented to the IWC Scientific Committee, May 2009 (unpublished). 23pp.*

Churchill, J., Levine, E., Connors, D., & Cornillon, P. (1993). Mixing of shelf, slope and Gulf Stream water over the continental slope of the Middle Atlantic Bight. *Deep Sea Research Part I: Oceanographic Research Papers, 40*(5), 1063-1085.

CIRVA. (1997). *Comite Internacional Para la Recuperacion de la Vaquita/International Committee for the Recovery of the Vaquita. Scientific Reports of: First Meeting, 25-26 January 1997*.

CIRVA. (1999). *Comite Internacional Para la Recuperacion de la Vaquita/International Committee for the Recovery of the Vaquita. Scientific Reports of the Second Meeting,7-11 February 1999.*

CIRVA. (2004). *Comite Internacional Para la Recuperacion de la Vaquita/International Committee for the Recovery of the Vaquita. Scientific Reports of the Third Meeting, 18-24 January 2004.*

Clapham, P., & Mattila, D. (1990). Humpback whale songs as indicators of migration routes. *Marine Mammal Science, 6*(2), 155-160.

Collins, T., Cerchio, S., Pomilla, C., Carvalho, I., Ngouessono, S., & Rosenbaum, H. (2008). Revised estimates of abundance for humpback whale breeding stock B1: Gabon. In: Paper SC/60/SH28 presented to the IWC Scientific Committee, May 2008 (unpublished). 17pp.

Collins, T., Ngouessono, S., & Rosenbaum, H. (2004). *A note on recent surveys for Atlantic humpback dolphins, Sousa teuszii (Kukenthal, 1892) in the coastal waters of Gabon*.

Craig, A., & Herman, L. (2000). Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. *Marine Ecology Progress Series, 193*, 209-216.

Crespo, E., Pedraza, S., Grandi, M., Dans, S., & Garaffo, G. (2004). *Abundance of franciscana dolphins, Pontoporia blainvillei, in the argentine coast, from aerial surveys. SC/56/SM9 Working paper submitted to the meeting of the International Whaling Commission, Sorrento, Italy, 29/6 to 10/7/04.*

Crespo, E., Pedraza, S., Grandi, M., Dans, S., & Garaffo, G. (2010). Abundance and distribution of endangered Franciscana dolphins in Argentine waters and conservation implications. *Marine Mammal Science, 26*(1), 17-35.

Croll, D. A., Marinovic, B., Benson, S., Chavez, F. P., Black, N., Ternullo, R., et al. (2005). From wind to whales: trophic links in a coastal upwelling system. *Marine Ecology Progress Series, 289*, 117-130.

D' Amico, A., Bergamasco, A., Zanasca, P., Carniel, S., Nacini, E., Portunato, N., et al. (2003). Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. *IEEE Journal of Oceanic Engineering, 28*(1), 29-43.

Danilewicz, D., Tavares, M., Moreno, I., Ott, P., & Trigo, C. (2009). Evidence of feeding by the humpback whale (Megaptera novaeangliae) in mid-latitude waters of the western South Atlantic. *Marine Biodiversity Records, 2*, e88.

De Forest, L., & Drazen, J. (2009). The influence of a Hawaiian seamount on mesopelagic micronekton. *Deep Sea Research Part I: Oceanographic Research Papers, 56*(2), 232-250.

DFO. (2007). *Recovery Potential Assessment Of Northern Bottlenose Whale, Scotian Shelf Population. Science Advisory Report 2007/011*.

Dolar, M. (1999). *Abundance, distribution and feeding ecology of small cetaceans in the eastern Sulu Sea and Tañon Strait, Philippines.* University of California, San Diego.

Dolar, M., Perrin, W., Taylor, B., Kooyman, G., & Alava, M. (2006). Abundance and distributional ecology of cetaceans in the central Philippines. *Journal of Cetacean Research and Management, 8*(1), 93.

DON. (2007a). *Navy OPAREA density estimates (NODE) for the Northeast OPAREAS: Boston, Narragansett Bay, and Atlantic. Naval Facilities Engineering Command, Atlantic; Norfolk, Virginia. Contract N62470-02-D-9997, Task Order 0045. Prepared by Geo-Marine, Inc., Plano, Texas*.

DON. (2007b). *Navy OPAREA Density Estimates (NODE) for the Southeast OPAREAS: VACAPES, CHPT, JAX/CHASN, and Southeastern Florida & AUTEC-Andros, Prepared for U.S. Fleet Forces Command, Norfolk, VA.*

Durbin, E., Campbell, R., Casas, M., Ohman, M., Niehoff, B., Runge, J., et al. (2003). Interannual variation in phytoplankton blooms and zooplankton productivity and abundance in the Gulf of Maine during winter. *Marine Ecology Progress Series, 254*, 81-100.

Ersts, P., & Rosenbaum, H. (2003). Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground. *Journal of Zoology, 260*(04), 337-345.

Falabella, V., Campagna, C., & Croxall, J. (2009). *Atlas del Mar Patagónico Especies y espacios, Wildlife Conservation Society Argentina. WCS*: Cambridge: BirdLife International.

Ferguson, M., & Barlow, J. (2001). *Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Admin. Rept*: LJ-01-04 available from the Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., La Jolla, CA 92037. 61pp.+ Addendum.

Ferguson, M., & Barlow, J. (2003). *Addendum: Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96*: Administrative Report LJ-01-04 (addendum), Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Ferguson, M., Barlow, J., Fiedler, P., Reilly, S., & Gerrodette, T. (2006). Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. *Ecological Modelling, 193*(3-4), 645-662.

Ferguson, M., Barlow, J., Reilly, S., & Gerrodette, T. (2006). Predicting Cuvier's (Ziphius cavirostris) and Mesoplodon beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. *Journal of Cetacean Research and Management, 7*(3), 287.

Fiedler, P., Reilly, S., Hewitt, R., Demer, D., Philbrick, V., Smith, S., et al. (1998). Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Research Part II, 45*(8-9), 1781-1801.

Findlay, K. (2001). A review of humpback whale catches by modern whaling operations in the Southern Hemisphere. *MEMOIRS-QUEENSLAND MUSEUM, 47*(2), 411-420.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X., & Aguilar, R. (2006). Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. *Marine Mammal Science, 10*(2), 137-150.

Forcada, J., Gazo, M., Aguilar, A., Gonzalvo, J., & Fernández-Contreras, M. (2004). Bottlenose dolphin abundance in the NW Mediterranean: addressing heterogeneity in distribution. *Marine Ecology Progress Series, 275*, 275-287.

Forcada, J., Notarbartolo di Sciara, G., & Fabbri, F. (1995). Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. *Mammalia*, *59*(1), 127-140.

Forney, K. (2007). Preliminary estimates of cetacean abundance along the US west coast and within four National Marine Sanctuaries during 2005. US Department of Commerce. *NOAA Technical Memorandum NMFS-SWFSC-406. 27p*.

Frantzis, A., Swift, R., Gillespie, D., Menhennett, C., Gordon, J., & Gialinakis, S. (1999). Sperm whale presence off south-west Crete, Greece, eastern Mediterranean. *Eur Res Cet, 13*, 214-217.

Fujino, K. (1960). Immunogenetic and marking approaches to identifying sub-populations of the North Pacific whales. *Sci. Rep. Whales Res. Inst., Tokyo, 15*, 84-142.

Gabriele, C., Rickards, S., Yin, S., & Frankel, A. (2003). *Trends in Relative Distribution, Abundance and Population Composition of Humpback Whales, Megaptera novaeangliae, in Kawaihae Bay, Hawai'i 1988-2003. Final Report August 2003 for the Department of Land and Natural Resources, State of Hawai'I and the Hawaiian Islands Humpback Whale National Marine Sanctuary, National Marine Sanctuary Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.*

Gannon, D., Craddock, J., & Read, A. (1998). Autumn food habits of harbor porpoises, Phocoena phocoena, in the Gulf of Maine. *Fishery Bulletin, 96*(3), 428-437.

Garrison, L., Martinez, A., & Maze-Foley, K. ((in review)). Habitat and abundance of marine mammals in continental slope waters of the Southeastern U.S. Atlantic.

Garrison, L., Swartz, S., Martinez, A., Burks, C., Stamates, J., & Fisheries, N. (2003). A marine mammal assessment survey of the southeast US continental shelf: February-April 2002. *NOAA Technical Memorandum NMFS-SEFSC-492. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center*.

GBRMP. (2000). Whale and dolphin conservation in the Great Barrier Reef Marine Park: policy document. *B. a. WHG Species Conservation Team & Conservation, ed. Great Barrier Reef Marine Park Authority*, 69.

Genov, T., Kotnjek, P., Lesjak, J., Hace, A., & Fortuna, C. (2008). *Bottlenose dolphins (Tursiops truncatus) in Slovenian and adjacent waters (northern Adriatic Sea)*.

Gill, P. (2002). A blue whale (Balaenoptera musculus) feeding ground in a southern Australian coastal upwelling zone. *J. Cetacean Res. Manage, 4*(2), 179-184.

Gilles, A., Herr, H., Lehnert, K., Scheidat, M., & Siebert, U. (2008). Harbour porpoises abundance estimates and seasonal distribution patterns. *Marine mammals and seabirds in front of offshore wind energy. Wiesbaden: BG Teuber Verlag/GWV Fachverlage GmbH*, 19-36.

GOJ. (2007). Government of Japan website for Dall's porpoise abundance estimates., from http://kokushi.job.affrc.go.jp/H20/H20_46.pdf

Gutiérrez, O., Marinone, S., & Parés-Sierra, A. (2004). Lagrangian surface circulation in the Gulf of California from a 3D numerical model. *Deep Sea Research Part II: Topical Studies in Oceanography, 51*(6-9), 659-672.

Gómez de Segura, A., Crespo, E., Pedraza, S., Hammond, P., & Raga, J. (2006). Abundance of small cetaceans in waters of the central Spanish Mediterranean. *Marine Biology, 150*(1), 149-160.

Haley, N., & Read, A. (1993). Summary of the workshop on harbor porpoise mortalities and human interaction. *NOAA Tech. Mem. NMFS-F/NER, 5*.

Hamazaki, T. (2002). Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic ocean(from Cape Hatteras, North Carolina, U. S. A. to Nova Scotia, Canada). *Marine Mammal Science, 18*(4), 920-939.

Hansen, L., Mullin, K., Jefferson, T., & Scott, G. (1996). Visual surveys aboard ships and aircraft. *Distribution and abundance of marine mammals in the north-central and western Gulf of Mexico: Final report, 2*, 96-0027.

Hare, J., Churchill, J., Cowen, R., Berger, T., Cornillon, P., Dragos, P., et al. (2002). Routes and rates of larval fish transport from the southeast to the northeast United States continental shelf. *Limnology and Oceanography*, 1774-1789.

Hayano, A. e. a. (2004). *Life history and group composition of melon-headed whales based on mass strandings on the Japanese coast. In: the Seventeenth Biennial Conference on the Biology of Marine Mammals, Abstract, Society for Marine Mammalogy, Cape Town, South Africa.* Paper presented at the Seventeenth Biennial Conference on the Biology of Marine Mammals.

Hayano, A. e. a. (2007). *Life history and group composition of melon-headed whales based on mass strandings on the Japanese coast. In: the Seventeenth Biennial Conference on the Biology of Marine Mammals, Abstract, Society for Marine Mammalogy, Cape Town, South Africa.* Paper presented at the Seventeenth Biennial Conference on the Biology of Marine Mammals.

Heimlich-Boran, J. R. (1993). *Social organization of the short-finned pilot whale, Globicephala macrorhynchus, with reference to the comparative social ecology of delphinids.* Cambridge University.

Holden, C. (2007). WHALE SENSING. *Science, 315*(5816), 1199d.

Hooker, S., Iverson, S., Ostrom, P., & Smith, S. (2001). Diet of northern bottlenose whales inferred from fatty-acid and stable-isotope analyses of biopsy samples. *Canadian Journal of Zoology, 79*(8), 1442-1454.

Hooker, S., Whitehead, H., & Gowans, S. (2002). Ecosystem consideration in conservation planning: energy demand of foraging bottlenose whales (Hyperoodon ampullatus) in a marine protected area. *Biological Conservation, 104*(1), 51-58.

Ichihara, T. (1957a). An application of linear discriminant function to external measurements of fin whale. *Scient. Rep. Whales Res. Inst., Tokyo, 12*, 127—189.

Ichihara, T. (1957b). An application of linear discriminant function to external measurements of fin whale. *Scient. Rep. Whales Res. Inst., Tokyo, 12*, 127—189.

IMO. (2007). *International Maritime Organization, Routing measures other than Traffic Separation Schemes. Ref. T2-OSS/2.7, SN.1/Circ.263,*.

Jaramillo-Legorreta, A., & Rojas-Bracho, L. (2008). *Passive acoustic assesment of vaquita. Paper SC/60/SM3 presented to the IWC Scientific Committee, 2008 (unpublished). 8pp.*

Jaramillo-Legorreta, A., Rojas-Bracho, L., Brownell, R., Read, A., Reeves, R., Ralls, K., et al. (2007). Saving the vaquita: immediate action, not more data. *Conservation Biology, 21*(6), 1653-1655.

Jaramillo-Legorreta, A., Rojas-Bracho, L., & Gerrodette, T. (1999). A new abundance estimate for vaquitas: first step for recovery. *Marine Mammal Science, 15*(4), 957-973.

Jefferson, T., Hung, S., Law, L., Torey, M., & Tregenza, N. (2002). Distribution and abundance of finless porpoises in Hong Kong and adjacent waters of China. *Raffles Bulletin of Zoology, 50*, 43-56.

Johnson, M., Madsen, P., Zimmer, W., De Soto, N., & Tyack, P. (2004). Beaked whales echolocate on prey. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 271*(Suppl 6), S383.

Johnson, S., Richardson, W., Yazvenko, S., Blokhin, S., Gailey, G., Jenkerson, M., et al. (2007). A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment, 134*(1), 1-19.

Johnston, D., McDonald, M., Polovina, J., Domokos, R., Wiggins, S., & Hildebrand, J. (2008). Temporal patterns in the acoustic signals of beaked whales at Cross Seamount. *Biology Letters, 4*(2), 208.

Johnston, D., Westgate, A., & Read, A. (2005). Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises *Phocoena phocoena* in the Bay of Fundy. *Marine Ecology Progress Series, 295*, 279-293.

Kahn, B. (2001). Komodo National Park cetacean surveys: A rapid ecological assessment of cetacean diversity, abundance, and distribution. Interim report - October 2001.

Kahn, B., Wawandono, N., & Subijanto, J. (2001). Positive identification of the rare pygmy Bryde's whale (*Balaenoptera edeni*) with the assistance of genetic profiling. Unpublished Unpublished contract report.

Kasuya, T., & Miyashita, T. (1988). Distribution of sperm whale stocks in the North Pacific. *Scientific Reports of the Whales Research Institute (Tokyo), 39*, 31-75.

Kasuya, T., & Miyashita, T. (1997). Distribution of Baird's beaked whales off Japan. *Report of the International Whaling Commission, 47*, 963–968.

Kasuya, T., Miyashita, T., & Kasamatsu, F. (1988). Segregation of two forms of short-finned pilot whales off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst, 39*, 77-90.

Kasuya, T., & Tai, S. (1993). Life history of short-finned pilot whale stocks off Japan and a description of the fishery. *Report of the International Whaling Commission*, 439-473.

Kato, H. (1992). *Body length, reproduction and stock separation of minke whales off northern Japan*.

Keller, C., Ward-Geiger, L., Brooks, W., Slay, C., Taylor, C., & Zoodsma, B. (2006). North Atlantic right whale distribution in relation to sea-surface temperature in the southeastern United States calving grounds. *Marine Mammal Science, 22*(2), 426.

Kenney, R., Winn, H., & Macaulay, M. (1995). Cetaceans in the Great South Channel, 1979-1989: right whale (Eubalaena glacialis). *Continental Shelf Research, 15*(4-5), 385-414.

Kenney, R., & Wishner, K. (1995). The South Channel Ocean Productivity EXperiment. *Continental Shelf Research, 15*(4-5), 373-384.

Kiszka, J., Berggren, P., Rosenbaum, H., Cerchio, S., Rowat, D., Drouot-Dulau, V., et al. (2009). *Cetaceans in the southwest Indian Ocean: a review of diversity, distribution and conservation issues. Paper SC/61/O18 presented to the IWC Scientific Committee, May 2009 (unpublished). 12pp.*

Koopman, H. (1998). Topographical distribution of the blubber of harbor porpoises (Phocoena phocoena). *Journal of Mammalogy, 79*(1), 260-270.

Kraus, S., Hamilton, P., Kenney, R., Knowlton, A., & Slay, C. (2001). Reproductive parameters of the North Atlantic right whale. *Journal of Cetacean Research and Management, 2*, 231-236.

Lasta, C. (1995). La Bahía Samborombón: zona de desove y cría de peces.

Lasta, C., & Acha, E. (1996). Cabo San Antonio: su importancia en el patrón reproductivo de peces marinos.[Cape San Antonio: its importance for reproductive pattern of marine fishes]. *Frente Marítimo, 16*, 39-45.

Leatherwood, S., Caldwell, D., Winn, H., Schevill, W., & Caldwell, M. (1976). Whales, dolphins, and porpoises of the western North Atlantic: a guide to their identification. from http://aquacomm.fcla.edu/1417/2/NOAA_Tech_Rpt_NMFS_CIRC-396.pdf

Lewis, T. (2010). *Preliminary abundance estimate of sperm whales in the SW Mediterranean from an acoustic line-transect survey. ACCOBAMS, 6th Meeting of the Scientific Committee, Casablanca, 11-13 January 2010. Document SC6-Inf 13. 8 p.*: ACCOBAMS.

Link, J., Overholtz, W., O'Reilly, J., Green, J., Dow, D., Palka, D., et al. (2008). The Northeast U.S. continental shelf Energy Modeling and Analysis exercise (EMAX): Ecological network model development and basic ecosystem metrics. *Journal of Marine Systems, 74*(1-2), 453-474.

Lázaro, M., Lessa, E., & Hamilton, H. (2004). Geographic genetic structure in the franciscana dolphin (Pontoporia blainvillei). *Marine Mammal Science, 20*(2), 201-214.

MacLeod, C., & Mitchell, G. (2005). Key areas for beaked whales worldwide. *Journal of Cetacean Research and Management, 7*(3), 309.

Mahabub, E. (2008). *Minimum population size of Bryde's whale (Balaenoptera edeni) estimated using photo-identification techniques in the Swatch-of-No-Ground, Bangladesh, during winter seasons 2005-2008. Senior thesis project,*. Independent University, Bangladesh.

Mahakunlayanakul, S. (1996). *Species distribution and status of dolphins in the inner Gulf of Thailand. Ph.D. thesis, Chulalongkorn University, 130 pp.*

Mate, B. R., Gisiner, R., & Mobley, J. (1998). Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Canadian Journal of Zoology/Revue Canadien de Zoologie, 76*(5), 863-868.

Mattila, D., Clapham, P., Katona, S., & Stone, G. (1989). Population composition of humpback whales, Megaptera novaeangliae, on Silver Bank, 1984. *Canadian Journal of Zoology, 67*(2), 281-285.

McDonald, M., Mesnick, S., & Hildebrand, J. (2006). Biogeographic characterization of blue whale song worldwide: using song to identify populations. *Journal of cetacean research and management, 8*(1).

Meier, S., Yazvenko, S., Blokhin, S., Wainwright, P., Maminov, M., Yakovlev, Y., et al. (2007). Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. *Environmental monitoring and assessment, 134*(1-3), 107.

Mendez, M., Rosenbaum, H., & Bordino, P. (2008). Conservation genetics of the franciscana dolphin in northern Argentina: population structure, by-catch impacts, and management implications. *Conservation Genetics, 9*(2), 419-435.

Mendez, M., Rosenbaum, H., Yackulic, C., Subramaniam, A., & Bordino, P. (2010). Isolation by environmental distance in mobile marine species: molecular ecology of franciscana dolphins at their southern range. . *Molecular Ecology. In press.*

Merrick, R., & Cole, T. (2007). *Evaluation of northern right whale ship strike reduction measures in the Great South Channel of Massachusetts, NOAA Tech Memo NMFS NE 202*: National Oceanic and Atmospheric Administration.

Michels, K. H., Suckow, A., Breitzke, M., Kudrass, H. R., & Kottke, B. (2003). Sediment transport in the shelf canyon "Swatch of No Ground" (Bay of Bengal). *Deep Sea Research Part II: Topical Studies in Oceanography, 50*(5), 1003-1022.

Minoda, T. (1989). *Oceanographic and biomass changes in the Oyashio Current ecosystem in Kenneth Sherman and Lewis M. Alexander (eds.), Biomass Yields and Geography of Large Marine Ecosystems (Boulder: Westview) AAAS Selected Symposium 111.*

Miyashita, T. (1986). Abundance of Baird's beaked whales off the Pacific coast of Japan. *Rep. Int. Whal. Comm., 36*, 383-386.

Miyashita, T. (1993). *Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery*.

Miyashita, T. (2004). *Cruise report of the common minke whale sighting surveys in the Sea of Okhotsk in 2003*: Paper SC/56/RMP1, available from the International Whaling Commission, Cambridge, UK.

Miyashita, T., & Kato, H. (1993). Population estimate of Baird's beaked whales off the Pacific coast of Japan using sighting data collected by R/V SHUNYO MARU in 1991 and 1992. *IWC/SC/45/SM6*.

Miyashita, T., & Kato, H. (1998). *Recent data on the status of right whales in the NW Pacific Ocean*.

Miyazaki, N., & Amano, M. (1994). Skull morphology of two forms of short-finned pilot whales off the Pacific coast of Japan. *Rep. Int. Whaling Commn, 44*, 499-508.

Miyazaki, N., & Nakayama, K. (1989). Records of cetaceans in the waters of the Amami Islands. *Mem. Natn. Sci. Mus. Tokyo, 22*, 235-249.

Mobley, J., Bauer, G., & Herman, L. (1999). Changes over a ten-year interval in the distribution and relative abundance of humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. *Aquatic Mammals, 25*, 63-72.

Mobley, J., Spitz, S., Grotefendt, R., Forestell, P., Frankel, A., & Bauer, G. (2001). Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. *Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary, 26*.

Mori, S. (2005). *Distribution and residency of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in the waters of the Ogasawara (Bonnin) Islands, Japan. In: Sixteenth Biennial Conference on the Biology of Marine Mammals.* Paper presented at the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

Mullin, K., & Fulling, G. (2003). Abundance of cetatceans in the southern US North Atlantic Ocean during summer 1998. *FISHERY BULLETIN, 101*(3), 603-613.

Mullin, K., & Hoggard, W. (2000). Visual surveys of cetaceans and sea turtles from aircraft and ships. *Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations, 2*, 96-0027.

Mussi, B., Miragliuolo, A., & Bearzi, G. (2002). Short-beaked common dolphins around the island of Ischia, Italy (Southern Tyrrhenian Sea). *European Research on Cetaceans, 16*, 15.

Mustika, P. (2006). *Marine mammals in the Savu Sea (Indonesia): indigenous knowledge, threat analysis and management options.* James Cook University.

Nanbu, Y., Hirose, J., Kubo, N., Kishiro, T., & Shinomiya, A. (2006). Location and number of individuals of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in Kagoshima Bay [Japan]. *Memoirs of Faculty of Fisheries-Kagoshima University (Japan)*.

NMFS. (1994). *Designated Critical Habitat; Northern Right Whale. 59 Federal Register 28793-28834, June 3, 1994*.

NMS. (2009a, March 26, 2008). Cordell Bank Sanctuary: Seamounts And Banks. Retrieved September 2009, from http://www.sanctuarysimon.org/cordell/sections/seamounts/overview.php?sec=sm

NMS. (2009c, March 26, 2008). Gulf of the Farrallones Sanctuary. Retrieved September 2009, from http://www.sanctuarysimon.org/farallones/index.php

Northridge, S. (1996). Seasonal distribution of harbour porpoises in US Atlantic waters. *REPORT-INTERNATIONAL WHALING COMMISSION, 46*, 613-618.

Northrop, J., Cummings, W., & Thompson, P. (1967). 20 Hz signals observed in the central Pacific. *The Journal of the Acoustical Society of America, 42*, 1211.

Notarbartolo di Sciara, G. (2010). Personal Communication. Tethys Research Institute. Milano, Italy.

Notarbartolo-Di-Sciara, G., Zanardelli, M., Jahoda, M., Panigada, S., & Airoldi. (2003). The fin whale Balaenoptera physalus (L. 1758) in the Mediterranean Sea. *Mammal Review, 33*(2), 105-150.

O'Hern, J., & Biggs, D. (2009). Sperm Whale (Physeter macrocephalus) Habitat in the Gulf of Mexico: Satellite Observed Ocean Color and Altimetry Applied to Small-Scale Variability in Distribution. *Aquatic Mammals, 35*(3), 358-366.

Oleson, E., Calambokidis, J., Barlow, J., & Hildebrand, J. B. W. V. A. A. E. R. I. T. S. C. B. (2007). Blue whale visual and acoustic encounter rates in the Southern California Bight. *Marine Mammal Science, 23*(3), 574-597.

Omura, H., & Sakiura, H. (1956). Studies on the little piked whale from the coast of Japan. *Sci. Rep. Whales Res. Inst. Tokyo, 11*, 1-37.

Overholtz, W., & Link, J. (2007). Consumption impacts by marine mammals, fish, and seabirds on the Gulf of Maine–Georges Bank Atlantic herring (Clupea harengus) complex during the years 1977–2002. *ICES Journal of Marine Science, 64*, 83-96.

Pace, R. M., & Merrick, R. L. (2008). *Northwest Atlantic ocean habitats important to the conservation of North Atlantic right whales (Eubalaena glacialis). US Dept Commerce, Northeast Fish Sci Cent Ref Doc 08-07*. Retrieved from http://www.nefsc.noaa.gov/publications/crd/crd0807/crd0807.pdf.

Palka, D. (1995). *Preliminary cruise report of the spring distribution survey of harbor porpoises in the Mid-Atlantic. Available at NOAA/NMFS/NEFSC, Woods Hole, MA 02543. 7pp.*

Palka, D. (2006). Summer abundance estimates of cetaceans in US North Atlantic navy operating areas. *US Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc*, 06-03.

Palka, D., Orphanides, C., & Warden, M. (2009). Summary of harbor porpoise (Phocoena phocoena) bycatch and levels of compliance in the northeast and mid-Atlantic gillnet fisheries after the implementation of the Take Reduction Plan: 1 January 1999-31 May 2007. *NOAA Technical Memorandum NMFS NE, 212*(89), 02543-01026.

Palka, D., Read, A., Westgate, A., & Johnston, D. (1996). *Summary of current knowledge of harbour porpoises in US and Canadian Atlantic waters. Rep. Int. Whal. Commn 46: 559-565.*

Panigada, S., & Azzellino, A. (2009). *Determinazione degli habitat critici delle specie di cetacei presenti nell'area del Santuario Pelagos (porzione occidentale), ai fini della gestione. Rapporto finale.* : Istituto Tethys.

Panigada, S., Burt, L., Lauriano, G., Pierantonio, N., & Donovan, G. (2009). Winter abundance of striped dolphins (Stenella coeruleoalba) in the Pelagos Sanctuary (north-western Mediterranean Sea) assessed through aerial survey. *Journal of Cetacean Research Management*(SC/61/SM7), 1-10.

Panigada, S., Notarbartolo di Sciara, G., Panigada, M., Airoldi, S., Borsani, J., & Jahoda, M. (2005). Fin whales (Balaenoptera physalus) summering in the Ligurian Sea: distribution, encounter rate, mean group size and relation to physiographic variables. *Journal of Cetacean Research Management, 7*(2), 137-145.

Paterson, R., & Paterson, P. (1984). A study of the past and present status of humpback whales in east Australian waters. *Biological Conservation, 29*(4), 321-343.

Payne, P., & Heinemann, D. (1993). The distribution of pilot whales (Globicephala spp.) in shelf/shelf-edge and slope waters of the Northeastern United States, 1978-1988 In: Biology of Northern Hemisphere Pilot Whales-Reports of the International Whaling Commission, Special issue 14. *IWC, Cambridge, UK*, 51-68.

Pegau, W., Boss, E., & Martínez, A. (2002). Ocean color observations of eddies during the summer in the Gulf of California. *Geophysical Research Letters, 29*(9), 9-1.

Perrin, W., Dolar, M., Amano, M., & Hayano, A. (2003). Cranial Sexual Dimorphism And Geographic Variation In Eraser's Dolphin, Lagenodelphis Hosei. *Marine Mammal Science, 19*(3), 484-501.

Perrin, W., & Hohn, A. (1994). Pan tropical spotted dolphin Stenella attenuata. *Handbook of marine mammals: The first book of dolphins*, 71.

Pet-Soede, L. (2002). *The Solor and Alor islands: Expedition results, data collected during 2 reconnaissance trips; 9-12 September 2001 and 7-19 May, 2002. Report of a joined activity by The Nature Conservancy Southeast Asia Center for Marine Protected Areas and World Wide Fund for Nature Wallacea Bioregional Program.*

Read, A. (1999). Harbour porpoise Phocoena phocoena (Linnaeus, 1758). *Handbook of marine mammals, 6*, 323-355.

Reeves, R., Mckenzie, M., & Smith, T. (2006). History of Bermuda shore whaling, mainly for humpback whales. *Journal of Cetacean Research and Management, 8*(1), 33.

Reilly, S., & Thayer, V. (1990). Blue Whale (Balaenoptera-Musculus) Distribution In The Eastern Tropical Pacific. *Marine Mammal Science, 6*(4), 265-277.

Rendell, L., Cañadas, A., & Mundy, C. (2005). *Scientific Report Balearics Sperm Whale Project 2003-2005*: The Nando Peretti Foundation, One World Wildlife.

Rice, D. (1998). Marine Mammals of the World: Systematics and Distribution, Special Publication Number 4, The Society for Marine Mammalogy: Allen Press, USA. ix+ 231pp.

Rojas-Bracho, L., & Taylor, B. (1999). Risk factors affecting the vaquita (Phocoena sinus). *Marine Mammal Science, 15*(4), 974-989.

Romero, S., Piola, A., Charo, M., & Garcia, C. (2006). Chlorophyll-a variability off Patagonia based on SeaWiFS data. *Journal of Geophysical Research, 111*(C5), C05021.

Rosa, S., Milinkovitch, M., Van Waerebeek, K., Berck, J., Oporto, J., Alfaro-Shigueto, J., et al. (2005). Population structure of nuclear and mitochondrial DNA variation among South American Burmeister's porpoises (Phocoena spinipinnis). *Conservation Genetics, 6*(3), 431-443.

Rosenbaum, H., & Collins, T. (2006). The Ecology, Population Characteristics and Conservation Efforts for Humpback Whales (Megaptera novaeangliae) on Their Wintering Grounds in the Coastal Waters of Gabon. *Bulletin of the Biological Society of Washington*, 425-433.

Rosenbaum, H., Pomilla, C., Mendez, M., Leslie, M., Best, P., Findlay, K., et al. (2009). Population Structure of Humpback Whales from Their Breeding Grounds in the South Atlantic and Indian Oceans.

Rosenbaum, H., Walsh, P., Razafindrakoto, Y., Vely, M., & Desalle, R. (1997). First description of a humpback whale wintering ground in Baie d'Antongil, Madagascar. *Conservation Biology, 11*(2), 308-314.

Rossman, M. (2009). Estimated Bycatch of Small Cetaceans in Northeast US Bottom Trawl Fishing Gear during 2000-2005. *J. Northw. Atl. Fish. Sci., 42*, 77-101.

Rugh, D., Shelden, K., & Schulman-Janiger, A. (2001). Timing of the southbound migration of gray whales. *J. Cetacean Res. Manage, 3*(1), 31-39.

Rutenko, A., Borisov, S., Gritsenko, A., & Jenkerson, M. (2007). Calibrating and monitoring the western gray whale mitigation zone and estimating acoustic transmission during a 3D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment, 134*(1), 21-44.

Saraceno, M., Provost, C., & Piola, A. (2005). On the relationship between satellite-retrieved surface temperature fronts and chlorophyll a in the western South Atlantic. *Journal of Geophysical Research-Oceans, 110*(C11), C11016.

Sarin, M., Krishnaswami, S., Dilli, K., Somayajulu, B., & Moore, W. (1989). Major ion chemistry of the Ganga-Brahmaputra river system: Weathering processes and fluxes to the Bay of Bengal. *Geochimica et Cosmochimica Acta, 53*(5), 997-1009.

Scheidat, M., Gilles, A., Kock, K., & Siebert, U. (2008). Harbour porpoise Phocoena phocoena abundance in the southwestern Baltic Sea. *Endangered species research*, 1-9.

Scheninin, A., Kerem, D., & Goffman, O. (2010). Personal Communication. University of Haifa.

Secchi, E., Danilewicz, D., & Ott, P. (2003). Applying the phylogeographic concept to identify franciscana dolphin stocks: implications to meet management objectives. *Journal of Cetacean Research and Management, 5*(1), 61-68.

Selzer, L., & Payne, P. (1988). The distribution of white-sided dolphins (Lagenorhynchus acutus) and common dolphins (Delphinus delphis) vs. environmental features of the continental shelf of the northeastern United States. *Mar. Mammal Sci, 4*, 141-153.

Sergeant, D. (1962). *The biology of the pilot or pothead whale Globicephala melaena (Traill) in Newfoundland waters*: Fisheries Research Board of Canada under the control of the honourable the Minister of Fisheries, Ottawa.

Shirakihara, M., Shirakihara, K., Tomonaga, J., & Takatsuki, M. (2002). A resident population of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in Amakusa, western Kyushu, Japan. *Marine Mammal Science, 18*(1), 30-41.

Siebert, U., Gilles, A., Lucke, K., Ludwig, M., Benke, H., Kock, K., et al. (2006). A decade of harbour porpoise occurrence in German waters--Analyses of aerial surveys, incidental sightings and strandings. *Journal of Sea Research, 56*(1), 65-80.

Smith, B., Ahmed, B., Mowgli, R., & Strindberg, S. (2008). Species occurrence and distributional ecology of nearshore cetaceans in the Bay of Bengal, Bangladesh, with abundance estimates for Irrawaddy dolphins Orcaella brevirostris and finless porpoises Neophocaena phocaenoides. *The Journal of Cetacean Research and Management, 10*(1), 45-58.

Smith, B., Jefferson, T., Ho, D., Leatherwood, S., Thuoc, C., Andersen, M., et al. (1995). Marine mammals of Vietnam: a preliminary checklist. *Tuyen Tap Nghien Cuu Bien (Collection of Marine Research Works), 6*, 147-176.

Somayajulu, Y., Murty, V., & Sarma, Y. (2003). Seasonal and inter-annual variability of surface circulation in the Bay of Bengal from TOPEX/Poseidon altimetry. *Deep Sea Research Part II: Topical Studies in Oceanography, 50*(5), 867-880.

Sparks, T. (1997). *Distributions of sperm whales along the continental slope in the northwestern and central Gulf of Mexico as determined from an acoustic survey*. Texas A& M University.

Stafford, K., Nieukirk, S., & Fox, C. (2001). Geographic and seasonal variation of blue whale calls in the North Pacific. *Journal of Cetacean Research and Management, 3*(1), 65-76.

Steele, J. H., Collie, J. S., Bisagni, J. J., Gifford, D. J., Fogarty, M. J., Link, J. S., et al. (2007). Balancing end-to-end budgets of the Georges Bank ecosystem. *Progress In Oceanography, 74*(4), 423-448.

Stone, G., Katona, S., & Tucker, E. J. B. C. (1987). History, migration and present status of humpback whales Megaptera novaeangliae at Bermuda. *42*(2), 133-145.

Strindberg, S., Ersts, P., Collins, T., Sounguet, G., & Rosenbaum, H. (In Press). Line Transect Estimates of Humpback Whale Abundance and Distribution on their Wintering Grounds in the Coastal Waters of Gabon. *Journal of Cetacean Research and Management.*

Subrahmanyam, V., Krishna, K., Ramana, M., & Murthy, K. (2008). Marine geophysical investigations across the submarine canyon (Swatch-of-No-Ground), northern Bay of Bengal. *Current Science, 94*(4), 507-513p.

Tomilin, A. (1967). Mammals of the USSR and adjacent countries. *Vol. IX. Cetacea. Moscow, Soviet Union (English translation, 1967, Israel Program for Scientific Translations, Jerusalem, Israel)*.

Townsend, C. (1935). The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, 19*(1), 1-50.

Tyack, P., & Whitehead, H. (1982). Male competition in large groups of wintering humpback whales. *Behaviour*, 132-154.

Van Waerebeek, K., Barnett, L., Camara, A., Cham, A., Diallo, M., Djiba, A., et al. (2004). Distribution, Status, and Biology of the Atlantic Humpback Dolphin, Sousa teuszii (Kukenthal, 1892). *Aquatic Mammals, 30*(1), 56-83.

Vella, A. (2005). Common dolphin *Delphinus delphis* research and conservation requirements in the Central Mediterranean around the Maltese Islands. In K. Stockin, A. Vella, P.G.H. Evans. Common dolphins: current research, threats and issues. *ECS Newsletter N. 45, Special Issue July 2005*, 4-12.

Verfuß, U., Honnef, C., Meding, A., Dähne, M., Mundry, R., & Benke, H. (2007). Geographical and seasonal variation of harbour porpoise (Phocoena phocoena) presence in the German Baltic Sea revealed by passive acoustic monitoring. *Journal of the Marine Biological Association of the UK, 87*(01), 165-176.

Vigness-Raposa, K., Kenney, R., Gonzalez, M., & August, P. (2009). Spatial patterns of humpback whale (Megaptera novaeangliae) sightings and survey effort: Insight into North Atlantic population structure. *Marine Mammal Science, 26*(1), 161-175.

Wada, S. (1988). Genetic differentiation between two forms of short-finned pilot whales off the Pacific coast of Japan. *Sci Rep Whales Res Inst, 39*, 91-101.

Walsh, P., Fay, J., Gulick, S., & Sounguet, G. (2000). Humpback whale activity near Cap Lopez, Gabon. *Journal of Cetacean Research and Management, 2*(1), 63-68.

Wang, J., & Yang, S. (2007). *An identification guide to the dolphins and other small cetacean of Taiwan.*: Jen Jen Publishing Co., Ltd.

Wang, P. (1999). Chinese cetaceans. *Hong kong: Ocean Enterprises Ltd*.

Waring, G., Josephson, E., Fairfield-Walsh, C., & Maze-Foley, K. (2009). US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments--2008. *NOAA Tech Memo NMFS NE 210, 210*(440), 02543-01026.

Watkins, W., Daher, M., Reppucci, G., George, J., Martin, D., DiMarzio, N., et al. (2000). Seasonality and distribution of whale calls in the North Pacific. *OCEANOGRAPHY-WASHINGTON DC-OCEANOGRAPHY SOCIETY-, 13*(1), 62-67.

Weir, C. (2006a). First confirmed records of Clymene dolphin, Stenella clymene (Gray, 1850), from Angola and Congo, south-east Atlantic Ocean. *African Zoology, 41*(2), 297-300.

Weir, C. (2006b). Short Communication Sightings of beaked whales (Cetacea: Ziphiidae) including first confirmed Cuvier's beaked whales Ziphius cavirostris from Angola. *African Journal of Marine Science, 28*(1), 173-175.

Weir, C. (2007). Occurrence and distribution of cetaceans off Northern Angola, 2004/05. *The Journal of Cetacean Research and Management, 9*(3).

Whitehead, H., Gowans, S., Faucher, A., & McCarrey, S. (1997). Population analysis of northern bottlenose whales in the Gully Nova Scotia. *Marine Mammal Science, 13*(2), 173-185.

Whitehead, H., & Moore, M. (1982). Distribution and movements of West Indian humpback whales in winter. *Canadian Journal of Zoology, 60*(9), 2203-2211.

Wimmer, T., & Whitehead, H. (2004). Movements and distribution of northern bottlenose whales, Hyperoodon ampullatus, on the Scotian Slope and in adjacent waters. *Canadian Journal of Zoology, 82*(11), 1782-1794.

Winn, H. (1982). A characterization of marine mammals and turtles in the Mid-and North Atlantic areas of the US outer continental shelf. *Final report. Sponsored by the Bureau of Land Management under contract AA551-CT8-48. 450pp*.

Yamada, T. (2009). *Balaenpotera omurai Wada, Oishi & Yamada, 2003. Pages 330-331, In: The Wild Mammals of Japan.* Kyoto: Shoukadoh Book Sellers.

Yen, P. P. W., Sydeman, W. J., & Hyrenbach, K. (2004). Marine bird and cetacean associations with bathymetric habitats and shallow- water topographies: implications for trophic transfer and conservation. *Journal of Marine Systems, 50*(1-2), 79-99.

Yoshida, H., Shirakihara, K., Kishino, H., & Shirakihara, M. (1997). A population size estimate of the finless porpoise, Neophocaena phocaenoides, from aerial sighting surveys in Ariake Sound and Tachibana Bay, Japan. *Researches on Population Ecology, 39*(2), 239-247.

Zhou, K. (2002). Marine mammal research and conservation in China. *Fisheries Science, 68*((Supplement 1)), 244-247.

Zhou, K. (2004). Cetacea Carnivora: Phocoidea, Sirenia. Fauna Sinica, Mammal 9:vi, 326.

Zhou, K., Leatherwood, S., & Jefferson, T. (1995). Records of small cetaceans in Chinese waters: a review. *Asian Marine Biology, 12,* 119-139.

APPENDIX D-7: RECOMMENDATIONS FOR MARINE MAMMAL OFFSHORE BIOLOGICALLY IMPORTANT AREAS (OBIAS) FOR THE SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR, REVISED 21 SEPTEMBER 2010

Recommendations for Marine Mammal Offshore Biologically Important Areas (OBIAs) for the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

National Marine Fisheries Service
Office of Protected Resources
21 September 2010

Table 1 – NMFS' Classification Methodology for OBIA Recommendations

Level	Level Description for High Density, Foraging, Breeding/Calving, Migration, or Small Distinct Populations	Level Description Boundary Consideration
0	Information not provided or information presented does not meet NMFS' definition of the corresponding OBIA criteria or the OBIA criteria are not applicable.	SME did not provide boundary information.
1	Clear justification (qualitative or quantitative) for corresponding OBIA criteria is not available; or the SME did not provide sufficient detail to NMFS for criteria evaluation; or for high density specifically, the SME provided strong abundance/presence information, but without the comparative information that supports *high* density.	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.
2	Designation inferred from analyses conducted for purposes other than quantifying the corresponding OBIA criteria. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.	Proposed boundary inferred from analyses conducted for purposes other than quantifying the boundary. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.
3	Designation inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented from a single source or is generally imprecise (e.g., CV => 30%).	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the proposed boundary.
4	Designation inferred from peer-reviewed analyses or surveys specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented is from multiple sources or is generally precise (e.g., CV < 30%).	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973).

Table 2 - List of Recommendations and NMFS' Classification of Supporting Data

Key

High Density – HD
Foraging – F
Breeding / Calving – BC
Migration – M
Critical Habitat – CH
Small Distinct Population - SD

Name	HD	F	BC	M	CH	SDP	Highest Rank for All Species	Highest Rank for LF Specialists
Northern Bay of Bengal and Swatch-of-No-Ground	1	2	2	0	0	4	4	2
Northern Bay of Bengal and Swatch-of-No-Ground (Head of Song)	0	0	2	0	0	0	-	2
Central California National Marine Sanctuaries	4	4	0	4	0	0	4	4
Coastal Waters of Gabon, Congo and Equatorial Guinea	1	1	4	4	0	2	4	4
Coastal Waters off Madagascar	1	1	4	1	0	0	4	4
Georges Bank	3	4	0	4	0	0	4	4
Great South Channel	0	3	0	0	4	0	4	4
Okhotsk Sea	0	4	0	2	0	0	4	4
Patagonian Shelf Break	0	4	0	0	0	0	4	4
Roseway Basin Right Whale Conservation Area	0	4	0	0	0	0	4	4
Silver Bank and Navidad Bank	0	0	4	0	0	0	4	4
Southeastern U.S. Right Whale Seasonal Habitat	0	0	4	0	4	0	4	4
Southern California Bight	0	4	0	4	0	0	4	4
Southern Right Whale Seasonal Habitat	0	0	4	0	0	0	4	4
Bonney Upwelling	0	3	0	0	0	0	3	3
Costa Rica Dome	0	3	0	0	0	0	3	3
Great Barrier Reef Between 16°E and 21°S	0	0	3	0	0	0	3	3
Madagascar Plateau, Madagascar Ridge, Walters Shoal	1	3	0	3	0	2	3	3
Ligurian-Corsican-Provençal Basin And Western Pelagos Sanctuary	0	3	0	0	0	0	3	3
Penguin Bank	3	0	3	0	0	0	3	3
Piltun and Chayvo Offshore Feeding Grounds	0	3	0	1	0	0	3	3

Name	HD	F	BC	M	CH	SDP	Highest Rank for All Species	Highest Rank for LF Specialists
Area in the Ombai Strait in the Savu Sea Marine Protected Area	0	2	0	2	0	0	2	2
Fairweather Grounds, Southeast Alaska	0	2	0	0	0	0	2	2
Felibres Hills, Calypso Hills, Spinola Spur, and Montpelier Canyon	2	2	2	0	0	0	2	2
Northwest of Challenger Bank	0	2	0	2	0	0	2	2
Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon	0	2	0	0	0	0	2	2
Southern Gulf of California	2	0	0	0	0	0	2	1
Barcelona Canyon, Tarragona Canyon, Mallorca Chanel, Pituisas Canyon	2	2	2	0	0	0	2	1
Caprera Canyon, Giglio Ridge, Oblia Terrace – Southeast of Pelagos Sanctuary	2	0	0	0	0	0	2	1
Exclusion for the East China Sea	1	0	0	0	0	0	1	1
Exclusion for the West Philippine Sea	1	0	0	0	0	0	1	1
Mediterranean Sea West of 10° E Ligurian Sea to Gibralter Strait	2	0	0	0	0	0	1	1
Pelagos Cetacean Sanctuary	2	0	0	0	0	0	2	1
Peñiscola Canyon, Valencia Basin, Benidorm Canyon, Alicante Canyon, Águilas Seamount	2	0	0	0	0	0	2	1
Sardinian Seamount, Comino Trough, Sardinia, Corsica Trough	2	2	2	0	0	0	2	1
Song of the Whale Surveys - Eastern Mediterranean	1	0	0	0	0	0	1	1
Area around Ischia Island and Regno di Nettuno Marine Protected Area	2	1	3	0	0	0	3	0
Area around Quarqannah Island	0	0	0	0	0	0	0	0
Area in the Northern Adriatic Sea	2	2	3	0	0	0	3	0
Area Malta Island and Malta Plateau	0	0	0	0	0	0	0	0
Area off Eastern Sicily, East of Messina Canyon	2	0	0	0	0	0	2	0
Area off of Southwest Greece and Crete, Ptolemy Mountains, Cretan-Rhodes Ridge	2	2	2	0	0	0	2	0
Area off the Gaza Strip and the Western Coast of Israel	1	0	0	0	0	0	1	0
Avenzar Bank, Câbliers Bank, and El Mansour Seamount	1	2	2	0	0	0	2	0

Name	HD	F	BC	M	CH	SDP	Highest Rank for All Species	Highest Rank for LF Specialists
Beaked Whale Habitat in the Coastal Waters off California, Washington, and Oregon	2	0	0	0	0	0	2	0
Buenos Aires Province Coastal Area	1	2	2	0	0	2	2	0
Canary Islands Cetacean Marine Sanctuary	1	0	0	0	0	0	1	0
Cape Hatteras Special Research Area	3	3	0	0	0	0	3	0
Continental Slope of the Northern Gulf of Mexico	1	1	0	0	0	0	1	0
Cross Seamount	0	3	0	0	0	0	3	0
Djibouti Bank, Ville de Djibouti Bank, and Alborán Channel	1	2	2	0	0	0	2	0
Dogger Bank	1	0	0	0	0	0	1	0
Exclusion around Japan and the Ryukyu Islands	2	0	0	0	0	0	2	0
Exclusion around Taiwan	0	0	0	0	0	0	0	0
Exclusion around Wake Island	0	0	0	0	0	0	0	0
Exclusion for the North Philippine Sea	0	0	0	0	0	0	0	0
Exclusion in the South China Sea	1	0	0	0	0	0	1	0
Gulf of Alaska Steller Sea Lion Critical Habitat	0	0	0	0	4	0	4	0
Gulf of Thailand	2	0	1	0	0	3	3	0
Harbor Porpoise Take Reduction Management Areas	3	3	0	3	0	0	3	0
Komodo National Park, Biosphere Reserve	2	0	0	0	0	0	2	0
Marseille Canyon, Cassis Canyon, Felibres Hill, Alabe Hill, Barcelona Canyon	2	2	0	0	0	0	2	0
North Alboran Sea, Gulf of Vera, Southern Almeria	1	2	2	0	0	0	2	0
Pommeranian Bay, Adler Ground, and Western Ronne Bank	0	0	2	0	0	0	2	0
Shortland Canyon and Haldimand Canyon	3	3	0	0	0	0	3	0
Southern Almería, Seco de los Olivos Seamount, Alborán Island, Águilas Seamount	2	2	2	0	0	0	2	0
Southwest Mediterranean	1	2	2	0	0	0	2	0
Sylt Outer Reef	1	0	3	0	0	0	3	0
The Gully Marine Protected Area	4	3	0	0	0	0	4	0

Name	HD	F	BC	M	CH	SDP	Highest Rank for All Species	Highest Rank for LF Specialists
The Sea of Japan	2	0	0	0	0	0	2	0
Total Exclusion in the Gulf of Tonkin	0	0	0	0	0	0	0	0
Total Exclusion within the Yellow Sea / East China Sea	0	0	0	0	0	0	0	0
Tristan da Cunha Cetacean Sanctuary	1	0	0	0	0	0	1	0
Vaquita Habitat in the Northern Gulf of California	0	0	0	0	0	4	4	0

IUCN Marine Region 3: Mediterranean Sea

Southwest Mediterranean Sea (South of Sardinia to Alborán Sea - IFAW Survey)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density 2B: Foraging Area 2B: Breeding Area 2B: Migration Corridor
Species of Concern:	Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: *Basis: G. Notobartolo di Sciara (GNdS) Submission Number 1*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- One of the areas with highest sperm whale densities[5] in the Mediterranean. Whales feed and breed here. Considering that there is some genetic exchange between Mediterranean and Atlantic sperm whales, the Alborán Sea can be considered a migration corridor between the two regions (Lewis, 2010).
- On the assumption that g(0)=1, standard DISTANCE analysis gives an abundance estimate for the survey block of 561 animals (Lewis, 2010).

Number of Supporting Documents[6]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers. Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt. Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2- Eligible	0 - Not Applicable
Breeding / Calving	2- Eligible	0 - Not Applicable
Migration Route	2- Eligible[7]	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

5 Statement based on expert opinion.
6 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
7 The SME did not select this criterion for consideration. However, NMFS believes that this area may qualify for consideration based on information in the background provided or in the supporting documents.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

North Alborán Sea, Gulf of Vera, Southern Almeria (Spain)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Short-Beaked Common Dolphin (*Delphinus delphis);* Striped dolphins (*Stenella coeruleoalba*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 2*	SME provided a KMZ file. Area proposed covers coast to 30 nm seaward of the Andalusian Coast. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	Year-round.

Background Provided by SME

- Paper describes mostly short-beaked common dolphins; however this and other studies clearly emphasize importance of area for: a) high densities[8] of a number of odontocete species, which feed and breed there year-round (Cañadas & Hammond, 2008).
- Area covered in map is only the one which was surveyed: critical habitat of described species certain to extend much further to the south, possibly all the way to the Moroccan and Algerian coasts.
- Ana Cañadas and colleagues have published during the past decade or so a large number of papers detailing the importance of the N. Alboran Sea for a number of odontocete species. These include long-finned pilot whales (*Globicephala melas*), Risso's dolphins (*Grampus griseus*), Cuvier's beaked whales (*Ziphius cavirostris*), common bottlenose dolphins (*Tursiops truncates*). (Notarbartolo di Sciara, 2010).

Number of Supporting Documents[9]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers. Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt. Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2- Eligible	0 - Not Applicable
Breeding / Calving	2- Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

---

8 Statement based on expert opinion.

9 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Avenzar Bank, Câbliers Bank, and El Mansour Seamount - MED 09 Surveys (Spain)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Cuvier's beaked whale (*Ziphius cavirostris*); Long-finned pilot whale (*Globicephala melas*); Risso's dolphin (*Grampus griseus*); Common dolphin (*Delphinus delphis*); Striped dolphin (*Stenella coeruleoalba*)
Proposed Boundary Consideration: *Basis: GNdS SubmissionNumber 3*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density[10] area for species mentioned.
- Breeding and feeding[11] known to occur in the area for all of them.
- Alborán East: area covered by [Med-09] cruise, where a very large number of sightings were made (in 45 hours of effort: 67 Cuvier's beaked whales, 168 long-finned pilot whales, 89 Risso's dolphins, 304 short-beaked common dolphins, 870 striped dolphins, plus a number of mixed-species groups and unidentified cetaceans) is certainly much smaller than the area actually used by the concerned populations (Anon., 2010).

Number of Supporting Documents[12]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers. Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt. Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2- Eligible	0 - Not Applicable
Breeding / Calving	2- Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

10 Statement based on expert opinion.
11 Statement based on expert opinion.
12 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Djibouti Bank, Ville de Djibouti Bank, and Alborán Channel - MED 09 Surveys (Spain)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Cuvier's beaked whale (*Ziphius cavirostris*); Long-finned pilot whale (*Globicephala melas*); Risso's dolphin (*Grampus griseus*); Common dolphin (*Delphinus delphis*); Striped dolphin (*Stenella coeruleoalba*); Bottlenose dolphin (*Tursiops truncatus*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 4*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density area[13] for species mentioned. Breeding and feeding[14] known to occur in the area for all of them.
- Alborán West: area covered by cruise, where a very large number of sightings were made (in 60 hours of effort: 56 Cuvier's beaked whales, 71 long-finned pilot whales, 38 Risso's dolphins, 222 short-beaked common dolphins, 550 striped dolphins, plus a number of mixed-species groups and unidentified cetaceans) is certainly much smaller than the area actually used by the concerned populations (Anon., 2010; Notarbartolo di Sciara, 2010).

Number of Supporting Documents[15]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers. Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2- Eligible	0 - Not Applicable
Breeding / Calving	2- Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

13 Statement based on expert opinion.
14 Statement based on expert opinion.
15 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Sardinian Seamount, Comino Trough, Sardinia/Corsica Trough - MED 09 Surveys (Sardinia/Italy)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Fin whale (*Balaenoptera physalus*); Sperm whale (*Physeter macrocephalus*); Cuvier's beaked whale (*Ziphius cavirostris*); Bottlenose dolphin (*Tursiops truncatus*); Common dolphin (*Delphinus delphis*); Striped dolphin (*Stenella coeruleoalba*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 5*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Tyrrhenian Sea: area covered by cruise, where a very large number of sightings[16] were made (in 53 hours of effort: 27 fin whales, 24 sperm whales, 12 Cuvier's beaked whales, 4 bottlenose dolphins, 45 short-beaked common dolphins, 366 striped dolphins, plus a number of mixed-species groups and unidentified cetaceans) is certainly much smaller than the area used by the concerned populations (Anon., 2010).
- However, a 1993 study (Notarbotolo di Sciara et al., 1993) reported that fin whales were occasionally observed in the Tyrrhenian Sea, but that their concentration was greatest in the Ligurian-Corsican Sea.
- Breeding and feeding[17] known to occur in the area for all of them.

Number of Supporting Documents[18]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers. Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt. Report or NGO Report	Note/ Abstracts / Proceedings
0	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Rank for All Species	Rank for LF Hearing Specialists
High Density	2 - Eligible	1 - Not Eligible
Foraging Area	2- Eligible	0 - Not Applicable
Breeding / Calving	2- Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[16] Proposed criteria for high density based on expert opinion.
[17] Statement based on expert opinion.
[18] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Barcelona Canyon, Tarragona Canyon, Mallorca Chanel, Pituisas Canyon (Spain and France)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Bottlenose dolphin (*Tursiops truncatus*); Sperm whale (*Physeter macrocephalus*); Striped dolphin (*Stenella coeruleoalba*); Fin whale (*Balaenoptera physalus*); Risso's dolphin (*Grampus griseusz*); Long-finned pilot whale (*Globicephala melas*); Common dolphin (*Delphinus delphis*); Unidentified beaked whales
Proposed Boundary Consideration: *Basis: GNdS Submission No. 6 and 7*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Area contains critical habitat[19] of the species (i.e., *Tursiops*) which feeds and breeds there (Forcada, Gazo, Aguilar, Gonzalvo, & Fernández-Contreras, 2004; Notarbartolo di Sciara, 2010).
- Breeding and feeding[20] known to occur in the area for at least all odontocetes.
- Large number of sightings of different species made during two summer cruises in 2003 and 2004 testify importance of Balearic waters for cetacean ecology and biodiversity (Notarbartolo di Sciara, 2010; Rendell, Cañadas, & Mundy, 2005).

Number of Supporting Documents[21]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[22]	1 - Not Eligible
Foraging Area	2- Eligible	0 - Not Applicable
Breeding / Calving	2- Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[19] Area does not qualify as critical habitat as defined in the NMFS classification schema.
[20] Statement based on expert opinion.
[21] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[22] Proposed criteria for high density based on expert opinion.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

Peñiscola Canyon, Valencia Basin, Benidorm Canyon, Alicante Canyon, Águilas Seamount (Spain)

Proposed Criteria Submitted by SME or NMFS:	2A: High Density
Species of Concern:	Fin whale (*Balaenoptera physalus*); Sperm whale (*Physeter macrocephalus*); Cuvier's beaked whale (*Ziphius cavirostris*); Bottlenose dolphin (*Tursiops truncatus*); Common dolphin (*Delphinus delphis*) Striped dolphin (*Stenella coeruleoalba*); Risso's dolphin (*Grampus griseus*); Long-finned pilot whale (*Globicephala melas*); Unidentified beaked whale
Proposed Boundary Consideration: *Basis:* *GNdS Submission Number 8*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density[23] area for species mentioned. However, a 1993 study (Notarbotolo di Sciara, et al., 1993) reported that fin whales concentrations were greatest in the Ligurian-Corsican Sea.
- Population estimates performed with aerial and vessel surveys demonstrated the high values of the study area for striped dolphins (mean abundance 15,778), bottlenose dolphins (1,333) and Risso's dolphins (493) (Gómez de Segura, Crespo, Pedraza, Hammond, & Raga, 2006; Notarbartolo di Sciara, 2010).

Number of Supporting Documents[24]

Peer-Reviewed Article(s)	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[25]	1 - Not Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

[23] Statement based on expert opinion.
[24] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[25] Proposed criteria for high density based on expert opinion.

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Southern Almería, Seco de los Olivos Seamount, Alborán Island, Águilas Seamount (Spain)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*); Cuvier's beaked whale (*Ziphius cavirostris*); Bottlenose dolphin (*Tursiops truncatus*); Common dolphin (*Delphinus delphis*); Striped dolphin (*Stenella coeruleoalba*); Risso's dolphin (*Grampus griseus*); Long-finned pilot whale (*Globicephala melas*); Unidentified beaked whale
Proposed Boundary Consideration: *Basis: GNdS Submission Number 9*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density[26] area for species mentioned. Breeding and feeding[27] known to occur in the area for all of them.
- "The results identified areas that are important for a number of cetacean species, thus illustrating the potential for MPAs to improve cetacean conservation generally in the Alborán Sea, a region of great importance for supporting biodiversity and ecological processes in the wider Mediterranean Sea (Cañadas, Sagarminaga, De Stephanis, Urquiola, & Hammond, 2005)."

Number of Supporting Documents[28]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	2 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[26] Statement based on expert opinion.
[27] Statement based on expert opinion.
[28] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Felibres Hills, Calypso Hills, Spinola Spur, and Montpelier Canyon (France, Italy, Monaco)

Potential Criteria:	2A: High Density 2B: Critical Habitat 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Striped dolphin (*Stenella coeruleoalba*); Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: *Basis: GNdS Submission No. 10 and 12*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Area (established as a cetacean sanctuary (i.e., Pelagos) contains critical habitat[29] for a number of cetacean species, in particular the two listed here (striped dolphin and fin whale), which are known to feed and breed in the area.
- In a recent aerial survey, unpublished at present, fin whale numbers seen in 2009 are smaller than in previous years, but still substantive. Whales likely to have moved wider and ranging beyond Sanctuary waters. High density, feeding and breeding area[30].
- This area coincides with distribution detected during 1992 survey, described in Forcada J., Notarbartolo di Sciara G., Fabbri F. (1995). Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. (Forcada, et al., 1995).

Number of Supporting Documents[31]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	2 - Eligible
Foraging Area	2 - Eligible	2 - Eligible
Breeding / Calving	2 - Eligible	2 - Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[29] Area does not qualify as critical habitat as defined in the NMFS classification schema.
[30] Statement based on expert opinion.
[31] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Mediterranean Sea West of 10°E–Ligurian Sea to Gibralter Strait (France, Italy, Monaco)

Potential Criteria:	2A: High Density
Species of Concern:	Striped dolphin (*Stenella coeruleoalba*); Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 11*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Study indicates locations of distributional "hot spots" for both species in a large portion of the west Mediterranean.
- See also: Forcada J., Aguilar A., Hammond P.S., Pastor X., Aguilar R. 1994. Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. Marine Mammal Science 10(2):137-150 (Forcada, Aguilar, Hammond, Pastor, & Aguilar, 2006).
- This area coincides with distribution detected during 1992 survey, described in Forcada J., Notarbartolo di Sciara G., Fabbri F. 1995 (1995). Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin.

Number of Supporting Documents[32]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[33]	1 - Not Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

---

[32] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[33] Proposed criteria for high density based on expert opinion.

Marseille Canyon, Cassis Canyon, Felibres Hill, Alabe Hill, Barcelona Canyon (France, Italy)

Potential Criteria:	2A: High Density 2B: Foraging Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 13*	SME provided a KMZ file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density, feeding area[34].
- Area stops at Lat 39° 35′ however there is just a small distance to cover to merge into area No. 1 (i.e., the Southwest Mediterranean - South of Sardinia to Alboran Sea - IFAW Survey recommendation (Anon., 2010)) so we should presume the two are contiguous .

Number of Supporting Documents[35]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	1	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[34] Statement based on expert opinion.
[35] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Pelagos Cetacean Sanctuary (France, Italy, Monaco)

Potential Criteria:	2A: High Density
Species of Concern:	Striped dolphin (*Stenella coeruleoalba*); Sperm whale (*Physeter macrocephalus*); Fin whale (*Balaenoptera physalus*); Long-finned pilot whale (*Globicephala melas*); Risso's Dolphin (*Grampus griseus*); Cuvier's beaked whale (*Ziphius cavirostris*); Bottlenose dolphin (*Tursiops truncatus*); Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: GNdS Submission No. 14 and 15*	SME provided a KMZ file.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High densities. High density confirmed also during winter[36].
- A total of 131 cetacean sightings of were made: striped dolphins (n=114), common bottlenose dolphins (7), fin whales (1), sperm whales (1), Cuvier's beaked whales (1) and unidentified small dolphins (7). Uncorrected striped dolphin population size was estimated to be 19,578 (% CV=19.2; 95% C.I.=12,318 – 27,039), with a density of 0.2218 individuals km-1 (%CV=19.23; 95% C.I.=0.1395-0.3063) (S. Panigada, Burt, Lauriano, Pierantonio, & Donovan, 2009).
- Panigada and Azzelino's (2009) report to the Italian Ministry of the environment, in Italian contains a summary of almost two decades of data, with spatial modeling to describe habitat for several species.

Number of Supporting Documents[37]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	1 - Not Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973).

[36] Statement based on expert opinion.
[37] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Caprera Canyon, Giglio Ridge, Oblia Terrace – Southeast of Pelagos Sanctuary (Italy)

Potential Criteria:	2A: High Density
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis:* *GNdS Submission Number 16*	SME provided a KMZ file.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High densities[38].
- Detected hitherto unsuspected high densities of fin whales (but also striped dolphin and common dolphin) outside of boundaries of Pelagos Sanctuary, to the southeast (Arcangeli et al., 2009).

Number of Supporting Documents[39]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	0	1

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	1 - Not Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

[38] Statement based on expert opinion.
[39] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Area around Ischia Island and Regno di Nettuno Marine Protected Area (Italy)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding Area
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 17*	SME provided a KMZ file. *Note that many areas (Napoli Canyon, Ponza-Salerno Terrace) are within 12 nm of island coastlines.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- One of the few remaining strongholds for the species in the Mediterranean, outside of the Alborán Sea.
- An MPA (i.e., Ischia – Regno di Nettuno MPA) was established by the Italian Government in large part to protect cetaceans (these also include sperm whales, frequenting the Cuma Canyon north of the island of Ischia).
- 46 Recognizable individuals have been catalogued, 19 of these re-sighted in different years, suggesting significant levels of site fidelity. Breeding activities are often observed, and calves are always present in one or more of the group sub-units. Sighted groups are relatively large (mean=65.5, SD=23.94, n=41, range 35–100 individuals) and often observed in association with striped dolphins (*Stenella coeruleoalba*), particularly during surface feeding targeting shoaling prey (Mussi, Miragliuolo, & Bearzi, 2002).

Number of Supporting Documents[40]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[41]	0 - Not Applicable
Foraging Area	1 - Not Eligible	0 - Not Applicable
Breeding / Calving	3 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

---

[40] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[41] Proposed criteria for high density based on expert opinion.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973).

Area off Eastern Sicily, East of Messina Canyon (Sicily, Italy)

Potential Criteria:	2A: High Density
Species of Concern:	Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 20*	SME provided a KMZ file. *Note that many areas are within 12 nm of island coastlines except for a small portion.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High densities[42].
- "...marine biologists from the University of Pavia piggy-backed a sea mammal–monitoring experiment on [an] array [of four sensors off Sicily to see whether background noise is low enough to allow for acoustic detection of neutrinos]. The ensuing log, which is still being analyzed by both biologists and physicists, indicates hundreds of sperm-whale transits per year over an area of about 1,000 square kilometers" (Holden, 2007).

Number of Supporting Documents[43]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	0	1

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[42] Statement based on expert opinion.
[43] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Area around Quarqannah Island (Tunisia)

Potential Criteria:	2B: Critical Habitat
Species of Concern:	Bottlenose dolphin (*Tursiops truncatus*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 21*	SME provided a KMZ file. *Note that many areas are within 12 nm of coastline.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Presence of critical habitat[44].
- "La densité du Grand dauphin a été estimée à 0,19 animaux/km², avec un coefficient de variation de 33%. L'effectif estimé pour l'ensemble de la zone étudiée est de 3977 dauphins, avec un intervalle de confiance relativement large, de 1982 à 7584 animals."
- **Translation from Abstract:** This campaign, ASPIS 2003, concerned the zone of the 15 MN of Kélibia to Zarzis, in the east and the south of the country. The density of the common bottlenose dolphin was 0.19 per km^2 with a CV of 33%. The valued strength for the whole of the studied zone is 3,977 dolphins, with a relatively large confidence interval, of 1,982 to 7,584 animals. The relative abundance of the bottlenose dolphin was 0.1383 individuals per km^2. The species was however abundant in the Monastirs-Chebba and the Gabes Gulf zones. In the zone of the Cap Bon, the relative abundance was relatively weak compared to the other zones (Ben Naceur et al., 2004).

Number of Supporting Documents[45]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Eligible	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[44] Area does not qualify as critical habitat as defined in the NMFS classification schema.
[45] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

Area Malta Island and Malta Plateau (Malta)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding/Calving Area
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis: GNdS Submission Number 23*	SME provided a KMZ file. *Note that many areas are within 12 nm of coastline.* *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Vella's (2005) preliminary study, detected important presence of species and recommends further research/conservation effort.

Number of Supporting Documents[46]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	0	1

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Eligible[47]	0 - Not Applicable
Foraging Area	0 - Not Eligible[48]	0 - Not Applicable
Breeding / Calving	0 - Not Eligible[49]	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

46 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
47 Proposed criteria for high density based on expert opinion.
48 Proposed criteria for foraging based on expert opinion.
49 Proposed criteria for breeding / calving based on expert opinion.

Area in the Northern Adriatic Sea (Italy, Greece, Slovenia)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding/Calving Area
Species of Concern:	Bottlenose dolphin (*Tursiops truncatus*)
Proposed Boundary Consideration: *Basis: GNdS Submission No. 24 and 25*	SME provided a KMZ file. *Note that many areas are within 12 nm of coastline.* *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Moderate density area; *Tursiops* is the only cetacean sighted.
- "…a total of 156 sightings between 1988 and 2007. Encounter rates ranged between 0.42 and 1.67 groups/100 km of effort (Bearzi et al., 2009).
- High density, breeding/calving area, foraging grounds (i.e., off the Slovenian coast)[50].
- "…A total of 120 sightings ...101 dolphins identified" between 2002 and 2008. High rate of site fidelity. Offspring present in 53.3% of groups. Annual mark-recapture estimate 0.069 dolphins/km^2 (Genov, Kotnjek, Lesjak, Hace, & Fortuna, 2008).

Number of Supporting Documents[51]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	3 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[50] Proposed criteria for high density, foraging, breeding and calving based on expert opinion.
[51] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Area off of Southwest Greece and Crete (Ptolemy Mountains, Cretan-Rhodes Ridge) (Greece)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Breeding/Calving Area
Species of Concern:	Sperm whale (*Physeter macrocephalus*); Cuvier's beaked whale (*Ziphius cavirostris*)
Proposed Boundary Consideration: *Basis:* *GNdS Submission Number 30*	SME provided a KMZ file. *Note that some areas are within 12 nm of coastline.* *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- High density, breeding/calving area, foraging grounds[52].
- Frantzis and colleagues have collected vast amounts of additional data during yearly cruises, which however remain unpublished. Data include information on another deep-diving species *Ziphius cavirostris*, which also apparently has important habitat in the area (Frantzis et al., 1999).

Number of Supporting Documents[53]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	1	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	2 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

---

[52] Statement based on expert opinion.
[53] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Area off the Gaza Strip and the Western Coast of Israel (Palestine, Israel)

Potential Criteria:	2A: High Density
Species of Concern:	Common dolphin (*Delphinus delphis*)
Proposed Boundary Consideration: *Basis:* *GNdS Submission Number 35*	SME provided a KMZ file. *Note that some areas are within 12 nm of coastline.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Hitherto unsuspected presence in large groups.
- Several sightings of large groups in recent years, contrasting with previous absence of the species from the area in the authors' collective experience (Scheninin, Kerem, & Goffman, 2010).

Number of Supporting Documents[54]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	1	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[55]	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[54] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[55] Proposed criteria for high density based on expert opinion.

Ligurian-Corsican-Provençal Basin and Western Pelagos Sanctuary

Potential Criterion:	2B: Foraging Area
Species of Concern:	Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: Location inferred from Azzellino et al. (2008) and G. Notobartolo di Sciara recommendations	NMFS provided new kml for boundaries. *This area is within a nationally-designated marine mammal sanctuary*.
Proposed Seasonal Consideration:	July through August

Background

- The total size of the fin whale population in the Mediterranean is unknown. However, one study estimates that approximately 3,500 individuals range in a portion of the western basin. High whale densities, comparable to those found in rich oceanic habitats, were found in well-defined areas of high productivity. Most whales concentrate in the Ligurian-Corsican-Provençal Basin; however, neither their movement patterns throughout the region nor their seasonal cycle are clear (Notarbartolo-Di-Sciara, Zanardelli, Jahoda, Panigada, & Airoldi, 2003).
- During the summer months, the species is known to concentrate in high numbers in the Corso-Ligurian Basin, described as one of the principal feeding grounds for fin whales in the Mediterranean Sea (Notarbartolo-Di-Sciara, et al., 2003)
- One nine-year study surveyed a total of 73,046 km and reported 540 sightings of fin whales in the Ligurian Sea. Water depth was the most significant variable in describing fin whale distribution, with more than 90% of sightings occurring in waters deeper than 2,000m (S Panigada et al., 2005).
- One study sought to correlate marine mammal presence in the Ligurian Sea with physical and biological parameters collected during NATO's SACLANT Undersea Research Centre's sea trials, called Sirena. The data suggested that large (sperm and fin) whales were predominately found in the deeper portion of the basin (D' Amico et al., 2003).
- In the western Ligurian Sea, many submarine canyons at the boundary between neritic and oceanic domains create the conditions for the accumulation of migratory micronektonic species in the continental slope waters. One study suggests that the periodic pattern of concentration of pelagic zooplankton near the bottom above the slope may provide an abundant food source for organisms living in the slope area, and it could also be the reason for the occasional presence of fin whales over the upper slope (Azzellino, Gaspari, Airoldi, & Nani, 2008)
- Most of the fin whale sightings occurred along the 2,000-m depth contour. Also, Fin whales showed also a periodic east-to west pattern in their movements during the July–August period. Such a pattern suggests once more a relationship with the counter-clockwise circulation of the Liguro-Provenc- al-Catalan Current (Azzellino, et al., 2008).
- Azzellino et al. (2008) noted that bottlenose dolphin, Risso's dolphin, sperm whale and Cuvier's beaked whale were all found associated with well-defined depth and slope gradients showing very clear preferences for specific physical habitats, respectively, the shelf-edge, the upper slope and the lower slope.

Number of Supporting Documents[56]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	3 - Eligible	3 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[56] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 4: Northwest Atlantic Ocean

Harbor Porpoise Take Reduction Management Areas (United States)

Potential Criteria:	2A: High Density 2B: Migration Route 2B: Foraging Area
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration: *Basis: U.S. Government These areas are designated in the Harbor porpoise take reduction plan* (75 FR 7402; 19 February 2010).	See management area tables below

MID-COAST MANAGEMENT AREA

Point	N. lat.	W. long.
MC1	42°30.0′	70°50.1′ (MA shoreline).
MC2	42°30.0′	70°15.0′
MC3	42°40.0′	70°15.0′
MC4	42°40.0′	70°00.0′
MC5	43°00.0′	70°00.0′
MC6	43°00.0′	69°30.0′
MC7	43°30.0′	69°30.0′
MC8	43°30.0′	69°00.0′
MC9	44°17.8′	69°00.0′ (ME shoreline).

STELLWAGEN BANK MANAGEMENT AREA

Point	N. lat.	W. long.
SB1	42°30.0′	70°30.0′
SB2	42°30.0′	70°15.0′
SB3	42°15.0′	70°15.0′
SB4	42°15.0′	70°30.0′
SB1	42°30.0′	70°30.0′

SOUTHERN NEW ENGLAND MANAGEMENT AREA

Point	N. lat.	W. long.
SNE1	Western boundary as specified[1]	
SNE2	40°00.0′	72°30.0′
SNE3	40°00.0′	69°30.0′
SNE4	42°15.0′	69°30.0′
SNE5	42°15.0′	70°00.0′
SNE6	41°58.3′	70°00.0′ (MA shoreline).

[1] Bounded on the west by a line running from the Rhode Island shoreline at 41°18.2′ N. lat. and 71°51.5′ W. long. (Watch Hill, RI), southwesterly through Fishers Island, NY, to Race Point, Fishers Island, NY; and from Race Point, Fishers Island, NY; southeasterly to the intersection of the 3-nautical mile line east of Montauk Point; southwesterly along the 3-nautical mile line to the intersection of 72°30.0′ W. long.

OFFSHORE MANAGEMENT AREA

Point	N. lat.	W. long.
OFS1	42°50.0′	69°30.0′

OFFSHORE MANAGEMENT AREA—Continued

Point	N. lat.	W. long.
OFS2	43°10.0′	69°10.0′
OFS3	43°10.0′	67°40.0′
OFS4	43°05.8′	67°40.0′ (EEZ boundary).
OFS5	42°53.1′	67°44.5′ (EEZ boundary).
OFS6	42°47.3′	67°40.0′ (EEZ boundary).
OFS7	42°10.0′	67°40.0′
OFS8	42°10.0′	69°30.0′
OFS1	42°50.0′	69°30.0′

MUDHOLE NORTH MANAGEMENT AREA

Point	N. lat.	W. long.
MN1	40°28.1′	74°00.0′ (NJ shoreline).
MN2	40°30.0′	74°00.0′
MN3	40°30.0′	73°20.0′
MN4	40°05.0′	73°20.0′
MN5	40°05.0′	74°02.0′ (NJ shoreline).

MUDHOLE SOUTH MANAGEMENT AREA

Point	N. lat.	W. long.
MS1	40°05.0′	73°31.0′
MS2	40°05.0′	73°00.0′

MUDHOLE SOUTH MANAGEMENT AREA—Continued

Point	N. lat.	W. long.
MS3	39°51.0′	73°00.0′
MS4	39°51.0′	73°31.0′
MS1	40°05.0′	73°31.0′

Proposed Temporal Consideration:	Regions outside of 12-nmi from the coast within the following areas: Mid-Coast Management Area: September 15 through May 31 Stellwagen Bank Management Area: November 1 through May 31 Southern New England Management Area: December 1 through May 31 Offshore Management Area: November 1 through May 31 Mudhole North: January 1 through April 30 Mudhole South: January 1 through April 30

Background Provided by SME

- The Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena*) stock annually migrate through U.S. Atlantic waters from North Carolina in the winter to the Gulf of Maine and Bay of Fundy in the summer (Palka, Read, Westgate, & Johnston, 1996). They are in the northern Gulf of Maine and lower Bay of Fundy, Canada region during July and begin to migrate out during September. During September to December and April to June, they are seen in the lower Gulf of Maine and off the Atlantic coast of Nova Scotia near Halifax, although not in the numbers observed in the Bay of Fundy. During December to March, some of the population is presumed to be offshore of the US mid-Atlantic, from North Carolina to Massachusetts, as indicated by beach strandings (Haley & Read, 1993) and several sighting surveys (Northridge, 1996; Palka, 1995; Read, 1999; Winn, 1982). Although a few strandings have been found in Florida, the typical southerly boundary is Cape Hatteras, North Carolina (Palka, et al., 1996).
- The Gulf of Maine/Bay of Fundy harbor porpoise stock is considered a strategic stock because human-related mortalities exceed the potential biological removal (PBR) level (Waring, Josephson, Fairfield-Walsh, & Maze-Foley, 2009).
- Harbor porpoises are small sized, so they are unable to carry large energy stores (Koopman, 1998). Thus, their patterns of movement are likely to be strongly related to the distribution of their prey (Johnston, Westgate, & Read, 2005). Their primary prey are juvenile Atlantic herring *Clupea harengus harengus* though they also feed on silver hake *Merluccius bilinearis*, hake *Urophycis* spp. and pearlsides *Maurolicus weitzmani* (Gannon, Craddock, & Read, 1998).
- Because during the harbor porpoise's annual migrations they have consistently been found to inhabit certain regions in high to intermediate density levels where their prey are commonly found and where gillnet fishing commonly occurs, management actions have been developed to reduce the bycatch of harbor porpoises during specific times in specific management areas (75 FR 7383-7402; 19 February 2010). These times and areas (detailed above in the Proposed Temporal Consideration section) are clearly important habitat for this species and should receive appropriate protection. Management actions include restricting gillnet fishing or require gillnets to use pingers.

Number of Supporting Documents[57]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	3	1	0	0	4	0

[57] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	3 - Eligible	0 - Not Applicable
Foraging Area	3 - Eligible	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	3 - Eligible	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Cape Hatteras Special Research Area (United States)

Potential Criterion:	2A: High Density 2B: Foraging Area
Species of Concern:	Pilot whale spp. (*Globicephala* spp.)
Proposed Boundary Consideration:	An area bounded by the following coordinates: 75 º W 36º 25'N ;74 º W 36º 25'N 74 º W 35 º N; 75 º W 35 º N
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- Mixing of shelf, slope and Gulf Stream water over the continental shelf edge of the Middle Atlantic Bight near Cape Hatteras, North Carolina results in upwelling and Gulf Stream meanders (Churchill, Levine, Connors, & Cornillon, 1993)
- (Böhm, Hopkins, Pietrafesa, & Churchill, 2006; Churchill, et al., 1993). This creates a highly productive region which allows temperate and tropical marine species to flourish; species ranging from larval fish (Hare et al., 2002) to cetaceans (DON, 2007b; Garrison et al., 2003; Waring, et al., 2009).
- The Cape Hatteras Special Research Area, an area off Cape Hatteras within the above productive region, has a high density of pilot whales and high bycatch rates of pilot whales in the pelagic long line fishery (74 FR 23349-23358; May 19, 2009).
- Inside this Research Area, pelagic long line fishers are required to carry an observer on board, if requested, and to participate in focused research on pilot whale interactions with the pelagic longline fishery.
- Sightings of pilot whales (*Globicephala sp*.) in the western North Atlantic occur primarily near the continental shelf break ranging from Florida to the Nova Scotian Shelf (Mullin & Fulling, 2003). The long-finned pilot whale (*Globicephala melaena*) is distributed from North Carolina to North Africa (and the Mediterranean) and north to Iceland, Greenland and the Barents Sea (Abend, 1993; Abend & Smith, 1999; Buckland, Anderson, Burnham, & Laake, 1993; Leatherwood, Caldwell, Winn, Schevill, & Caldwell, 1976; Sergeant, 1962). Long-finned pilot whales and short-finned pilot whales (*Globicephala macrorhynchus*) overlap spatially along the mid-Atlantic shelf break between Cape Hatteras, North Carolina and New Jersey (Garrison, Martinez, & Maze-Foley, (in review); Payne & Heinemann, 1993). In addition, short-finned pilot whales are documented along the continental shelf and continental slope in the northern Gulf of Mexico (Hansen, Mullin, Jefferson, & Scott, 1996; Mullin & Fulling, 2003; Mullin & Hoggard, 2000), and they have also been seen in the wider Caribbean.
- Pilot whales are bycaught in the U.S. Atlantic pelagic longline, mid-Atlantic midwater trawl and the mid-Atlantic bottom trawl fisheries (Waring, et al., 2009).

Number of Supporting Documents[58]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
6	1	0	0	1	6	0

[58] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	3 - Eligible	0 - Not Applicable
Foraging Area	3 - Eligible	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Georges Bank (United States)

Potential Criterion:	2A: High Density 2B: Foraging Area 2B: Migration Route
Species of Concern:	North Atlantic Right whale (*Eubalaena glacialis*); Beaked whales (*Mesoplodon spp*. and *Ziphius spp*.); Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration:	An area bounded by the following coordinates: 40º 00' N, 72º 30' W 39º 20' N, 71º 54' W 39º 30' N, 71º 25' W 39º 45' N, 69º 00' W 40º 26' N, 66º 43' W 41º 45' N, 65º 26' W 42º 20' N, 66º 06' W 42º 18' N, 67º 23' W *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically designated area of biological importance.*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- Georges Bank is a region very rich with marine life, ranging from plankton to marine mammals (Link et al., 2008; Steele et al., 2007) and is among the most diverse, productive, and trophically complex marine temperate areas in the world (Link, et al., 2008; Overholtz & Link, 2007).
- The northern edge of Georges Bank is a relative shallow, cool region where the Georges Bank anti-cyclonic frontal circulation system deposits abundant amounts of copepods, such as *Calanus* (Durbin et al., 2003). As a result of this abundant food, the northern edge of Georges Bank is a foraging area for many cetaceans including endangered whales, such as right whales (*Eubalaena glacialis*), humpback whales (*Megaptera novaeangliae*), sei whales (*Balaenoptera borealis*), and fin whales (*Balaenoptera physalus*), and a variety of small cetaceans, such as pilot whales (*Globicephala spp.*), white-sided dolphins (*Lagenorhynchus acutus*), common dolphins (*Delphinus delphis*), and Risso's dolphins (*Grampus griseus*) (DON, 2007a; Pace & Merrick, 2008; Palka, 2006; Rossman, 2009; Selzer & Payne, 1988; Vigness-Raposa, Kenney, Gonzalez, & August, 2009; Waring, et al., 2009; Winn, 1982)
- The southern edge of Georges Bank is a different habitat with its warmer shelf-slope front, many deep canyons (e.g. Hydrographer and Oceanographer canyons), warm intrusions of the Gulf Stream, and steep shelf edge (Mooers et al. 1979). This habitat also has high densities of cetaceans, though some of the species are different from the northern edge of Georges Bank. Species commonly found foraging on the southern edge of Georges Bank include beaked whales (Mesoplodon spp. and Ziphius spp.), fin whales, sperm whales (*Physeter macrocephalus*), pilot whales, spotted dolphins (*Stenella attenuata*), striped dolphins (*Stenella coeruleoalba*), offshore bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins, and common dolphins (DON, 2007a, 2007b; Hamazaki, 2002; Palka, 2006; Selzer & Payne, 1988; Waring, et al., 2009).
- In addition, the cetacean density is even larger because some species migrate through Georges Bank and do not reside for long time periods on George Bank. Examples of these species are harbor porpoises (*Phocoena phocoena*), minke whales (*Balaenoptera acutorostrata*), and killer whales (*Orcinus orca*) (Hamazaki, 2002; Palka, Orphanides, & Warden, 2009).

- The species composition in the northern and southern edges of Georges Bank differs from season to season; however, in total there are high densities of foraging cetaceans during all parts of the year, where the winter has the lowest densities (DON, 2007a; Winn, 1982).

Number of Supporting Documents[59]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	0	0	0	0	8	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	3 – Eligible	3 – Eligible
Foraging Area	4 – Eligible	4 – Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	4 – Eligible	4 – Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

[59] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Challenger Bank (Bermuda)

Potential Criteria:	2B: Migration Route 2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Stone et al. (1987)	Challenger Seamount 32° 7.708'N, 65° 4.888'W to 32° 5.661'N, 65° 7.881'W to 32° 2.151'N, 65° 6.009'W to 32° 1.064'N, 65° 2.303'W to 32° 2.557'N, 64° 59.360'W to 32° 5.051'N, 65° 1.071'W to 32° 5.812'N, 65° 1.675'W *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	March and April

Background

- Historical accounts show that humpback whales have frequented Bermuda waters, which are located half-way between wintering and summering grounds in the western North Atlantic, since the early 17th century (Stone, Katona, & Tucker, 1987). Stone et al. (1987) suggested that humpback whales from the North Atlantic feed briefly and opportunistically at Bermuda (32°20'N) while migrating (Danilewicz, Tavares, Moreno, Ott, & Trigo, 2009).
- Humpback whales were common in Bermudian coastal waters during the late winter and spring (March-May); sperm whales, in offshore waters probably throughout much of the year (Reeves, Mckenzie, & Smith, 2006)
- Humpbacks utilize Bermuda as a mid-ocean habitat through which all members of the western North Atlantic population migrate during spring (Stone, et al., 1987).
- Humpbacks returning to their northern feeding grounds may take more westerly routes that in many cases pass close to Bermuda where as suggested by Stone et al. (1987), they may linger and feed (Clapham & Mattila, 1990).
- Stone et al. (1987) suggest that the presence of humpbacks at Bermuda, a way-point during the springtime northward migration, may be attributed to increased food availability, providing the first opportunity to feed after the wintering ground fast (Baraff, Clapham, Mattila, & Bowman, 1991).
- There is also evidence suggesting that humpback whales feed at Bermuda on deep water scattering layers during their stop-over (Stone, et al., 1987).
- It seems likely that humpbacks returning to their northern feeding grounds may take more westerly routes that in many cases pass close to Bermuda where, as suggested by Stone et al. (1987), they may linger and feed (Clapham & Mattila, 1990).
- The Humpback Whale Research Project, Bermuda states that the humpbacks migrate past Bermuda starting late February until mid-May. Humpback whales are located on the Sally Tucker (N 32°10.8170' W 064°59.4890') and Challenger seamounts some two to fifteen miles offshore. http://www.whalesbermuda.com/index.php?option=com_content&view=section&layout=blog&id=7&Itemid=59

Number of Supporting Documents[60]

[60] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
5	0	0	1	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	2 – Eligible	2 – Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	2 –Eligible	2 –Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

Roseway Basin Right Whale Conservation Area (Canada)

Potential Criterion:	2B: Foraging Grounds
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: *Canadian Govt.*	An area bounded by the following coordinates: NW 43° 05'N, 65° 40'W NE 43° 05'N, 65° 03'W SW 42° 45'N, 65° 40'W SE 42° 45'N, 65° 03'W
Proposed Seasonal Consideration:	*Canadian Restriction is June through December.*

Background

- In 2008, Transport Canada implemented the Roseway Basin Area to be Avoided (ATBA) following its adoption by the International Maritime Organization (IMO). The measure is seasonal and recommended for all vessels ≥ 300 gross tonnage from June through December. The aim of this ATBA is to protect the endangered North Atlantic right whale from ship strikes and to enhance maritime safety (IMO, 2007).
- From 1999 to 2001, Baumgartner et al. (2003) conducted surveys in Roseway Basin to investigate the physical and biological oceanographic factors associated with North Atlantic right whale occurrence. They noted that right whales in these regions fed on *Calanus finmarchicus*.
- Spatial variability in right whale occurrence was associated with water depth and the depth of the bottom mixed layer. *C. finmarchicus* CS aggregated over the deepest water depths in both regions, and within these areas, right whales occurred where the bottom mixed layer forced discrete layers of *C. finmarchicus* to occur shallower in the water column (allowing more efficient foraging) (Baumgartner, et al., 2003).
- Baumgartner et al. (2003) concluded that annual increases in right whale occurrence appeared to be associated with decreases in sea surface temperature (SST) in both regions; however, they any further observation merits based on the short duration of the three-year study.
- Baumgartner et al. (2003) concluded that spatial variability in right whale occurrence was associated with water depth and the depth of the bottom mixed layer, within the Bay of Fundy and Roseway Basins. Copepods (*Calanus finmarchicus*) aggregated over the deepest water depths in these areas. Within these areas, right whales occurred where the bottom mixed layer forced discrete layers of *C. finmarchicus* to occur shallower in the water column, which allows more efficient foraging.
- The spatial and interannual variability in occurrences observed for right whales might be associated with the SST gradient, a proxy for ocean fronts (Baumgartner, et al., 2003).
- The summer feeding areas are in waters near Nova Scotia and the principal spring feeding ground (April-June) is in the GSC (Kenney & Wishner, 1995).

Number of Supporting Documents[61]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

[61] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	4 – Eligible	4 – Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Great South Channel (United States)

Potential Criteria:	2B: Critical Habitat 2B: Foraging Area
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: U.S. Government.	It is bounded by the following coordinates: 42°30′00.0″ N, 069°45′00.0″ W 41°40′00.0″ N, 069°45′00.0″ W 41°00′00.0″ N, 069°05′00.0″ W 42°09′00.0″ N, 067°08′24.0″ W 42°30′00.0″ N, 067°27′00.0″ W 42°30′00.0″ N, 069°45′00.0″ W *This area is within designated critical habitat.*
Proposed Seasonal Consideration:	*Ship Strike Rule is April 1 to July 31.*

Background

- The Great South Channel (GSC) area lies east of Cape Cod, Massachusetts, U.S.A. between Nantucket Shoals on the west and Georges Bank on the east. Right whales are the world's most endangered large whale species, and the GSC is the principal feeding ground of the western North Atlantic population (Kenney & Wishner, 1995).
- The South Channel Ocean Productivity Experiment (SCOPEX), a multidisciplinary study of a whale-zooplankton predator-prey system in the southwestern Gulf of Maine, confirmed the co-occurrence of right whales with high density *Calanus finmarchicus* patches. Also, the whales fed on patches with higher proportions of larger lifestages of *C. finmarchius* (Kenney & Wishner, 1995).
- The summer feeding areas are in waters near Nova Scotia and the principal spring feeding ground (April-June) is in the GSC (Kenney & Wishner, 1995).
- Right whales were only rarely observed in the GSC during the fall and winter seasons. Most sightings occurred in April, May, and June, with a large peak in sighting frequency in May (Kenney, Winn, & Macaulay, 1995).
- In the Great South Channel Seasonal Management Area, NOAA has proposed an April through July requirement that all vessels over 300 gross tons travel no faster than 10 knots. To physically separate whales and vessels, NOAA has also considered designating the Great South Channel critical habitat area as an International Maritime Organization-approved Area To Be Avoided (ATBA). NMFS proposed seasonal restriction of the April through July based on the number of greatest sighting densities found in the southwest corner of the GSC Critical Habitat (Merrick & Cole, 2007).
- NMFS designated this area as critical habitat and an important feeding area for the North Atlantic right whale in 1994 (NMFS, 1994).

Number of Supporting Documents[62]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	1	0

[62] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	3 – Eligible	3 – Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	4 – Eligible	4 – Eligible
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

The Gully Marine Protected Area (Canada)

Potential Criteria:	2A: High Density 2B: Foraging Grounds
Species of Concern:	Northern bottlenose whales (*Hyperoodon ampullatus*)
Proposed Boundary Consideration: Basis: Canadian Government	An area bounded by the following coordinates: 44°13′ N, 59°06′ W to 43°47′ N, 58°35′W; 43°35′ N, 58°35′ W to 43°35′ N, 59°08′ W to 44°06′ N, 59°20′ W
Proposed Seasonal Consideration:	Year Round

Background

- The Gully, a submarine canyon off eastern Canada, was nominated as a pilot Marine Protected Area (MPA) in 1998, largely to safeguard the vulnerable population of northern bottlenose whales (Hooker, Whitehead, & Gowans, 2002).
- Northern bottlenose whales are consistently found through the year in the Gully (Whitehead, Gowans, Faucher, & McCarrey, 1997).
- A small, apparently isolated, and endangered population of approximately 130 northern bottlenose whales is found on the Scotian Slope south of Nova Scotia, Canada (Wimmer & Whitehead, 2004).
- A ship survey along the 1,000 m depth contour in 2001 showed northern bottlenose whales only in the Gully, Shortland Canyon, and Haldimand Canyon. Studies in 2002 reconfirmed the presence of the whales in the other canyons, although densities were about 50% lower than in the Gully (Wimmer & Whitehead, 2004)
- Hooker et al. (2002) estimated the energy consumption of bottlenose whales in The Gully and suggested that there must be a substantial spatial subsidy in the underlying food web of the submarine canyon to support the bottlenose whales using the Gully. Studies of this species' diet elsewhere in the North Atlantic Ocean have suggested specialization on the deep-sea squid, Gonatus fabricii (Hooker, Iverson, Ostrom, & Smith, 2001).

Number of Supporting Documents[63]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	4 – Eligible	0 - Not Applicable
Foraging Area	3 – Eligible	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[63] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

Shortland Canyon and Haldimand Canyon (Canada)

Potential Criteria:	2A: High Density 2B: Foraging Grounds
Species of Concern:	Northern bottlenose whales (*Hyperoodon ampullatus*)
Proposed Boundary Consideration: Location inferred from Wimmer and Whitehead (2004)	An area bounded by the following coordinates: 58°38'16.385"W, 44°11'56.984"N 57°54'5.541"W, 44°31'42.32"N 57°42'35.89"W, 44°8'43.019"N 58°29'39.147"W, 43°50'23.889"N
Proposed Seasonal Consideration:	Year Round

Background

- On the Scotian Shelf, northern bottlenose whales have been sighted most often in the deep waters of three underwater canyons (the Gully, Shortland Canyon, and Haldimand Canyon) along the shelf edge. They are thought to be year-round residents but winter distribution is not understood (DFO, 2007)
- The carrying capacity (the maximum number of individuals that a given environment can support) of northern bottlenose whales on the Scotian Shelf is unknown. The density of whales is higher in the Gully than in the other two canyons. This could indicate that there is room for population expansion in Shortland and Haldimand canyons. However a large canyon such as the Gully can have proportionately higher productivity due to its oceanographic and bathymetric (ocean depths) characteristics suggesting that it would be able to support higher densities of whales than smaller canyons (DFO, 2007).
- Haldimand and Shortland canyons are clearly important habitat for this species, and should receive appropriate protection. Research in 2002 confirmed that northern bottlenose whales regularly use Shortland and Haldimand canyons (Wimmer & Whitehead, 2004).
- Northern bottlenose whales were encountered in Shortland and Haldimand canyons at a rate about half that in The Gully, which suggests about half the density. Also, the whales seem to prefer waters between about 800 and 1500 m deep within all three canyons (Wimmer & Whitehead, 2004).
- Although there have been several sightings of northern bottlenose whales in other areas on and surrounding the Scotian Slope, the only areas in which we know they can be reliably found are the Gully and Shortland and Haldimand canyons (Wimmer & Whitehead, 2004) .
- Northern bottlenose whales do move between the three canyons. The function of this movement can be considered from the perspective of optimal foraging on dispersed patches of prey. As the Gully (the richer patch) fills with more northern bottlenose whales, individuals would likely do better in terms of individual net gain to use other, albeit poorer, areas with fewer competitors (Haldimand and Shortland canyons and other areas (Wimmer & Whitehead, 2004).

Number of Supporting Documents[64]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	1	0

[64] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	3 – Eligible	0 - Not Applicable
Foraging Area	3 – Eligible	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

IUCN Marine Region 5: Northeast Atlantic Ocean

Dogger Bank (OSPAR International)

Potential Criterion:	2A: High Density
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	None submitted.
Proposed Seasonal Consideration:	None submitted.

Background

- In 2002 and 2003, Germany's Federal Agency for Nature Conservation (BfN) conducted aerial surveys in the German EEZ and 12 nm zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. The BfN found that the densities estimated for this site were fairly high, indicating an important area for porpoises. Also, Dogger Bank was the only area where sightings of other species could be observed (white-beaked dolphin and minke whale) (Gilles, Herr, Lehnert, Scheidat, & Siebert, 2008).
- Other studies (Siebert et al., 2006) have collected data on the occurrence of harbour porpoises in German waters from 1988 to 2002 from dedicated aerial surveys, incidental sightings and strandings. In the article, Siebert et al. notes that aerial surveys conducted in 1995 and 1996 revealed a mean abundance of 4288 (in 1995) and 7356 harbour porpoises (in 1996) in the German North Sea study area. Further, they describe reports of 791 incidental sightings of harbour porpoise pods in German and partly Danish coastal waters of the North and Baltic Seas from 1988 to 2002.
- Siebert et al. (2006) also found that 996 harbour porpoise strandings along the German North Sea coast in the period 1990 to 2001. Only 17 animals were identified as by-catch.
- Siebert et al. (2006) noted that their observational data demonstrated a strong seasonality of harbour porpoise occurrence off the German coast with highest numbers during the summer months.

Number of Supporting Documents[65]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[65] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Sylt Outer Reef (Germany)

Potential Criteria:	2A: High Density 2B: Calving Grounds
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	None submitted.
Proposed Seasonal Consideration:	None submitted.

Background

- In 2002 and 2003, Germany's Federal Agency for Nature Conservation (BfN) conducted aerial surveys in the German EEZ and 12 nm zone to assess proposed Sites of Community Importance under the European Union (EU) Habitats Directive. The BfN found that the densities estimated for this site were fairly high, indicating an important area for porpoises.
- Giles et al. (2008) noted that the highest density was estimated for Sylt Outer Reef (2002: 2.7 individuals/km^2; 2003: 3.7 individuals/km^2).
- Important habitats for harbour porpoises were detected west of the islands of Sylt and Amrum in the North Sea and around the Schlei estuary, in waters west of Fehmarn and the Fischland-Darss area in the Baltic Sea (Siebert, et al., 2006).
- In the BfN evaluation of sites in the North Sea, only the Sylt Outer Reef was delineated for porpoises using the criteria of Article 4.1 Habitats Directive. There, three selection criteria were positively validated: (1) continuous or regular presence, (2) good population density, and (3) a high ratio of mother-calf pairs (60%) (Gilles, et al., 2008).

Number of Supporting Documents[66]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	3 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[66] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 6: Baltic Sea

Pommeranian Bay, Adler Ground, and Western Ronne Bank (Germany)

Potential Criterion:	2B: Breeding Area
Species of Concern:	Harbor porpoise (*Phocoena phocoena*)
Proposed Boundary Consideration:	None submitted.
Proposed Seasonal Consideration:	Spring – Fall

Background

- The harbor porpoise is the only resident cetacean species in the German Baltic Sea (Scheidat, Gilles, Kock, & Siebert, 2008).
- One study (Verfuß et al., 2007) indicated regular presence of harbor porpoises within the Baltic Sea and noted that the porpoise usage patterns of the area indicated geographical and seasonal variation.
- The larger numbers of harbor porpoise detections in spring to autumn compared with winter suggests that the German Baltic Sea is an important breeding and mating area for these animals (Verfuß, et al., 2007).
- A recent Danish effort (http://www2.dmu.dk/Pub/FR657.pdf) to designate and identify areas of high harbor porpoise density has collected all relevant data on movements and density of the harbor porpoises in Danish and adjacent waters.

Number of Supporting Documents[67]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	2 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[67] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 7: Caribbean

Continental Slope of the Northern Gulf of Mexico (United States)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Critical Habitat
Species of Concern:	Sperm whale, several cetacean species
Proposed Boundary Consideration: *Basis: T. Jefferson*	Between 200 and 1,000 meter depth contours. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited (Sparks, 1997) and (O'Hern & Biggs, 2009) for support.

Number of Supporting Documents[68]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible[69]	0 - Not Applicable
Foraging Area	1 - Not Eligible[70]	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

68 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
69 Proposed criteria for high density based on expert opinion.
70 Proposed criteria for foraging based on expert opinion.

Southeastern U.S. Right Whale Seasonal Habitat (United States)

Potential Criteria:	2B: Calving Area 2B: Designated Critical Habitat
Species of Concern:	North Atlantic right whale (*Eubalena glacialis*)
Proposed Boundary Consideration: Basis: U.S. Government	The coastal waters between 31°15' N and 30°15' N from the coast out 15 nautical miles; and the coastal waters between 30°15' N and 28°00' N from the coast out 5 nautical miles. *This area is within designated critical habitat.*
Proposed Seasonal Consideration:	November through March

Background

- NMFS has designated critical habitat for the NARW in coastal waters of the southeastern United States (SEUS) (NMFS, 1994). This area is the only known calving ground for NARW off the SEUS in the winter (Kraus, Hamilton, Kenney, Knowlton, & Slay, 2001).
- The NARW calving season extends from late November through early March with an observed peak in January. The presence of females with calves was primarily limited to the coastal waters between 27°30'N and 32°00'N latitudes (NMFS, 1994).
- Based on the number of calves and females with calves in the SEUS since 1980, NMFS considers the SEUS as the primary calving area for the population (NMFS, 1994).
- Keller et al. (2006) found that SST likely plays an important role in the distribution of right whales in the southeastern, winter habitat. Warm Gulf Stream waters, generally found south and east of delineated critical habitat, represent a thermal limit for right whales and play an important role in their distribution within the calving grounds (Keller et al., 2006).

Number of Supporting Documents[71]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	4 - Eligible	4 – Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	4 - Eligible	4 – Eligible
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

[71] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Silver Bank and Navidad Bank (Dominican Republic)

Potential Criteria:	2B: Breeding Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration:	Silver Bank: 20° 38.899'N, 69° 23.640'W to 20° 55.706'N, 69° 57.984'W to 20° 25.221'N, 70° 0.387'W to 20° 12.833'N, 69° 40.604'W to 20° 13.918'N, 69° 31.518'W to 20° 28.680'N, 69° 31.900'W Navidad Bank: 20° 15.596'N, 68° 47.967'W to 20° 11.971'N, 68° 54.810'W to 19° 52.514'N, 69° 0.443'W to 19° 54.957'N, 68° 51.430'W to 19° 51.513'N, 68° 41.399'W *This area is within a nationally-designated marine mammal sanctuary*.
Proposed Seasonal Consideration:	December through April

Background

- One survey conducted between 14 February and 19 March 1984 reported 317 whales were individually identified from photographs of ventral fluke patterns. Analysis of matches suggests that whales from the various high-latitude feeding stocks mix randomly on Silver Bank. Overall, the number of whales, calves, and surface-active groups observed during this study confirms the apparently singular importance of Silver Bank to the breeding ecology of western North Atlantic humpback whales (Mattila, Clapham, Katona, & Stone, 1989).
- Fast moving groups containing three or more adult humpback whales are found in the winter on Silver Bank in the West Indies. Many of these groups (Mattila, et al., 1989) have a definite structure: a central Nuclear Animal, with or without a calf, is surrounded by escorts who compete, sometimes violently, for proximity to the Nuclear Animal (Tyack & Whitehead, 1982).
- The humpback whales which winter in the West Indies are principally found over banks which are at latitudes between 10° and 22° N, have substantial areas of flat bottom between 15 and 60 m deep, and lie less than 30 km from the North Atlantic 2000-m contour. The surface sea temperatures in these areas are between 24 and 28° C (Whitehead & Moore, 1982).
- The major concentrations of the humpbacks, which feed little in winter, are on Silver and Navidad banks. On Silver Bank the humpback and humpback song densities peak in the centre of the Bank. Mothers with calves are generally found in areas of calm water, and singers are found over areas with a flat bottom, where they meander slowly (Whitehead & Moore, 1982).
- In 1992, researchers with the large-scale project known as Years of the North Atlantic Humpback (YONAH), obtained several hundred biopsies from humpback whales on Silver Bank, a limestone platform reef off the Dominican Republic’s northern coast. Silver Bank represents the most important mating and calving area for North Atlantic humpbacks (Balcomb and Nichols 1982, Mattila et al. 1989), with as many as two or three thousand individuals present during the peak of the season (Clapham & Mattila, 1993).

Number of Supporting Documents[72]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	4 - Eligible	4 – Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

[72] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 8: West Africa

Canary Islands Cetacean Marine Sanctuary (Canary Islands)

Potential Criteria:	2A: High Density 2B: Critical Habitat
Species of Concern:	Short-finned Pilot Whale (*Globicephala macrorhynchus*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	*This area is a proposed nationally-designated marine mammal sanctuary.* The proposed boundary for the sanctuary could encompass: either all or portion of national waters to the limit of the EEZ of the Canary Islands, or possibly the waters between the islands, with or without the main whale watch areas off southwest Tenerife and La Gomera. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Canary Islands represent a major area of concentration for the short-finned pilot whale (*Globicephala macrorhynchus*).
- This population is resident and is under significant stress from ship strikes and poorly-regulated whale-watching activities (Heimlich-Boran, 1993).

Number of Supporting Documents[73]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible[74]	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable[75]	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[73] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[74] Proposed criteria for high density based on expert opinion.
[75] Area does not qualify as critical habitat as defined in the NMFS classification schema.

Tristan da Cunha Cetacean Sanctuary (British Overseas Territory)

Potential Criteria:	2A: High Density 2B: Critical Habitat
Species of Concern:	Tasman beaked whale (*Tasmacetus shepherdi*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	*This area is a nationally-designated marine mammal sanctuary.* SME did not submit a spatial file.
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- This subantarctic island has recently been found to contain a relatively high concentration of Shepherd's beaked whale (*Tasmactus shepherdi*), a beaked whale species that is considered rare and presumably highly-susceptible to impacts from naval sonar (Best, Glass, Ryan, & Dalebout, 2009).

Number of Supporting Documents[76]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible[77]	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable[78]	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

[76] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[77] Proposed criteria for high density based on expert opinion.
[78] Area does not qualify as critical habitat as defined in the NMFS classification schema.

Coastal Waters of Gabon, Congo and Equatorial Guinea (West Africa)

Potential Criteria:	2A: High Density (*TJ*, *HR*) 2B: Breeding / Calving (*TJ*, *HR*) 2B: Foraging Grounds (*HR*) 2B: Migratory Route (*HR*) 2B: Critical Habitat (*TJ*, *HR*) 2C: Small, Distinct Population (*HR*)
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) (*TJ*, *HR*); Blue Whale (*Balaenoptera musculus*) (*HR*); Sperm Whale (*Physeter macrocephalus*) (*HR*); Beaked Whales (Ziphiidae) (*HR*); Bottlenose Dolphins (*Tursiops truncates*) (*HR*); Atlantic Humpback Dolphins (*Sousa teuszii*) (*HR*); Melon-headed Whales (*Peponocephala electra*) (*HR*)
Proposed Boundary Consideration:	SME: Territorial sea to 20 nm offshore. (*TJ*); Coasts of Gabon, Congo and Equatorial Guinea to 40 nm. (*HR*). *Basis: T. Jefferson, H. Rosenbaum. Published literature, IWC reports and Wildlife Conservation Society unpublished data. NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.* NMFS boundary: An exclusion zone following the 500-m isobath extending from 3° 31.055'N, 9° 12.226'E in the north offshore of Malabo southward to 8° 57.470'S, 12° 55.873'E offshore of Luanda.
Proposed Temporal Consideration:	Year-round (*HR*)

Background Provided by SME

- Well documented breeding habitat and migratory corridor for humpback whales, with particularly good documentation of dense aggregations in coastal waters of Gabon, particularly areas around Port Gentil, and the coastal shelf north and south to Luanda and northwards to Bioko (Findlay, 2001; Rosenbaum & Collins, 2006; Townsend, 1935; Walsh, Fay, Gulick, & Sounguet, 2000) and (Collins et al., 2008; Rosenbaum et al., 2009; Strindberg, Ersts, Collins, Sounguet, & Rosenbaum, In Press).
- Documented presence of the rare and likely endangered Atlantic Humpback dolphin in coastal waters of Gabon and Congo. The global population is small, and their range heavily fragmented. Gabon and Congo may host the healthiest habitat and populations remaining (low hundreds). (Collins, Ngouessono, & Rosenbaum, 2004; Van Waerebeek et al., 2004).
- Presence of sperm whales and beaked whales (Best, 2007; Townsend, 1935; Weir, 2006b, 2007).
- High biodiversity documented in the Port Gentil region due to the convergence of habitat suitable for both inshore, shallow water, and offshore, deep water species (Rosenbaum & Collins, 2006; Weir, 2006a) Findlay et al. 2006; Best 2007).
- Blue whales recorded on multiple occasions in the inshore waters of Northern Angola during dedicated study in 2008 (WCS unpublished data). Whaling catch record also suggests blue whales form a typical component of the cetacean species assemblage of the area (Best, 2007; Branch et al., 2007).
- Humpback whales (*Megaptera novaeangliae*) use the waters offshore of Gabon as a major breeding area in the Southern Hemisphere winter. There is concern about the impacts of extensive oil exploration and extraction has on the population, which has been studied in detail for several years (Rosenbaum & Collins, 2006).

- Although their current status in waters of Congo and Equatorial Guinea are unknown, the coastal waters of Gabon are inhabited by an apparently small and localized population of Atlantic humpback dolphins (*Sousa teuszii*), which is listed by the IUCN as Vulnerable to extinction. Several sightings of these animals have been made there in recent years and preliminary evidence suggests that all populations of this species are small and fragmented (Collins, et al., 2004; Van Waerebeek, et al., 2004). In addition, these dolphins are highly vulnerable to impacts from oil exploration and extraction, which occurs along much of the West Africa coast.

Number of Supporting Documents[79]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
11	2	0	0	0	4	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible[80]	0 - Not Applicable
Foraging Area	1 - Not Eligible[81]	0 - Not Applicable
Breeding / Calving	4 - Eligible	4 – Eligible
Migration Route	4 - Eligible	4 – Eligible
Critical Habitat	0 - Not Applicable[82]	0 - Not Applicable
Small Distinct Population	2 – Eligible	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

79 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
80 Proposed criteria for high density based on expert opinion.
81 Proposed criteria for foraging based on expert opinion.
82 Area does not qualify as critical habitat as defined in the NMFS classification schema.

IUCN Marine Region 9: South Atlantic Ocean

Buenos Aires Province Coastal Area (Argentina)

Potential Criterion:	2A: High Density 2B: Breeding / Calving 2B: Foraging Area 2C: Small, Distinct Population
Species of Concern:	Franciscana dolphin (*Pontoporia blainvillei*), Burmeister's Porpoise (*Phocoena spinipinnis*)
Proposed Boundary Consideration: *Location inferred from H. Rosenbaum*	The coastal waters of the Buenos Aires Province, from the coast out 10 nautical miles, between 35°00' S and 38°57' S. The coastal waters of the Buenos Aires Province, from the coast out 50 nautical miles, between 38°57'S and 40°37'S, to cover the island systems in the area. The coastal waters of the Buenos Aires Province, from the coast out 10 nautical miles, between 40°37' S and 42°00' S. *This area includes 12 nationally and/or internationally (UNESCO)-designated marine protected areas* (*MPAs*)
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The Franciscana dolphin is endemic to the Southwestern Atlantic Ocean, from Northern Brazil to Northern Argentina, and has been recognized as the most endangered cetacean in the region (Bordino et al., 2002; Secchi, Danilewicz, & Ott, 2003).
- This species is listed as Vulnerable by the IUCN and in Appendix II of CITES. The Burmeister's porpoise is endemic to the coasts of South America, from Southern Brazil to Northern Peru. This species is listed as conservation dependent-Data Deficient by the IUCN and in Appendix II of CITES. The coastal area of the Buenos Aires represents the southern limit of the Franciscana dolphin distribution range, and approaches the northern distribution range limit of Burmeister's porpoises.
- Density estimations for Franciscanas in the Buenos Aires area range between 0.37 and 0.48 ind/km^2 in the Buenos Aires area, which translates to an estimated abundance of approximately 30,000 individuals for this area (Bordino, Albareda, & Fidalgo, 2004; Crespo, Pedraza, Grandi, Dans, & Garaffo, 2004; Crespo, Pedraza, Grandi, Dans, & Garaffo, 2010) .
- Recent genetic data shows clear evidence of population structure of Franciscanas in Argentina, within the Buenos Aires Area (Lázaro, Lessa, & Hamilton, 2004; Mendez, Rosenbaum, & Bordino, 2008). Specifically, Mendez and colleagues provided evidence of at least three distinct populations in this area: one in northern Buenos Aires in the Samborombón area, at least one in eastern Buenos Aires between 36°30' deg. S and 38°00' deg. S., and at least another isolated population in southern Buenos Aires between 38°00' deg. S. and the species' distribution limit at 42°00' deg. S. (Mendez, et al., 2008; Mendez, Rosenbaum, Yackulic, Subramaniam, & Bordino, 2010). This genetic evidence is strongly supported by satellite tracking data for the species in northern and southern Buenos Aires (Bordino & Wells, 2005; Bordino, Wells, & Stamper, 2008).
- Based on environmental data and studies of fish community structure and abundance (Lasta, 1995; Lasta & Acha, 1996), coupled with the genetic evidence of *Franciscana* population structure in

Buenos Aires, Mendez et al. (2008) suggested that northern Buenos Aires could be a feeding area and calving ground for these dolphins.

- Genetic evidence suggests the existence of at least three isolated populations of Burmeister's porpoises along their distribution range: one population in coastal Peru, a second one in southern Chile, and a third one in Southern Argentina (Rosa et al., 2005). Because the Argentinean samples were collected in the Tierra del Fuego Province, over 2000 km of linear coastal distance from Buenos Aires, it is likely that future studies including specimens in this area uncover further population structure in Argentina.
- The Buenos Aires coastal area includes the following designated MPAs: Bahía de Samborombón (RAMSAR), Bahía San Blas-Isla Gama (National), Caleta de los Loros (National), Campos del Tuyú (National), Complejo Islote Lobos (National), Costero del Sur (National) ,Parque Costero del Sur (UNESCO), Dunas Atlántico Sur Mar Chiquita (National), Islas Embudo, Bermeja y Trinidad (National), Mar Chiquito (UNESCO), Punta Bermeja (National), and Rincon de Ajo (National).

Number of Supporting Documents[83]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	3	0	0	1	0	1

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	2 - Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	2 - Eligible	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

[83] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Patagonian Shelf Break (Argentina)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Southern elephant seal (*Mirounga leonina*)
Proposed Boundary Consideration: *Location inferred from Campagna et al. (1995, 1998, 1999, 2006) and Falabella et al. (2009). H. Rosenbaum*	Relevant areas are located between the isobaths of 200 and 2000 meters and the following latitudes: 1) 35°00'S and 39°00'S 2) 56°30'S and 58°30'S 3) 40°40'S and 42°30'S 2) 46°00'S and 48°50'S
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The breeding aggregation of southern elephant seal at Peninsula Valdes is estimated to number some 50,000 individuals one year old or older. It is the only colony for the species that grew during about three decades and is today stable.
- Contrary to all other colonies of southern elephant seals, Peninsula Valdes is continental and is located in temperate waters rather than Antarctic of subantarctic waters (Campagna & Lewis, 1992).
- During foraging seasons (up to 7 month at sea), elephant seals combine exceptionally deep diving (up to 1500 m) with long-distance traveling, covering millions of square kilometers.
- The shelf break is an oceanic front exploited throughout the year by elephant seals. In summer (January – March) there is an intense use of the slope from the Rio de la Plata to the south of the San Jorge Gulf. In autumn, the main foraging areas are distributed to the south of the slope and around the Malvinas Islands (Falabella, Campagna, & Croxall, 2009).
- The shelf break front is a narrow transition region between subpolar and shelf waters that shows a moderate sea surface temperature front and chlorophyll-a maxima in summer resulting from upwelling created by the Malvinas Current interaction with the bottom topography (Romero, Piola, Charo, & Garcia, 2006; Saraceno, Provost, & Piola, 2005).
- During the foraging season, adults disperse widely, over millions of square kilometers. Females migrate longer distances than males, to the Argentine Basin. Males apparently prefer the edge of the continental shelf, which is much closer and more predictable in terms of productivity than the Basin. Juveniles behave as adults in terms of the extent of their migrations, although they show seasonal differences. While adults breed on land in the spring, juveniles are at sea, and while adult females are at sea after giving birth, juveniles molt on land see (Campagna, Fedak, & McConnell, 1999; Campagna, Le Boeuf, Blackwell, Crocker, & Quintana, 1995; Campagna et al., 2007; Campagna, Piola, Rosa Marin, Lewis, & Fernández, 2006; Campagna, Quintana, Le Boeuf, Blackwell, & Crocker, 1998; Campagna, Rivas, & Marin, 2000).

Number of Supporting Documents[84]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
9	0	0	0	0	1	0

[84] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	**Rank for LF Hearing Specialists**
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	4 - Eligible	4 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	**Description**
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Southern Right Whale Seasonal Habitat (Argentina)

Potential Criteria:	2B: Calving Area 2B: Designated Critical Habitat
Species of Concern:	South Atlantic right whale (*Eubalena australis*)
Proposed Boundary Consideration: *Basis: H. Rosenbaum*	The coastal waters between 42°00'S and 43°00'S from the coast out 15 nautical miles including the enclosed bays of Golfo Nuevo, Golfo San Jose and San Matias *This area is contains designated calving habitat.*
Proposed Temporal Consideration:	May through December

Background Provided by SME

- The coastal waters surrounding Peninsula Valdes off the coast of Argentina contain one of the main calving areas for this species (Paine ref.).
- The southern right whale calving season extends from late May through late December with an observed peak in September. The presence of females with calves was primarily limited to the coastal waters between 42°00' S and 42°45'S latitudes (Paine et. Al, ref).
- Based on the number of females with calves in this area since 1970, this is considered one of the primary calving areas for the southern right whale population (Paine ref; Best ref).
- Although parts of Golfo Nuevo and all of Golfo San Jose have protected area status, southern right whales also range outside these bays throughout the season into Golfo San Matias and the Atlantic Ocean adjoining peninsula Valdes to 15nm from shore and further.

Number of Supporting Documents[85]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	4 - Eligible	4 - Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable[86]	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

[85] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[86] Area does not qualify as critical habitat as defined in the NMFS classification schema.

IUCN Marine Region 10: Central Indian Ocean

Northern Bay of Bengal and Swatch-of-No-Ground (India)

Potential Criterion:	2A: High Density 2B: Breeding Calving 2B: Foraging Area 2C: Small, Distinct Population
Species of Concern:	Irrawaddy dolphin (*Orcaella brevirostris)* Finless porpoise (*Neophocaena phocaenoides)* Indo-Pacific humpback dolphin (*Sousa chinensis)* Indo-Pacific bottlenose dolphin (*Tursiops aduncus)* Bryde's whale (small form) (*Balaenoptera edeni)* Pantropical spotted dolphin (*Stenella attenuate)* Spinner dolphin (*S. longirostris)*
Proposed Boundary Consideration:	Area is inclusive of the Swatch-of-No-Ground Submarine Canyon and adjacent coastal waters, Bangladesh and northeastern India. SME Boundary: Polygon extending along the margins of the Sundarbans mangrove forest from a point in the east at 22º30'N, 91º40'E to a point in the west at 21º26'N, 87º41'E, following the Bangladesh coast south to 20º30'N, 92º30'E and to an offshore point at 20º30'N, 87º41'E, inclusive of the Swatch-of-No-Ground (SoNG) submarine canyon and St. Martin's Island. *Location inferred from Smith et al. (2008) and Mansur et al. (unpublished – MS submitted to Marine Mammal Science) in Bangladesh waters and inferred from similar habitat in Indian waters. This area lies adjacent to three UNESCO World Heritage sites in the Sundarbans and includes a proposed international Marine Protected Area for cetaceans in the SoNG (Bangladesh Cetacean Diversity Project, 2008).* NMFS' Suggested Boundary: Head of Song area inferred from Smith et al. (2008) for the area of Bryde's whale/calf sightings relative to depth contours in the Swatch-of-No-Ground of Bangladesh. 20° 59.735'N, 89° 7.675'E to 20° 55.494'N, 89° 9.484'E to 20° 52.883'N, 89° 12.704'E to 20° 55.275'N, 89° 18.133'E to 21° 4.558'N, 89° 25.294'E to 21° 12.655'N, 89° 25.354'E to 21° 13.279'N, 89° 16.833'E to 21° 6.347'N, 89° 15.011'E
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The coastal and deep-sea waters of Bangladesh have recently been identified as a global 'hotspot' of cetacean abundance and diversity (Smith, Ahmed, Mowgli, & Strindberg, 2008).
- Coastal waters are influenced by discharge from the third-largest river system in the world, the Ganges/Brahmaputra/Meghna (GBM), which supplies about 133 x 10^9mol yr^{-1} to the Bay of Bengal that is more than 1.5% of the total riverine input to the world's oceans (Sarin, Krishnaswami, Dilli, Somayajulu, & Moore, 1989) and a seasonally reversing, wind-driven, basin-scale gyre (Somayajulu, Murty, & Sarma, 2003). These conditions combine to produce a highly stratified and productive sea-surface layer that supports relatively large populations of Irrawaddy dolphins, finless porpoises, and

Indo-Pacific humpback dolphins (Smith, et al., 2008). The first two species are Red Listed by the IUCN as 'vulnerable' and the third as 'near threatened.'

- A distance analysis of Irrawaddy dolphin and finless porpoise sightings made during a survey conducted in the winter season of 2004 resulted in abundance estimates of 5,383 (CV=39.5) and 1,382 (CV=54.8%) individuals, respectively (Smith, et al., 2008). This is the largest documented population of Irrawaddy dolphins by more than an order of magnitude. Its large size can almost certainly be explained by the extensive freshwater influence of the GBM system. The population estimate for finless porpoises also compares favorably to other marine areas where the species has been surveyed - e.g., Ariake Sound and Tachibana Bay (Yoshida, Shirakihara, Kishino, & Shirakihara, 1997) and Hong Kong and adjacent waters (Jefferson, Hung, Law, Torey, & Tregenza, 2002). Although an insufficient number of Indo-Pacific humpback dolphin groups were observed during the 2004 survey to estimate abundance (n=6), the relatively large size of some groups (>50 individuals) probably indicates a significant population.
- During the 2004 survey mentioned above all three species were found much farther offshore compared to other areas of their distribution (>30 nm for Irrawaddy dolphin, >36 nm for finless porpoise, and >19 nm for Indo-Pacific humpback dolphins) even though the survey was conducted in the winter when freshwater discharge was at its lowest. Habitat selection models for Irrawaddy dolphins indicate that the species would almost certainly be found even farther offshore with increasing freshwater flow during the monsoon season (Smith, et al., 2008).
- The Swatch-of-No-Ground (SoNG) is a 900+ meter deep submarine canyon that incises approximately 65 nm inside the continental shelf in a northeast direction to within 20 nm of the rim of the Sundarbans mangrove forest. The canyon has relatively steep walls (12-15°), ranges from about 40 km wide at its mouth to about 6 km wide at its head, and carries sediments that sustain the world's largest submarine fan (Michels, Suckow, Breitzke, Kudrass, & Kottke, 2003; Subrahmanyam, Krishna, Ramana, & Murthy, 2008). According to a mark-resight analysis under Pollock's robust design of 907 individuals photo-identified during the winter seasons of 2005-2007, a population of about 1,800 Indo-Pacific bottlenose dolphins was estimated to occur in a 2,455 km^2 area at the head of the SoNG (Mansur *et al.* in review). This makes it one of the largest populations assessed of the species. The probability of animals transitioning from an observable state in season 1 to an unobservable state in season 2 was 15.2% or less which may indicate that the actual size of the population is higher than the estimate of 1,800 individuals (Mansur *et al.* in review).
- During the photo-identification study of Indo-Pacific bottlenose dolphins mentioned above eight sightings were made of pantropical spotted dolphins (mean group size = 137, range 20-350) in the far offshore fringes of the study area in waters >100 m deep (Brian D. Smith and Rubaiyat Mansur, unpublished). A single pantropical spotted dolphin group (~800 individuals) was also detected during the 2004 survey of coastal cetaceans at the far offshore and high salinity extreme of survey coverage (Smith, et al., 2008),which only touched the margin of the species' preferred habitat in warm, stratified, pelagic waters see (Perrin & Hohn, 1994). This implies that significant numbers of the species may also occur farther offshore in un-surveyed waters where stratification remains high due to the basin-scale current gyre in the Bay of Bengal (Smith, et al., 2008). During the same the photo-identification study, 14 sightings were made of spinner dolphins (mean group size = 85.0, SD=74.2, range = 2-200) in waters at the outer fringes of the study area >120 m deep (Brian D. Smith and Rubaiyat Mansur, unpublished).
- During 2005-2008, 114 sightings were made of Bryde's whales (mean groups size = 2.3, SD=2.0, range=1-15) in similar habitat as Indo-Pacific bottlenose dolphins at the head of the SoNG (Brian D. Smith and Rubaiyat Mansur, unpublished). A total of 15 individuals were identified from photographs of their dorsal fin, of which six were re-identified during all three seasons (Mahabub, 2008). MtDNA control region data from 38 skin samples collected from these whales indicated that these animals were closely aligned with the "small form" of Bryde's whales (Matt Leslie, unpublished). Bryde's whales are not known to undergo long-range seasonal migrations and the high,

predictable productivity in the SoNG may support a resident population of this species. The common occurrence of calves may also indicate that the area is important for breeding.

- Smith et al., (2008) report that Bryde's whales distribution was closely tied to environmental gradients –occurring where the water is much deeper, oceanically saline and turns from green to blue.
- Although there are no empirical data on the abundance of cetaceans inhabiting the coastal or deep-sea waters on the Indian side of the border of the proposed Offshore Biologically Important Area, similar high densities of cetaceans may be inferred from the existence of similar habitat including freshwater discharge from the Sundarbans and Hooghly River and at western edge of the SoNG.

Number of Supporting Documents[87]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	0	0	0	1	2	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	2 - Eligible	2 - Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	4 - Eligible	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

[87] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 12: East Africa

Coastal Waters off Madagascar (Madagascar)

Potential Criteria:	2A: High Density 2B: Breeding and Calving Grounds 2B: Foraging Grounds 2B: Migratory Route 2B: Critical Habitat
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Blue whale (*Balaenoptera musculus*) Sperm whale (*Physeter macrocephalus*) Beaked whales (family Ziphiidae) Bottlenose dolphins (*Tursiops aduncus, T. truncates*) Indo-Pacific Humpback dolphin (*Sousa chinensis*) Melon-headed whale (*Peponocephala electra*)
Proposed Boundary Consideration:	SME Boundary: All coasts of Madagascar out to 50 nm. *Basis: H. Rosenbaum. Published literature, IWC reports and Wildlife Conservation Society unpublished data. NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.* NMFS boundary on East coast inferred from Pomilla & Rosenbaum (2005): 16° 3'55.04"S, 50°27'12.59"E to 16°12'23.03"S, 51° 3'37.38"E to 24°30'45.06"S, 48°26'0.94"E to 24°15'28.07"S, 47°46'51.16"E to 22°18'0.74"S, 48°14'13.52"E to 20°52'24.12"S, 48°43'13.49"E to 19°22'33.24"S, 49°15'45.47"E to 18°29'46.08"S, 49°37'32.25"E to 17°38'27.89"S, 49°44'27.17"E to 17°24'39.12"S, 49°39'17.03"E to 17°19'35.34"S, 49°54'23.82"E to 16°45'41.71"S, 50°15'56.35"E
Proposed Temporal Consideration:	SME: Year-round NMFS: June – September (East Coast)

Background Provided by SME

- Well documented breeding habitat for humpback whales, with particularly good documentation of dense aggregations in the northeast (Antongil Bay, Isle Ste. Marie), the southeast (Ft. Dauphin), southwest regions (Toliara/Anakao), the Comoros Archipelago off the northeast coast, and suggestions of distribution throughout the entire region (Cerchio, Andrianarivelo, Razafindrakoto, Mendez, & Rosenbaum, 2009; Cerchio et al., 2009; Ersts & Rosenbaum, 2003; Rosenbaum, et al., 2009; Rosenbaum, Walsh, Razafindrakoto, Vely, & Desalle, 1997).
- Presence of sperm whales and beaked whales documented in waters off shelf in the northeast, southwest and northwest regions (Kiszka et al., 2009; Townsend, 1935). Likely foraging grounds in these deep waters.
- Sensitive populations of coastal dolphins, including impacted populations of humpback dolphins, bottlenose dolphins and spinner dolphins off the west coast (Cerchio, Andrianarivelo, et al., 2009). Clearly foraging and breeding habitat for all these non-migratory species.
- High biodiversity documented in the southwest region with 13 different cetacean species due to the close proximity of foraging habitat suitable for both inshore, shallow water species and offshore, deep water species (Cerchio, Andrianarivelo, et al., 2009).
- Documented mass stranding of melon-headed whales off the northeast coast associated with oil and gas exploration activities and the introduction of noise into the regional waters.

- Likely migratory routes for blue whales in the offshore waters off both the east coast and west coast (Mozambique Channel) (Branch, et al., 2007).
- Considered part of the Indian Ocean, Antongil Bay is a haven for humpback whales. Every year between June and September, about 7,000 whales migrate to its coastal waters to breed, calve, and nurse their babies. During this time, the calm of the bay is frequently punctuated by the mating songs of the male whales (WCS, 2010).
- Pomilla and Rosenbaum (Pomilla & Rosenbaum, 2005) have projected migration routes for humpback whales from the Indian to the South Atlantic Ocean passing through the feeding grounds of Madagascar. Their paper, which is the basis of NMFS' boundary consideration, describes humpback whale distribution in the wintering destinations and in the feeding grounds off the coasts of Madagascar.

Number of Supporting Documents[88]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
5	3	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	2 - Eligible	0 - Not Applicable
Breeding / Calving	4 - Eligible	4 - Eligible
Migration Route	3 - Eligible	3 - Eligible
Critical Habitat	0 - Not Applicable[89]	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[88] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[89] Area does not qualify as critical habitat as defined in the NMFS classification schema.

Madagascar Plateau / Madagascar Ridge / Walters Shoal (Madagascar)

Potential Criteria:	2A: High Density 2B: Foraging Grounds 2B: Migratory Route 2C: Small Distinct Population
Species of Concern:	Pygmy Blue Whale (*Balaenoptera musculus brevicauda*) Humpback Whale (*Megaptera novaeangliae*) Brydes Whale (*Balaenoptera edeni*)
Proposed Boundary Consideration:	SME Boundary inferred from Best et al. (2003), Branch et al. (2007) Approximately 25ºS to 40ºS and 40ºE to 55ºE NMFS' Boundary inferred from Branch et al. (2007) 25°55'20.00"S, 44° 5'15.45"E to 25°46'31.36"S, 47°22'35.90"E to 27° 2'37.71"S, 48° 3'31.08"E to 35°13'51.37"S, 46°26'19.98"E to 35°14'28.59"S, 42°35'49.20"E to 31°36'57.96"S, 42°37'49.35"E to 27°41'11.21"S, 44°30'11.01"E
Proposed Temporal Consideration:	SME: Year-round NMFS: November and December for Blue Whales

Background Provided by SME

- Historic concentrations of catch records of blue whales, likely pygmy blue whale sub-species (Branch, et al., 2007).
- Currently, best documented congregation and feeding area for a pygmy blue whale population in the Indian Ocean, with abundance estimated by line transect distance-sampling at 424 individuals (CV = 0.42) (Best et al., 2003).
- Population identity is likely one of three suspected populations of pygmy blue whales in the Indian Ocean, characterized acoustically by stereotyped "Madagascar" call type (Branch, et al., 2007; McDonald, Mesnick, & Hildebrand, 2006), and restricted to the larger southwest Indian Ocean region (though range extent is currently unknown).
- Documented feeding area and migratory route / stopping area for southwest Indian Ocean population of Humpback whales, Breeding Stock C (Best et al., 1998).
- Documented concentrations of Bryde's whales, they are believed to represent a stock/population/subspecies distinct from two coastal African populations (Best, 2001).
- Additional supporting evidence of seasonality McDonald et al (2006) report that hydrophones off Diego Garcia have recorded blue whale songs south of Madagascar, at 32°S (Ljungblad et al., 1998). The songs were heard in the southern summer (December) on two successive years (McDonald, et al., 2006).

Number of Supporting Documents[90]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
5	0	0	0	0	0	0

[90] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	1 - Not Eligible
Foraging Area	3 - Eligible	3 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	3 - Eligible	3 - Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	2 - Eligible	2 - Eligible

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

IUCN Marine Region 13: East Asia

Gulf of Thailand (Thailand, Malaysia, Cambodia)

Potential Criteria:	2A: High Density 2B: Breeding / Calving 2B: Critical Habitat 2C: Small Distinct Population
Species of Concern:	Indo-Pacific humpback dolphin (*Sousa chinensis*) Irrawaddy dolphin (*Orcaella brevirostris*) Finless porpoise (*Neophocaena phocaenoides)*
Proposed Boundary Consideration: *Basis: T. Jefferson*	SME did not submit a spatial file. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Gulf of Thailand is an area of concentration for three species of coastal small cetaceans that are threatened by human activities: the Indo-Pacific humpback dolphin, Irrawaddy dolphin, and finless porpoise.
- These populations are under stress from serious habitat alteration and unregulated captures for live-display (Beasley, Davidson, Somany, & Ath, 2002; Mahakunlayanakul, 1996).

Number of Supporting Documents[91]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	1	1	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[92]	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	1 - Not Eligible	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable[93]	0 - Not Applicable
Small Distinct Population	3 - Eligible	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

[91] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[92] Proposed criteria for high density based on expert opinion.
[93] Area does not qualify as critical habitat as defined in the NMFS classification schema.

Komodo National Park, Biosphere Reserve (Indonesia)

Potential Criteria:	2A: High Density
Species of Concern:	Omura's whale (*Balaenoptera omurai*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	SME did not submit a spatial file. *Note that some areas are within 12 nm of coastline.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The waters around Komodo Island have been found to contain significant numbers of Omura's whales (*Balaenoptera omurai*). This is a newly-recognized species of baleen whale, which has been subjected to whaling operations by Japan, and currently is of unknown status (Kahn, 2001; Kahn, Wawandono, & Subijanto, 2001).

Number of Supporting Documents[94]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	2	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[95]	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

[94] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[95] Proposed criteria for high density based on expert opinion.

Area in the Ombai Strait in the Savu Sea Marine Protected Area (Indonesia)

Potential Criteria:	2B: Migration Route 2B: Feeding Grounds
Species of Concern:	Blue Whale (*Balaenoptera musculus*); Sperm whale (*Physeter macrocephalus*)
Proposed Boundary Consideration: Location inferred from Pet Soede (2002)	124°19'2.12"E, 8°40'3.814"S to 125°0'5.731"E, 8°32'35.885"S to 124°49'57.827"E, 8°46'59.748"S to 124°26'46.047"E, 8°57'55.645"S Revised Boundary: 8°43'34.99"S, 124°44'17.02"E to 8°40'48.48"S, 124°48'17.19"E to 8°37'2.35"S, 124°51'13.07"E to 8°34'45.48"S, 124°47'21.45"E to 8°37'22.64"S, 124°43'3.46"E to 8°40'52.05"S, 124°38'6.76"E to 8°43'54.81"S, 124°40'25.72"E *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	June through September

Background

- The Indonesian Marine Affairs and Fisheries Minister Freddy Numberi announced the designation of the Savu Sea National Marine Park — a blue whale hotspot, in May 2009. There is little species information on this area. However, The Nature Conservancy has sponsored the Solor-Alor Visual and Acoustic Cetacean Survey & Research Program in this area since 2001. Their studies consider the southeastern cape of Alor and the entrance of Ombai Strait, is considered to be a wide and important migratory corridor between Alor and East Timor (Pet-Soede, 2002).
- Initial comparisons between blue whale sightings south of Alor (Savu Sea) and north of Komodo (Flores Sea) suggests that blue whales enter and exit Indonesian Seas through different routes and corridors; perhaps initially migrating east towards Ombai Strait, between E. Alor and Timor, and then move into the Banda Sea (Pet-Soede, 2002).
- The small passages between the Solor-Alor Islands in the Savu Sea are considered feeding grounds and corridors for cetacean migration (Mustika, 2006).

Number of Supporting Documents[96]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	1	1	1

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	2 - Eligible	1 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	2 - Eligible	2 - Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[96] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

IUCN Marine Region 15: Northeast Pacific

Beaked Whale Habitat in the Coastal Waters off California, Washington, and Oregon (United States)

Potential Criteria:	2A: High Density 2B: Critical Habitat
Species of Concern:	Beaked whales (*Ziphiidae*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	Bathymetry: Between 550 and 2,000 meter depth contours. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited MacLeod and Mitchell (2005) for support.

Number of Supporting Documents[97]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible[98]	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Eligible[99]	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[97] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[98] Proposed criteria for high density based on expert opinion.
[99] Area does not qualify as critical habitat as defined in the NMFS classification schema.

Central California National Marine Sanctuaries (United States)

Potential Criteria:	2A: High Density 2B: Foraging Area 2B: Migration Route
Species of Concern:	Blue whale (*Balaenoptera musculus*); Humpback whale (*Megaptera novaeangliae*); Dall's porpoise (*Phocoenoides dalli*); Pacific white-sided dolphin (*Lagenorhynchus obliquidens*); Northern right whale dolphin (*Lissodelphis borealis*); Risso's dolphin (*Grampus griseus*); Eastern gray whale (*Eschrichtius robustus*) Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Location inferred from Forney (2007)	Single stratum boundary created from the Cordell Bank, Gulf of the Farallones, and Monterey Bay legal boundaries.
Proposed Temporal Consideration:	Blue and humpback whale feeding in this area is largely limited to June-November. Gray whales migrate through this area December-May but are likely to be greater than 12 miles from shore only when crossing Monterey Bay. All other species are year-round residents.

Background Provided by SME

- During the summer and fall of 2005, the Southwest Fisheries Science Center conducted a shipboard line-transect survey of marine mammals in the waters off California, Oregon, and Washington out to 300 nm, with fine-scale survey effort in four National Marine Sanctuaries (NMSs), namely the Olympic Coast, Cordell Bank, Gulf of the Farallones, and Monterey Bay NMSs (Forney, 2007). Geographically-stratified line-transect analyses were used to derive density and abundance estimates for three strata with coarse survey coverage (southern California, central and northern California combined, and Oregon and Washington combined) and three strata with fine-scale survey coverage (the Olympic Coast slope, Olympic Coast NMS, and the three central California NMSs combined). Based on the stratified line-transect analyses, the densities in the central California NMS stratum were the highest among all geographic strata for five cetacean species, Dall's porpoise, northern right whale dolphins, Risso's dolphins, humpback whales, and blue whales. Furthermore, the density of Pacific white-sided dolphins in the central California NMS stratum was the second highest among all strata.
- Each fall, gray whales migrate south along the coast of North America from Alaska to Baja California, in Mexico, most of them starting in November or December (Rugh, Shelden, & Schulman-Janiger, 2001). Gray whale northbound migration generally begins in mid-February and continues through May with cows and newborn calves migrating northward primarily between March and June along the U.S. West Coast (Carretta et al., 2008). Gray whales are greater than 12 nm from shore when they migrate across the mouth of Monterey Bay.
- In the Monterey Bay, blue whales feed on dense euphausiid aggregations between 150 and 200 m on the edge of the Monterey Bay Submarine Canyon. (Croll et al., 2005). Blue whale feeding is also particularly common from the Cordell Bank shoreward to Bodega Bay (Barlow & Forney, 2007) and at the southern extent of the Monterey Bay National Marine Sanctuary (Barlow & Forney, 2007).
- Humpback whale feeding is particularly concentrated with the Cordell Bank, Gulf of the Farallon and Monterey Bay National Marine Sanctuaries (Barlow & Forney, 2007; Forney, 2007).
- The cyclic annual migration of the northeastern Pacific blue whale population is associated with feeding at mid- to high-latitudes throughout the highly productive summer and fall, followed by a

southbound migration to tropical regions to give birth and mate in the winter and spring. Primary production off southern California typically peaks in the spring allowing particular euphausiid species to grow to maturity by summer, coinciding with the arrival of blue whales (Burtenshaw et al., 2004).

- Cordell Bank is located about 80 kilometers (50 miles) northwest of San Francisco and 32 kilometers west of the Point Reyes lighthouse. It is approximately 7 kilometers wide and 15 kilometers long and sits on the edge of the continental shelf. The bank is located on the edge of an underwater peninsula and is surrounded by deep water on three sides. Within 11 kilometers of its western edge, the seafloor drops to 1,829 meters at the sanctuary's western boundary (NMS, 2009a).
- Vertical entrapment and/or forcing of prey near the surface likely plays a role in predator aggregation over Cordell Bank. Also, Cordell Bank is shallower than the diurnal depth range of many zooplankton species, especially euphausiids and could vertically trap these prey species in shallow regions within the diving depth of many predators (Yen, Sydeman, & Hyrenbach, 2004)
- Northern fur seals and California sea lions are seasonally abundant in the Cordell Bank NMS, coming here to forage during the fall through the spring.
- Since 1982 Steller sea lion southernmost breeding colonies are within the Monterey Bay and Gulf of the Farallones National Marine Sanctuaries at Año Nuevo Island and the Farallon Islands, respectively. Females and juveniles Steller sea lions stay within the Gulf year-round, while males migrate north and offshore during the non-breeding season from the end of August through May (NMS, 2009c).

Number of Supporting Documents[100]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
7	0	0	0	2	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	4 - Eligible	4 - Eligible
Foraging Area	4 - Eligible	4 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	4 - Eligible	4 - Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

[100] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Vaquita Habitat in the Northern Gulf of California (Mexico)

Potential Criteria:	2C: Small, Distinct Population with Limited Distribution
Species of Concern:	vaquita (*Phocoena sinus*)
Proposed Boundary Consideration: Location inferred from PACE recovery plan	All of the waters in the Gulf of California located north of the line defined by the following coordinates: 114°42'00"W, 30°36'00"N 113°33'00"W, 31°18'54"N
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The vaquita (also known as the Gulf of California harbor porpoise) is listed as Critically Endangered by the IUCN and as Endangered by both the Mexican Official Standard NOM-059 and the U.S. Endangered Species Act.
- A 2007 abundance estimate suggested that only about 150 individuals remained in the population (Jaramillo-Legorreta et al., 2007), and recent acoustic surveys indicate that the population is currently declining rapidly (Jaramillo-Legorreta & Rojas-Bracho, 2008).
- The range of the vaquita population is very small, limited to the northern Gulf of California (Jaramillo-Legorreta, Rojas-Bracho, & Gerrodette, 1999).
- Vaquitas are occasionally found more than 12 nm from shore.
- The primary and ongoing threat to the vaquita is mortality resulting from bycatch in commercial and artisanal gillnet fisheries for shrimp and fish (CIRVA, 1997, 1999, 2004; Rojas-Bracho & Taylor, 1999).

Number of Supporting Documents[101]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	3	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	4 - Eligible	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

[101] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed .

Southern Gulf of California (Mexico)

Potential Criteria:	2A: High Density
Species of Concern:	Cuvier's beaked whale (*Ziphius cavirostris*) Blainville's beaked whale(*Mesoplodon densirostris*) Peruvian beaked whale (*Mesoplodon peruvianus*) Sperm whales (*Physeter macrocephalus*) Coastal spotted dolphin (*Stenella attenuate graffmani*) Long-beaked common dolphin (*Delphinus delphis*) Bottlenose dolphins (*Tursiops truncatus*) Risso's dolphin (*Grampus griseus*) Short-finned pilot whale (*Globicephala macrorhynchus*) Dwarf sperm whale (*Kogia sima*) Bryde's whale (*Balaenoptera edeni*) Fin whale (*Balaenoptera physalus*)
Proposed Boundary Consideration: Location inferred from references cetacean and oceanographic cited in Background material	All of the waters in the southern Gulf of California between 22.88 ^{o}N and 30^{o}N *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically designated area of biological importance.*
Proposed Temporal Consideration:	Year-round

Background Provided by SME

- The southern Gulf of California is an area of particularly high population density[102] for Cuvier's and *Mesoplodon* beaked whales, sperm whales, Bryde's whales, fin whales, coastal spotted dolphins, long-beaked common dolphins, bottlenose dolphins, Risso's dolphins, short-finned pilot whales, and dwarf sperm whales, based on two different analytical methods, geographically stratified line-transect analyses (Ferguson & Barlow, 2001, 2003) and cetacean-habitat models (Ferguson, Barlow, Fiedler, Reilly, & Gerrodette, 2006; Ferguson, Barlow, Reilly, & Gerrodette, 2006). Data for both analyses were based on cetacean sighting data from shipboard line-transect surveys conducted by the Southwest Fisheries Science Center that were designed to study the distribution and abundance of cetaceans.
- The Gulf of California is a narrow sea, with considerable habitat diversity from the northern to the southern end of the Gulf. The Midriff Islands, located between 28^{o}-30^{o} N, separate the shallow (approximately 120 m) northern Gulf from the deep (approximately 2000 m) basin of the southern Gulf (Gutiérrez, Marinone, & Parés-Sierra, 2004).
- Basin-wide eddies that reliably form between the Midriff Islands and the mouth of the Gulf enhances productivity in this region of the Gulf (Pegau, Boss, & Martínez, 2002).
- The northern Gulf (north of approximately 29^{o} N) is characterized by a large-scale, seasonally-reversing gyre (Beier & Ripa, 1999; Carrillo & Palacios-Hernandez, 2002). Collectively, this oceanographic evidence supports placing the boundary between ecosystems in the southern and northern Gulf at approximately 30^{o}N.

[102] Statement based on expert opinion.

Number of Supporting Documents[103]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2- Eligible[104]	1 – Not Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance.

[103] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[104] Statement based on expert opinion.

Southern California Bight (United States)

Potential Criteria:	2B: Foraging Area 2B: Migration Route
Species of Concern:	Pacific gray whale (*Eschrichtius robustus*) Blue whale (*Balaenoptera musculus*) Short-beaked common dolphin (*Delphinus delphis*) Long-beaked common dolphin (*Delphinus capensis*) Risso's dolphins (*Grampus griseus*)
Proposed Boundary Consideration: Location inferred from Barlow et al. (2009)	120.5°W, 34.5°N to120.5°W, 32°N to 118.605°W, 31.1318°N to 117.8253°W, 32.6269°N to 117.4637°W, 32.5895°N to 117.121°W, 32.507°N
Proposed Temporal Consideration:	Jun through Nov for blue whales, Dec through May for gray whales, year-round for all other species

Background Provided by SME

- The Southern California Bight is a high-density feeding area for a wide variety of cetacean species. The most abundant species is the short-beaked common dolphin, *Delphinus delphis*. The boundaries of this area are taken approximately as the area where *D. delphis* density is estimated to be over 1 animal per km-2 (Barlow et al. 2009). High density areas for other species listed above fall within this zone.
- The waters around the Channel Islands within the Southern California Bight have particularly high densities of Risso's dolphins (Barlow et al. 2009) and long-beaked common dolphins (Barlow & Forney, 2007).
- For blue whales, feeding was noted at a significant fraction of blue whale sightings over the shelf (out to 3.5 km beyond the 200 m isobath) in three areas: around Santa Rosa and San Miguel Islands, north of San Nicolas Island, and along the mainland coast from Pt. Conception north (Fiedler et al., 1998)
- The results of the Whale Habitat and Prey Studies (WHAPS) show that blue whales aggregated near the Channel Islands during the summer, where they feed on dense patches of krill associated with the island shelf. Krill were most abundant along the shelf on the north and west sides of San Miguel Island and the north side of Santa Rosa Island (Fiedler, et al., 1998).
- Blue whales feed off the California coast from roughly June through November, and move southward to waters off Mexico in winter and spring (Calambokidis et al., 1990).
- A study on visual and acoustic encounter rates for blue whales in the SAB reported elevated detection rates of in the Cortez Bank and Butterfly Bank subregions, as the dynamic bathymetry in those regions may concentrate high densities of euphausiids (Oleson, Calambokidis, Barlow, & Hildebrand, 2007). Oleson et al. also notes that the similarity in the visual and acoustic encounter rates in the Cortez Bank and Butterfly Bank subregions suggests that these areas may represent portions of the Bight important to both feeding and traveling whales.
- Each fall, gray whales migrate south along the coast of North America from Alaska to Baja California, in Mexico, most of them starting in November or December (Rugh, et al., 2001). Gray whale northbound migration generally begins in mid-February and continues through May with cows and newborn calves migrating northward primarily between March and June along the U.S. West Coast (Carretta, et al., 2008). Although some gray whales follow the coast in Southern California, many or most are greater than 12 nm from shore when they migrate across the Southern California Bight.

Number of Supporting Documents[105]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
9	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	4 - Eligible	4 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	4 - Eligible	4 - Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance. .

[105] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Fairweather Grounds, Southeast Alaska (United States)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Bounded by 58° 10'N, 58° 30'N, 137° 30'W, and 139° 10'W
Proposed Temporal Consideration:	June through September

Background Provided by SME

- The Fairweather Grounds, located offshore of Mount Fairweather in the Gulf of Alaska, is an offshore bump in the continental shelf waters off Southeast Alaska, rising to within 50 m of the surface. This bathymetric relief provides an area of concentration for fish and zooplankton food sources for humpback whales.
- The Fairweather Grounds has long been recognized as a rich whaling ground (Davidson 1869, Coast Pilot of Alaska, US Govt. Printing Office, Washington D.C.). In that report, the area was described as being from Pamploma Reef eastward to the shores off of Mount Fairweather.
- A recent NOAA survey in 2004 found dense groups of humpback whales feeding in the same area, between 58° 10'N and 58°30'N and between 137°30'W and 139° 10'W, with super-groups of 16, 20 and 25 whales (J. Barlow, pers. comm).
- Local fishermen from Sitka often report seeing whales in the Fairweather Grounds (J. Straley, pers. comm.).
- Most of the Fairweather Grounds is more than 12 nm from shore and thus would be considered an offshore biologically important area for feeding humpback whales.

Number of Supporting Documents[106]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	2	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	2 - Eligible	2 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[106] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Olympic Coast: The Prairie, Barkley Canyon, and Nitnat Canyon (Washington)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Humpback whale (*Megaptera novaeangliae*) Killer whale (*Orcinus orca*)
Proposed Boundary Consideration: Location inferred from Calambokidis et al. (2004)	125°58'38.786"W, 48°30'1.995"N to 125°38'52.052"W, 48°16'55.605"N to 125°17'10.935"W, 48°23'7.353"N to 125°16'42.339"W, 48°12'38.241"N to 125°31'14.517"W, 47°58'20.361"N to 126°6'16.322"W, 47°58'20.361"N to 126°25'48.758"W, 48°9'46.665"N *and existing OBIA boundary as defined in the 2007 Rule.*
Proposed Seasonal Consideration:	June through September

Background

- A CSCAPE survey reported that humpback whale sightings were concentrated in the northern part of the study area between Juan de Fuca Canyon and the outer edge of the continental shelf, an area known as "the Prairie" (Fig. 2). A small area east of the mouth of Barkley Canyon and north of the Nitnat Canyon where the water depth was 125−145 m had a high density of sightings in all years (Calambokidis, Steiger, Ellifrit, Troutman, & Bowlby, 2004). http://www.cascadiaresearch.org/reports/Fish-bul-OCSwEratum.pdf
- NOAA Technical Memorandum 406 estimated that the abundance of humpback whales within the combined three OC strata during 2005 (208, CV=0.28) was about twice the observed abundance during 1995-2000 (range of abundance estimates: 85 - 125, CVs ~0.32), but lower than the peak year of 2002 with 562 (CV=0.21) humpback whales.
- NOAA Technical Memorandum 406 reports that humpback whales were observed largely in the same areas of the OCNMS as during previous years and noted that regions within and to the north (Canadian waters) and west (slope waters) of the OCNMS were likely important foraging regions for West Coast humpback whales.

Number of Supporting Documents[107]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	2 - Eligible	2 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[107] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Gulf of Alaska Steller Sea Lion Critical Habitat (Alaska)

Potential Criterion:	2B: Designated Critical Habitat
Species of Concern:	Steller sea lion (*Eumetopias jubatus*)
Proposed Boundary Consideration: Basis: U.S. Government	Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144°W longitude. 145°43'7.708"W, 60°17'41.42"N to 143°37'31.682"W, 59°38'59.715"N to 146°26'15.838"W, 59°6'38.618"N to 147°34'46.397"W, 59°30'6.865"N to 150°15'53.824"W, 58°57'45.767"N to 151°45'20.388"W, 57°8'1.26"N to 155°30'50.98"W, 55°26'1.094"N to 159°22'19.342"W, 54°24'29.203"N to 162°43'58.85"W, 53°54'32.736"N to 163°23'18.616"W, 54°12'18.436"N to 172°57'38.806"W, 51°40'49.533"N to 179°25'44.364"W, 50°49'26.613"N to 179°39'3.639"W, 51°6'34.253"N to 163°49'34.33"W, 54°21'56.96"N to 157°56'22.112"W, 56°20'3.869"N to 153°11'13.812"W, 58°25'39.894"N to 148°41'53.223"W, 59°49'8.687"N to 148°2'52.488"W, 59°38'59.715"N
Proposed Seasonal Consideration:	Year-Round

Background

- NMFS has designated critical habitat for the Steller sea lion in certain areas and waters of Alaska. Steller sea lions are dependent on these areas and features for its continued existence and any Federal action that may affect these areas or features is subject to the consultation requirements of section 7 of the ESA 58 (58 Federal Register 45269-45285, August 27, 1993).
- Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in State- and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is east of 144°W longitude. Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally-managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144°W longitude.

Number of Supporting Documents[108]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	4 - Eligible	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[108] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
4	Proposed boundary is well documented and/or codified by national law or regulation (e.g., regulatory boundaries pursuant to the U.S. Endangered Species Act of 1973) and proposed.

Piltun and Chayvo Offshore Feeding Grounds (Russia)

Potential Criteria:	2B: Migration Route 2B: Foraging Area
Species of Concern:	Western Pacific gray whale (*Eschrichtius robustus*)
Proposed Boundary Consideration: Location inferred from IWC and Tyurneva (2006)	143°33'26.5"E, 53°30'42.938"N to 143°40'42.039"E, 53°34'13.683"N to 143°48'39.728"E ,52°41'4.409"N to 143°51'56.423"E, 52°1'44.066"N to 143°24'32.613"E, 52°2'54.314"N to 143°40'13.94"E, 52°38'43.912"N to 143°33'26.5"E, 53°30'42.938"N
Proposed Seasonal Consideration:	June through November

Background

- The critically endangered western gray whale spends the summer-fall open water period feeding off northeast Sakhalin Island (Rutenko, Borisov, Gritsenko, & Jenkerson, 2007). A previously unknown gray whale feeding area (the Offshore feeding area) was discovered south and offshore from the nearshore Piltun feeding area. The Offshore area has subsequently been shown to be used by feeding gray whales during several years when no anthropogenic activity occurred near the Piltun feeding area (S. Johnson et al., 2007).
- Results of a 2001-2003 aerial survey of the area indicated that gray whales occurred in predominantly two areas, (1) adjacent to Piltun Bay, and (2) offshore from Chayvo Bay (offshore feeding areas). In the Piltun feeding area, the majority of whales were observed in waters shallower than 20 m and were distributed from several hundred meters to similar to 5 km from the shoreline.
- In the offshore feeding area during all years, the distribution of gray whales extended from southwest to northeast in waters 30-65 m in depth. Fluctuations in the number of whales observed within the Piltun and offshore feeding areas and few sightings outside of these two areas indicate that gray whales move between the Piltun and offshore feeding areas during their summer-fall feeding season. Seasonal shifts in the distribution and abundance of gray whales between and within both the Piltun and offshore feeding areas are thought, in part, to be a response to seasonal changes in the distribution and abundance of prey (Meier et al., 2007).

Number of Supporting Documents[109]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	3 - Eligible	3 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	1- Not Eligible	1- Not Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

[109] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

IUCN Marine Region 16: Northwest Pacific

Okhotsk Sea (Russia)

Potential Criteria:	2B: Foraging Area 2B: Migration Route
Species of Concern:	Fin whale (*Balaenoptera physalus*) Minke whale (*Balaenoptera acutorostrata*) North Pacific Humpback whale (*Megaptera novaeangliae*) Western Pacific Right whale (*Eubalaena japonica*) Okhotsk Sea bowhead whale (*Balaena mysticetus*) Baird's beaked whale (*Berardius bairdii*) Dall's porpoise (*Phocoenoides dalli*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	SME did not submit a spatial file. ** NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- A separate population of bowhead whales is restricted to the Okhotsk Sea. During the late spring and early summer these whales concentrate in Shelikhov Bay in the northeastern Okhotsk Sea and then are found from May to October in the Shantar region of the northwestern Okhotsk Sea. However, little is known about their winter distribution, but these whales do not leave the Okhotsk Sea. These concentrations are found within the 12 nm of the coast. The population is estimated in the low hundreds, but this is not based on any quantitative analysis.
- The western population of right whales summers and feeds in the Okhotsk Sea mainly off southern Sakhalin Island and the western side of the Kamchatka Peninsula. The population was depleted during 19th century whaling and again by Soviet whaling in the 1960s. Based on summer sightings during a Japanese-Russian surveys in the Okhotsk Sea in Miyashita and Kato (1998) derived a population estimate of 922 whales (95% CI 404-2,108) using line transect analysis.
- Fin whales seem to be abundant in the central offshore part of the Okhotsk Sea based on recent Japanese surveys, but no abundance estimate has been calculated (Miyashita, 2004).
- A joint Japanese-Russian surveys in the summers of 1989 and 1990 yielded an abundance estimate for western North Pacific minke whales of 25,049 (CV 0.316), but most of these whales (19,209; CV 0.339) were found in the Okhotsk Sea (Buckland, Cattanach, & Miyashita, 1992). The Okhotsk Sea has been surveyed again in 2003 (Miyashita, 2004), but no updated abundance estimate has been derived.
- The main summer feeding grounds for the western North Pacific humpback whales are the waters off easternmost Russian, including the western Bering Sea, the Okhotsk Sea, south to the Sanriku coast of Honshu, Japan (Rice, 1998) [plus any new SPLASH data population estimate of ca. 1,000 whales]).
- Three species of beaked whales (*Z. cavirostris*, *B. bairdii*, and *M. steinegeri*) are known from the waters of the Russian Far East (Tomilin, 1967). The first stranding of a Cuvier's beaked whale was in 1882 from Bering Island, Commander Islands and this specimen is the holotype of *Ziphius grebnitzkii* (Stejneger 1883). Most of the strandings for these species are from the Commander Islands where Cuvier's beaked whale is the most frequently found (Tomilin, 1967).
- Dall's porpoise are recognized as two different color type: the dalli-type and the truei-type. Based on 2003 survey data the population estimates for dalli-type and truei-type porpoises are 173,638 and

178,157, respectively (GOJ, 2007). The true-type breed in the central part of the Okhotsk Sea in summer.

Number of Supporting Documents[110]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
7	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	4 - Eligible	4 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	2- Eligible	2- Eligible
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
0	SME did not provide boundary information.

110 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Exclusion around Japan and the Ryukyu Islands (Japan)

Potential Criteria:	SME did not submit criteria. (NMFS West Coast) 2A: High Density (TJ) 2B: Critical Habitat (TJ)
Species of Concern:	At least 39 species of cetaceans, including eight species of baleen whales, seven species of beaked whales are known from Japanese waters. Beaked whales (*Ziphiidae*) (TJ)
Proposed Boundary Consideration: *Basis: NMFS West Coast or T. Jefferson*	Exclusion around the main Japanese Islands and Ryukyu Islands, extending 100 km (54 nm) seaward of the 12 nm border along the Pacific side (eastern coastline of Japan) and extending 100 km on both sides of the Ryukyu Islands (Okinawa, Kerama, Miiyako, Yaeyama, Kume, Iriomote, and Ishigaki). Bathymetry: between 550 and 2,000 meter depth contours. (TJ) *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Japanese Archipelago is the world's seventh largest island. The waters around the Japanese Islands have a large diversity of cetaceans because of a distant cool-temperate and warm-temperate fauna to the north and to the south, respectively. The cold water along the northern half of Japan is from the Oyashio Current which supports the Oyashio Large Marine Ecosystem (OLME). The OLME is one of the most productive ecosystems in the North Pacific Ocean (Minoda, 1989). Along the southern half of Japan warmer waters are found from the Kuroshio Current which supports the Kuroshio Large Marine Ecosystem and extends south to its origin off the Philippines.
- At least 39 species of cetaceans are found within these two large marine ecosystems in the Japanese EEZ, including many ecologically and genetically distinct populations. (e.g., (Fujino, 1960; Hayano, 2004, 2007; Ichihara, 1957b; Kasuya & Miyashita, 1988, 1997; Kasuya, Miyashita, & Kasamatsu, 1988; Kasuya & Tai, 1993; Kato, 1992; Miyazaki & Amano, 1994; Miyazaki & Nakayama, 1989; Wada, 1988).
- Eight species of baleen whales (fin whales, sei whales, minke whales, Bryde's whales, Omura's whales, humpback whales, gray whales and North Pacific right whales) are known from Japanese waters.
- In the western North Pacific, there are at least two distinct populations of minke whale. The "J stock" which appears to be an autumn-breeding population that occurs in the Yellow Sea, East China Sea and Sea of Japan. They also occur at least seasonally in the coastal waters along the Pacific coast of Japan with limited penetration into the Okhotsk Sea in summer; The other population is the "O-stock" which breeds in winter like most baleen whales, and occurs in summer in the northwestern Pacific including the northeastern coasts of Japan, and in the Okhotsk Sea, but the "J stock" with a with conception peak in the fall (Kato, 1992; Omura & Sakiura, 1956). J stock whales are found out to at least 50 nm from the Pacific coast of Japan. The population is considered depleted because of past commercial whaling and current bycatch in both Korean and Japanese waters.
- Seven species of beaked whales (*I. pacificus*, *B. bairdii*, *Z. cavirostris*, *M. carlhubbsi*, *M. densirostris*, *M. ginkodens*, *M. stejnegeri*) are known from Japanese waters. Longman's beaked whale was not recorded until July 2002 at Sendai-shi, Kyushu (Yamada). Three of these species (*B. bairdii*, *M. carlhubbsi*, and *M. stejnegeri*) are restriched to the cold waters of the Oyashio Current and the others

are found in the warm Kuroshio Current to the south of 35 N. Cuvier's beaked whales are found in all waters around Japan and six mass strandings (with three or more individuals) of these whales occurred in Sagami Bay and Suruga Bay between 1963 and 1990 (Brownell, Yamada, Mead, & Van Helden, 2004).

- Baird's beaked whales are found off the slope of the eastern coast of Japan to about 35 N. Vessel surveys were conducted between 1983 and 1991 and in 1992. These surveys produced Overall abundance estimates of 4,220 and 5,029, respectively (Miyashita, 1986; Miyashita & Kato, 1993). No abundance estimates are available for any of the other species of beaked whales in Japanese waters and little is known about these actual distributions except from stranded animals.
- Miyashita (1993) estimated population size of the northern form of the short-finned pilot whales in the cold water Oyashio Current off the NE coast of Japan, based on summer surveys in 1982 through 1988 was 4,239 (CV=0.61).
- Dall's porpoise are found only in the North Pacific and two forms are found in the west. These are the dalli-type found along the east side of Japan north of 35 N. and the truei-type known from northern Japan and southern half of the Okhotsk Sea. Based on 2003, abundance estimates for the dalli-type and truei-type were 173,638 and 178,157, respectively (GOJ, 2007). During the winter the truei-type are found in the Oyashio Current offshore from Choshi, Japan to Hokkiado, Japan but in the summer they move to the central Okhotsk Sea. The dalli-type spend the winter in the northern part of the Sea of Japan north of the Shimane Pref. and breed in the Okhotsk Sea.
- Miyashita (1993) estimated the population size of the northern form of the short-finned pilot whales in the cold water Oyashio Current off the NE coast of Japan, based on summer surveys in 1982 through 1988, was 4,239 (CV=0.61).
- Dall's porpoise are found only in the North Pacific and two forms are found in Japanese waters. These are the dalli-type found along the east side of Japan north of 35° N. and the truei-type known from northern Japan and the southern half of the Okhotsk Sea. Based on surveys in 2003, abundance estimates for the dalli-type and truei-type were 173,638 and 178,157, respectively (GOJ, 2007). During the winter the truei-type are found in the Oyashio Current offshore from Choshi, Japan to Hokkaido, Japan but in the summer they move to the central Okhotsk Sea. The dalli-type spends the winter in the northern part of the Sea of Japan (north of the Shimane Pref.) and breed in the Okhotsk Sea.
- Other small cetaceans found in the Oyashio Current include: short-beaked dolphins, striped dolphins, common bottlenose dolphins, Risso's dolphins, northern right whale dolphins, Pacific white-sided dolphins, false killer whales, and killer whales.
- Small cetaceans in the Kuroshio Current in Japanese waters south of 34° N are the tropical and warm-temperate species found worldwide in these types of waters. Some of the more abundant small cetaceans here include: striped dolphins, spotted dolphins, common bottlenose dolphins, Risso's dolphins, southern short-finned pilot whales, and false killer whales. These species are well studied off Japan because they are taken by the Japanese drive fishery. Based on Japanese sightings surveys from 1983 to 1991 in the waters off Japan, population estimates were made for these six species (Miyashita, 1993). These are summarized below:
- Striped dolphins were found in August and September in three geographic concentrations in waters between 25°N - 41°N and 135°E to 180°. The total population estimate for this area was 570,000 (CV=0.18). Spotted dolphins were found in August and September and most were concentrated north of 30°. The area surveyed was between 25ºN-38ºN and west of 180º. The total population estimate for the area was 438,000 (CV=0.17).
- Common bottlenose dolphins were found in August and September in waters between 30ºN - 42ºN and west to 160ºE. The total population estimate for the area was 168,000 (CV=0.26).
- Risso's dolphins were found in three concentrations in waters south of 40ºN and west of 180º but their southern boundary was not determined during the surveys. The total abundance estimate was 838,000 (CV=0.17).

- The population size for southern form of short-finned pilot whales was estimated at 53,000 (CV=0.22) during the months of August and September in coastal and offshore waters west to 165ºE and between 25ºN - 36ºN.
- False killer whales were found in generally the same area as the short-finned pilot whales but their northern limit was more southern at 39ºN. The total abundance estimate was 16,000 (CV=0.26).
- Other small cetaceans found in the Kuroshio Current include the following: long-beaked common dolphins, pygmy killer whale, Fraser's dolphins, killer whales, melon-headed whales, spinner dolphins and rough-toothed dolphins. The melon-headed whales is known from nine mass stranding events in Japanese waters south of 36° N between 1982 and 2006 (Brownell, Yamada, Mead, & Allen, 2006).
- Also, the Indo-Pacific bottlenose dolphin is found in small seven discontinuous, isolated populations, within the main Japanese islands and offshore islands, in the Kuroshio Current. These populations are: (1) in the Bungo Channel, Amakusa (Shirakihara, Shirakihara, Tomonaga, & Takatsuki, 2002) (2) Kagoshima Bay (Nanbu, Hirose, Kubo, Kishiro, & Shinomiya, 2006) (3) in the Sea of Japan, around Noto-jima (Mori, 2005) (Mori and Yoshioka 2009), (4) Mikura Island and (6) Ogasawara Islands (Mori *et al*. 2005). Mikura and Ogasawara are about 200 km and about 1,000 km, respectively, southeast of Tokyo. The seventh population is in the waters around the Amami Islands which are part of the Ryukyu Islands chain (Miyazaki and Nakayama 1989). Most of these Indo-Pacific bottlenose dolphins, like in other populations throughout their range, are year-around residents (Mori and Yoshioka 2009).
- Eight species of pinnipeds (Kurile harbor seal, larga seal, ringed seal, ribbon seal, bearded seal, and northern fur seal) including one endangered one (Steller sea lion) and one extinct species (Japanese sea lion) are known from northern Japanese waters, mainly in the southern Okhotsk Sea off the northern coast on Hokkaido.

Number of Supporting Documents[111]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
8	3	0	0	0	8	3

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Eligible[112]	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description

[111] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.
[112] Area does not qualify as critical habitat as defined in the NMFS classification schema.

2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

The Sea of Japan (Japan)

Potential Criteria:	SME did not submit criteria. (NMFS West Coast) 2A: High Density (TJ)
Species of Concern:	Finless porpoise (*Neophocaena phocaenoides*) (NMFS West Coast) Beaked whales (*Ziphiidae*) (TJ)
Proposed Boundary Consideration: *Basis: NMFS West Coast or T. Jefferson*	Total exclusion within the Sea of Japan, extending seaward of the 12 nm borders of the Korean Peninsula and Japan. Bathymetry: between 550 and 2,000 meter depth contours. (TJ) *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The cetaceans, including both baleen whales and small cetaceans, found in the Sea of Japan approximately north from the southern end of the Korean Peninsula are the same as those found in the Oyashio Large Marine Ecosystem and the cetaceans to the south of the Korean Peninsula are the same as those found in the Kuroshio Large Marine Ecosystem.
- Finless porpoise are found outside the 12 nm zone of the Sea of Japan because of the shallow nature of this region. Anon. (2005) reported that "In the offshore waters (33°00′ to 37°30′N, 122°00′ to 126°00′E), two sighting surveys were conducted using the R/V Tamgu-3 in 2001 and 2004." Anon. (2005) also says that "Park reported the stock status in the Korean waters based on the abundance estimate. 2 shipboard surveys for finless porpoise were made in each offshore and inshore of the west coast of Korea. The first surveys in offshore and inshore were carried out in each 2001 and 2003 estimated an abundance of 58,650 animals in offshore and 1,571 porpoises in inshore. In 2004, it was estimated that current abundance was 21,532 animals in offshore and 5,464 porpoises in inshore."

Number of Supporting Documents[113]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	2 - Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

[113] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Total Exclusion within the Yellow Sea / East China Sea (China, North Korea, South Korea)

Potential Criteria:	SME did not submit criteria.
Species of Concern:	Gray whale (*Eschrichtius robustus*); Minke whale (*Balaenoptera acutorostrata*); Fin whale (*Balaenoptera physalus*); Humpback whale (*Megaptera novaeangliae*); Omura's whale (*Balaenoptera omurai*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Total exclusion within the Yellow Sea and East China Sea (China) extending seaward of the 12 nm borders of the Korean Peninsula, China and Japan. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The Yellow Sea Large Marine Ecosystem is a semi-enclosed Sea bordered by three countries: China, North Korea and South Korea. The southern Yellow Sea is adjacent to the East China Sea Large Marine Ecosystem which is also a semi-enclosed body of water bordered by China, South Korean and Japan. The southern limit of the East China Sea connects to the Taiwan Strait. The warm Tsushima Current, a branch of the Kuroshio Current, is a major influence in the ECS ecosystem.
- The main baleen whales known to occur in the inshore waters are: gray whales, minke whales, fin whales and humpback whales (Zhou, 2004). In addition, Omura's whales should also be present in the coastal and offshore regions of the ECS but not the Yellow Sea (Yamada, 2009).
- A resident population of fin whales, depleted from past commercial whaling operations, is found in both the Yellow Sea and the East China Sea (Fujino, 1960). Ichihara (1957a) reported differences in the general shapes of fin whales between the western Aleutian Islands and the northern part of the East China Sea.
- Three species of beaked whales (Baird's beaked whales, Blainville's beaked whales, and gingko-toothed beaked whales) are recorded from Chinese waters (P. Wang, 1999; Zhou, 2004). No abundance estimates are available for any of these species in Chinese waters and little is known about their actual distribution except from stranded animals.

Number of Supporting Documents[114]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	5	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable

[114] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion around Taiwan (China)

Potential Criteria:	SME did not submit criteria.
Species of Concern:	SME did not submit any species information.
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Exclusion around Taiwan, extending 100 km (54 nm) seaward of the 12 nm border along the Pacific side (eastern coastline of Taiwan). *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Historically, the humpback whale was the most important baleen whale in Taiwanese waters, but the population was greatly depleted by commercial whalers during the first half of the 20th century.
- Additional baleen whales include minke whales, Bryde's whales and Omura's whales, but gray whales have not been confirmed from Taiwanese waters. All of the small cetaceans listed above from the Kuroshio Large Marine Ecosystem are also found in the same current off the east coast of Taiwan (J. Wang & Yang, 2007) and southward to the Philippines (Dolar, Perrin, Taylor, Kooyman, & Alava, 2006).
- Deep water is found close to shore off the eastern and southern coast of Taiwan. Population estimates are not available for these waters, but small cetaceans are abundant and form the core of the local whale-watching operations along the east coast of Taiwan. Also the same species within distant regions of the Kuroshio Large Marine Ecosystem are different populations and therefore must be assessed and managed separately (Perrin, Dolar, Amano, & Hayano, 2003).
- One of these species, the pygmy killer whale is known from six mass stranding events from the southwestern region of the island between 1995 and 2005 and an additional three near mass stranding events (Brownell et al., 2009). Additional MSEs in Taiwan are known for melon-headed whales, rough-toothed dolphins, and short-finned pilot whales (J. Wang & Yang, 2007).

Number of Supporting Documents[115]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

115 Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion in the South China Sea (China)

Potential Criteria:	SME did not submit criteria. (NMFS West Coast) 2A: High Density (TJ)
Species of Concern:	Misc. Species (TJ)
Proposed Boundary Consideration: *Basis: NMFS West Coast or T. Jefferson*	Bathymetry: 100 km seaward of the shallow water area (NMFS West Coast) Continental shelf. (TJ) *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- The main character of the South China Sea Large Marine Ecosystem (SCS) is its tropical climate. The countries bordering the SCS are: Vietnam, China, Taiwan, the Philippines, Malaysia, Thailand, Indonesia and Cambodia.
- The SCS is divided into two major areas: (1) a coastal region less them 200 m from the coast out to about 100 km and (2) a deep water region to the east of the shallow water area.
- The cetaceans found in the shallow waters are not well known and mainly consist of Indo-Pacific bottlenose dolphins, common bottlenose dolphins, Pacific humpbacked dolphins and finless porpoise.
- The offshore cetacean fauna are the same species found in the Kuroshio Large Marine Ecosystem. The main baleen whales known to occur in the offshore waters of the SCS are Bryde's whales and some humpback whales in the northeastern most SCS.
- Within the coastal region the following species have been recorded: gray whales, minke whale, fin whales and humpback whales (Zhou, 2004). In addition, Omura's whales should also be present in the coastal and offshore regions of the SCS (Yamada, 2009).

Number of Supporting Documents[116]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	2	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

[116] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Total Exclusion in the Gulf of Tonkin (Vietnam)

Potential Criteria:	None submitted.
Species of Concern:	Indo-Pacific humpback dolphin (*Sousa chinensis*) Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) Finless porpoise (*Neophocaena phocaenoides*)
Proposed Boundary Consideration: *Basis: NMFS West Coast*	Seaward of the 12 nm borders of Vietnam and China *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- This region is the northwest arm of the South China Sea and is bounded by China to the north and east (Hainan Island) and northern Vietnam to the west. Its size is about 500 km long and 250 km wide with waters only to 70 m deep.
- The Vietnam cetacean fauna is poorly known except for coastal small cetaceans like Indo-Pacific humpback dolphin, Indo-Pacific bottlenose dolphin and finless porpoise (Smith et al., 1995).
- Other species of small cetaceans from the Kuroshio Large Marine Ecosystem are reported from Vietnam but the locations and densities are unknown. Most records from Vietnam are whales that likely stranded near the 'Whale Temples" where their bones were deposited (Smith, et al., 1995).
- The area outside the 2 nm EEZ could be an important wintering region for some of the critically endangered western gray whales and western North Pacific humpback whales (Zhou, 2004).

Number of Supporting Documents[117]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
0	0	0	0	0	2	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

[117] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

Exclusion around Wake Island (United States)

Potential Criteria:	None submitted.
Species of Concern:	None submitted.
Proposed Boundary Consideration: *Basis: NMFS West Coast*	An area extending 100 km seaward of the 12 nm EEZ. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- Wake Island is the most northern of the Marshall Island chain. It is part of Wake Atoll, which consists of three fringing islands, Wake, Wilkes, and Peale, with a total land area of 6.5 km^2.
- The cetacean fauna in the waters around Wake is poorly known and only three species have been recorded (Brownell & Ralls, 2008). No abundance estimates are available for any of these species.
- Two Cuvier's beaked whales stranded live on Wake Island in January and February 1977 (PIRO Stranding database). Blue whales have been recorded near Wake (McDonald, et al., 2006; Stafford, Nieukirk, & Fox, 2001; Watkins et al., 2000), as have fin whales (Northrop, Cummings, & Thompson, 1967). Stafford *et al*. (2001) believed that some of the calls they reported near Wake were the Eastern Type, but it is now clear that the blue whale song type around Wake is exclusively the Western Type (M. McDonald, pers. comm.).

Number of Supporting Documents[118]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	1	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[118] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Exclusion for the North Philippine Sea (Philippines)

Potential Criteria:	2A: High Density
Species of Concern:	Misc. species
Proposed Boundary Consideration: *Basis: T. Jefferson*	Bathymetry: to the 1,000 meter depth contour. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited Dolar (1999) and Dolar et al. (2006).

Number of Supporting Documents[119]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	1	0	0

1.2

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[119] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Exclusion for the West Philippine Sea (Philippines)

Potential Criteria:	2A: High Density
Species of Concern:	Misc. species
Proposed Boundary Consideration: *Basis: T. Jefferson*	Bathymetry: to the 1,000 meter depth contour. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited Dolar (1999) and Dolar et al. (2006).

Number of Supporting Documents[120]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
1	0	0	0	1	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[120] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Exclusion for the East China Sea (China)

Potential Criteria:	2A: High Density
Species of Concern:	Baleen whales (*Mysticeti*)
Proposed Boundary Consideration: *Basis: T. Jefferson*	The continental shelf. *NMFS: The proposed boundary appears to have a buffer zone that extends beyond the specifically identified area of biological importance.*
Proposed Temporal Consideration:	SME did not submit a temporal restriction.

Background Provided by SME

- SME cited (Zhou, Leatherwood, & Jefferson, 1995) and (Zhou, 2002).

Number of Supporting Documents[121]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	1 - Not Eligible	1 - Not Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
1	Clear justification (qualitative or quantitative) for boundary consideration is not available or SME did not provide sufficient detail to NMFS for appropriate boundary evaluation.

[121] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 17: Southeast Pacific

Penguin Bank (Hawaii)

Potential Criteria:	2A: High Density 2B: Breeding Area
Species of Concern:	Humpback whales (*Megaptera novaeangliae*)
Proposed Boundary Consideration: Location inferred from Mobley (2001)	157°30'58.217"W, 21°10'2.179"N to 157°30'22.367"W, 21°9'46.815"N to 157°31'0.778"W, 21°6'39.882"N to 157°30'30.049"W, 21°2'51.976"N to 157°29'28.591"W, 20°59'52.725"N to 157°27'35.919"W, 20°58'5.174"N to 157°30'58.217"W, 20°55'49.456"N to 157°42'42.418"W, 20°50'44.729"N to 157°44'45.333"W, 20°51'2.654"N to 157°46'4.716"W, 20°53'56.784"N to 157°45'33.987"W, 20°56'32.988"N to 157°43'10.586"W, 21°1'27.472"N to 157°39'27.802"W, 21°5'20.499"N to 157°30'58.217"W, 21°10'2.179" *This area is within a nationally-designated marine mammal sanctuary.*
Proposed Seasonal Consideration:	January through April

Background

- The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawai'i. The sanctuary, which lies within the shallow (less than 600 feet), warm waters surrounding the main Hawaiian Islands, constitutes one of the world's most important humpback whale habitats (http://hawaiihumpbackwhale.noaa.gov/about/welcome.html)
- With the exception of a portion of Penguin Banks, the Hawaiian Islands Humpback Whale National Marine Sanctuary is located within 12 nautical miles (nm) of the islands. Penguin Bank is a shallow area of known humpback whale concentration (Mate, Gisiner, & Mobley, 1998).
- The primary period of humpback whale presence in Hawaiian waters is January through April, with peak abundance occurring earlier near the island of Hawai'i than the other islands (Gabriele, Rickards, Yin, & Frankel, 2003). Their report identified the highest whale densities near Keahole Point and just north of Kawaihae Harbor, and lower densities near the resorts along the shore south of Kawaihae (Gabriele, et al., 2003).
- The main Hawaiian Islands (MHI) are the primary winter reproductive area for the majority of North Pacific humpback whales. Identification photographs of individual whales, including 63 females sighted in at least 2 different years and with at least 1 calf, were collected from waters off the islands of Maui and Hawaii between 1977 and 1994 (Craig & Herman, 2000).
- Calves formed a significantly larger proportion of the population off Maui than off the Big Island. The overall proportion of calves to all whales identified (crude birth rate) was 0.099 off Maui and 0.061 off the Big Island (Craig & Herman, 2000).
- Aerial surveys conducted in Hawaiian waters during the winter months (Jan-Apr) of 1976-80 showed humpbacks to be most prevalent in coastal regions and shallow banks where the expanse of water less than 100-fathoms (183 m) was more extensive. Greatest densities of adult humpbacks and calf pods were found in the "four island region" (FIR) consisting of Maui, Molokai, Kahoolawe and Lanai, as well as Penguin Bank (Mobley et al., 2001).
- Mobley, Bauer and Herman (1999) confirmed the earlier preference of both adult humpbacks and calf pods for the FIR and Penguin Bank regions, but also showed a substantial increase of adult humpbacks in the Kauai/Niihau region (Mobley, et al., 2001).

Number of Supporting Documents[122]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
4	0	0	0	0	1	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	3 - Eligible	3 – Eligible
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	3 - Eligible	3 – Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at quantifying a core area of biological significance

[122] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Cross Seamount (United States)

Potential Criteria:	2B: Foraging Area
Species of Concern:	Cuvier's beaked whales (*Ziphius cavirostris*) Blainville's beaked whales (*Mesoplodon densirostris*)
Proposed Boundary Consideration:	18° 36′ N, 158° 26′ W 18° 36′ N, 158° 6′ W 18° 50′ N, 158° 26′ W 18° 50′ N, 158° 6′ W
Proposed Temporal Consideration:	Year-round, but particularly at night.

Background Provided by NMFS

- Cross Seamount is located at 18° 41′ N and 158° 18′ W in the central Pacific Ocean. The summit is approximately 5 by 7 km across and ranges in depth between 450 and 350 m.
- Johnston et al. (2008) conducted passive acoustic monitoring at Cross Seamount between 26 April 2005 and 19 November 2005 using a high-frequency acoustic recording package to detect odontocete echolocation sweeps. Visual examination of scrolling spectrograms from these data discovered that the most frequently detected cetacean signals were echolocation sweeps similar to those produced by Cuvier's beaked whales or Blainville's beaked whales. Almost all detections occurred during the night.
- Acoustic backscatter data indicate higher densities of organisms over the seamount and at its flanks relative to those in ambient water and show a prominent diel cycle due to vertical migratory behavior of sound scattering organisms.
- Feeding buzzes that were not frequency modulated were also occasionally associated with the echolocation signals described in the article, somewhat resembling those known to be associated with Cuvier's and Blainville's beaked whale echolocation sounds (Johnson et al. 2004).
- Highest densities over the plateau were observed during the night-time, with a prominent SSL in the upper 200 m and dense patches of aggregations near the seafloor of the seamount. Trawl surveys of SSL layers in this region revealed squid and fishes, which are potential prey items for beaked whales.
- Their acoustic monitoring reveals that beaked whales foraged at Cross Seamount during most nights. The detection range (based on seafloor reflections) for these signals appears to be less than 5 km, thus detected animals were at the seamount summit. Few beaked whale detections occurred during daylight hours, and several hypotheses may explain this pattern. It is possible that the whales were not present at Cross during the day or that the whales were present in the area but not echolocating. It is also possible that the whales were present, but diving past the summit of the seamount before echolocating at depth.
- It is possible that dense concentrations of prey at Cross may reduce diving demands for beaked whales, allowing them to spend greater time foraging at depth. In this case, the presence of the seamount summit may facilitate prey capture by providing a barrier against which whales concentrate prey. The author further hypothesizes that this may stem from the enhancement of local productivity by ‘seamount effects’, providing predictable patches of prey in an otherwise dilute and oligotrophic environment (Johnston, et al., 2008).
- Johnson et al. (2004) attached acoustic tags to four beaked whales (two *Mesoplodon densirostris* and two *Ziphius cavirostris*) and recorded high–frequency clicks during deep dives. The tagged whales only clicked at depths below 200 m, down to a maximum depth of 1267 m. Both species produced a large number of short, directional, ultrasonic clicks with no significant energy below 20 kHz. The tags recorded echoes from prey items; to the author’s knowledge, a first for any animal echolocating in the wild. They conclude that these echoes provide the first direct evidence on how free-ranging

toothed whales use echolocation in foraging. The strength of these echoes suggests that the source level of *Mesoplodon* clicks is in the range of 200–220 dB re 1 µPa at 1 m.

- The mesopelagic community over the summit contains two species that appear to be found in higher abundance over the summit as opposed to away and may be considered as seamount-associated species. These are a cranchiid squid, *Liocranchia reinhardti*, and a myctophid fish, *Benthosema fibulatum*. This seamount is known to impact the mesopelagic micronekton community and tuna community, but the mechanisms behind these impacts are largely unknown at this time (De Forest & Drazen, 2009).

Number of Supporting Documents[123]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
3	0	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	3 - Eligible	0 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
3	Proposed boundary inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the proposed boundary. Boundary surrounds the location of a core biological area of importance.

[123] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

Costa Rica Dome (Costa Rica, Panama)

Potential Criteria:	2B: Foraging Area 2B: Wintering Ground
Species of Concern:	Blue whale (Balaenoptera musculus) Humpback whale (*Megaptera novaeangliae*)
Proposed Boundary Consideration:	Existing boundary as defined in the 2007 Final Rule.
Proposed Seasonal Consideration:	Year-Round

Background

- The distribution of blue whales, in the eastern tropical Pacific (ETP) was analyzed from 211 sightings of 355 whales recorded during research vessel sighting surveys or by biologists aboard fishing vessels. Over 90% of the sightings were made in just two areas: along Baja California, and in the vicinity of the Costa Rica Dome. All sightings occurred in relatively cool, upwelling-modified waters. The Costa Rica Dome area was occupied year round, suggesting either a resident population, or that both northern and southern hemisphere whales visit with temporal overlap (Reilly & Thayer, 1990).
- Research conducted in the 1990s reported that some humpback whales from the North Pacific were also using Costa Rican waters as a wintering ground (Acevedo-Gutiérrez & Smultea, 1995).
- With blue whales, the greatest unknown is whether their year-round residency on the Costa Rica Dome is indicative of a distinct, non-migratory population segment or whether some individuals may choose not to migrate every year (Calambokidis, et al., 1990).

Number of Supporting Documents[124]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	1	0	0	0	0	0

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	3 - Eligible	3 - Not Applicable
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

[124] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

IUCN Marine Region 18: Australia – New Zealand

Great Barrier Reef Between 16°S and 21°S (Australia)

Potential Criterion:	2B: Breeding Ground
Species of Concern:	Humpback whale (Megaptera novaeangliae) Dwarf Minke whale (Balaenoptera acutorostrata)
Proposed Boundary Consideration: Location inferred from Arnold (1997)	145°38'46.988"E, 16°1'49.75"S to 146°20'56.18"E, 15°52'12.917"S to 146°59'23.514"E, 17°28'21.251"S to 151°39'40.427"E, 20°16'13.65"S to 150°30'53.849"E, 20°58'22.843"S to 146°49'46.681"E, 18°51'10.893"S to 145°38'46.988"E ,16°1'49.75"S
Proposed Seasonal Consideration:	May through September

Background

- Of particular concern in the Marine Park is a population of dwarf minke whales occurring off northern Queensland, most often seen in the Ribbon Reefs area in June and July although present in the Park from about May to October (GBRMP, 2000).
- An IWC compilation of 181 sightings from the central and northern Great Barrier Reef indicated that dwarf minke whales were regularly seen between Cairns (16°55' S) and Yonge Reef (14° 36' S). Sightings occurred from May to September, with 79.5% of sightings in June and July. Observations suggest, however, that groups of animals may occur in open water on the continental shelf, inshore of the reefs where most whales have been reported. Records of stranded animals 3 m or less in length indicate calving can occur at about 24E-38E S in Australia. There were four reports of cow-calf pairs on the northern Great Barrier Reef, between 15°-16°S, but more information is needed to assess the extent to which the area is a calving/nursery ground (Arnold, 1997).
- Humpback whales which migrate along the east Australian coast comprise part of the Area V (130° E - 170° W) stock. Sheltered water within the Great Barrier Reef between latitudes 16°-21° S appear to be an important breeding ground for the east Australian humpback whale stock (Paterson & Paterson, 1984).
- The humpback whales present in the marine park generally spend the summer feeding in the nutrient-rich waters of Antarctica, migrate northwards in the autumn, and winter in warm-water breeding areas, including the waters off the coast of Queensland. Humpbacks are usually present in the Marine Park from June to October. Of particular concern in the Marine Park are possible adverse effects on pregnant females and cows with young calves. Lactating females typically migrate north before pregnant females, and cows with newborn calves tend to be last to leave the breeding areas to return south to the feeding grounds. Thus, cows who are pregnant or who have young (dependent) calves are present in the Marine Park throughout the season (GBRMP, 2000).

Number of Supporting Documents[125]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	0	0	1	0

[125] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	0 - Not Applicable	0 - Not Applicable
Breeding / Calving	3 - Eligible	3 - Eligible
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Bonney Upwelling (Australia)

Potential Criterion:	2B: Foraging Area
Species of Concern:	Blue whale (*Balaenoptera musculus*) Pygmy blue whale (*B. m. brevicauda*) New Zealand fur seal (*Arctocephalus forsteri*) Southern right whale (Eubalaena australis) Australian sea lion (*Neophoca cinera*)
Proposed Boundary Consideration: Location inferred from Gill (2002)	139°31'17.703"E, 37°12'20.036"S to 139°42'42.508"E, 37°37'33.815"S to 140°22'57.345"E, 38°10'36.144"S to 141°33'50.342"E, 38°44'50.558"S to 141°11'0.733"E, 39°7'4.125"S to 139°10'52.263"E, 37°28'33.179"S
Proposed Seasonal Consideration:	November through May

- **Background**
- The Bonney Upwelling (formerly the Blue Whale aggregation) is characterized by classical upwelling plumes regularly observed along the Bonney Coast (Robe, South Australia to Portland, Victoria).
- To assess how seasonal changes in ocean productivity influenced foraging behavior, one study fitted18 lactating New Zealand fur seals with satellite transmitters and time-depth recorders (TDRs). Using temperature and depth data from TDRs, they used the presence of thermoclines as a surrogate measure of upwelling activity in continental- shelf waters. The study concluded that lactating New Zealand fur seals shift their foraging location from continental-shelf to oceanic waters in response to a seasonal decline in productivity over the continental shelf, attributed to the cessation of the Bonney upwelling (Baylis, Page, & Goldsworthy, 2008).
- A localized aggregation of blue whales, which may be pygmy blue whales, occurs in southern Australian coastal waters (between 139°45' E-143°E) during summer and autumn (December-May), where they feed on coastal krill (*Nyctiphanes australis*), a species which often forms surface swarms. While the abundance of blue whales using this area is unknown, up to 32 blue whales have been sighted in individual aerial surveys. Krill appear to aggregate in response to enhanced productivity resulting from the summer-autumn wind-forced Bonney Coast upwelling along the continental shelf. During the upwelling's quiescent (winter-spring) period, blue whales appear to be absent from the region. Krill surface swarms have been associated with 48% of 261 blue whale sightings since 1998, with direct evidence of feeding observed in 36% of all sightings. Mean blue whale group size was 1.55 (SD = 0.839), with all size classes represented including claves. This seasonally predictable upwelling system is evidently a regular feeding ground for blue whales (Gill, 2002).
- http://bluewhalestudy.com/home.html

Number of Supporting Documents[126]

Peer-Reviewed Articles	Scientific Committee Reports	Cruise Reports or Transects	Pers Comm. or Unpublished Report	Dissertation or Thesis	Book , Govt Report or NGO Report	Note/ Abstracts / Proceedings
2	0	0	1	0	0	0

[126] Eligibility for all species based on supporting documents. Eligibility for LF specialists only is broken out in the table.

NMFS' Classification Scores for Supporting Documents

	Preliminary Classification Rank	Rank for LF Hearing Specialists
High Density	0 - Not Applicable	0 - Not Applicable
Foraging Area	3 - Eligible	3 - Eligible
Breeding / Calving	0 - Not Applicable	0 - Not Applicable
Migration Route	0 - Not Applicable	0 - Not Applicable
Critical Habitat	0 - Not Applicable	0 - Not Applicable
Small Distinct Population	0 - Not Applicable	0 - Not Applicable

NMFS' Classification Scores for the Boundary Consideration

Rank	Description
2	Proposed boundary inferred from analyses conducted for purposes other than quantifying a core area of biological significance. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.

Works Cited

Abend, A. (1993). *Distribution and diet of long-finned pilot whales as determined from stable carbon and nitrogen ratio isotope tracers.* University of Massachusetts, Amherst, MA.

Abend, A., & Smith, T. (1999). Review of Distribution of the Long-finned Pilot Whale (Globicephala melas) in the North Atlantic and Mediterranean.

Acevedo-Gutiérrez, A., & Smultea, M. (1995). First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of Northern and Southern hemisphere populations. *Marine Mammal Science., 11*(4), 554-560.

Anon. (2005). *Report of the Workshop on Finless Porpoises in theWestern North Pacific. (Available from IWC, The Red House, 135 Station Road, Impington, Cambridge C24 9NP, UK.).*

Anon. (2010). *Progress report on the Med09 cruise. ACCOBAMS, 6th Meeting of the Scientific Committee, Casablanca, 11-13 January 2010. Document SC6-Inf 06. 21 p.*

Arcangeli, A., Muzi, E., Tepsich, P., Carcassi, S., Castelli, A., Crosti, R., et al. (2009). *Large-scale cetacean monitoring from passenger ferries in Italy: networking summer 2008 surveys. Proceedings of the 23rd Conference of the European Cetacean Society, Istanbul. 6 p.*

Arnold, P. (1997). *Occurrence of dwarf minke whales (Balaenoptera acutorostrata) on the northern Great Barrier Reef, Australia*.

Azzellino, A., Gaspari, S., Airoldi, S., & Nani, B. (2008). Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep-Sea Research Part I: Oceanographic Research Papers, 55*(3), 296-323.

Baraff, L., Clapham, P., Mattila, D., & Bowman, R. (1991). Feeding behavior of a humpback whale in low-latitude waters. *Marine Mammal Science, 7*(2), 197-202.

Barlow, J., & Forney, K. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *FISHERY BULLETIN-NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 105*(4), 509.

Baumgartner, M., Cole, T., Clapham, P., & Mate, B. (2003). North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. *Marine Ecology Progress Series, 264*, 137-154.

Baylis, A., Page, B., & Goldsworthy, S. (2008). Effect of seasonal changes in upwelling activity on the foraging locations of a wide-ranging central-place forager, the New Zealand fur seal. *Canadian Journal of Zoology, 86*(8), 774-789.

Bearzi, G., Costa, M., Politi, E., Agazzi, S., Pierantonio, N., Tonini, D., et al. (2009). Cetacean records and encounter rates in the Northern Adriatic Sea during the years 1988-2007. *Annales, 19*(2), 145-150.

Beasley, I., Davidson, P., Somany, P., & Ath, L. (2002). *Abundance, distribution and conservation management of marine mammals in Cambodia's coastal waters. Unpublished report.*

Beier, E., & Ripa, P. (1999). Seasonal gyres in the northern Gulf of California. *Journal of Physical Oceanography, 29*(2), 305-311.

Ben Naceur, L., Gannier, A., Bradai, M. N., Drouot, V., Bourreau, S., Laran, S., et al. (2004). Recensement du grand dauphin Tursiops truncatus dans les eaux tunisiennes. *Bull. Inst. Natn. Scien. Tech. Mer de Salammbô, 31*.

Best, P. (2001). Distribution and population separation of Bryde's whale Balaenoptera edeni off southern Africa. *Marine Ecology Progress Series, 220*, 277-289.

Best, P. (2007). *Whales and dolphins of the southern African subregion*: Cambridge University Press.

Best, P., Findlay, K., Sekiguchi, K., Peddemors, V., Rakotonirina, B., Rossouw, A., et al. (1998). Winter distribution and possible migration routes of humpback whales Megaptera novaeangliae in the southwest Indian Ocean. *MEPS, 162*, 287-299.

Best, P., Glass, J., Ryan, P., & Dalebout, M. (2009). Cetacean records from Tristan da Cunha, South Atlantic. *Journal of the Marine Biological Association of the UK, 89*(Special Issue 05), 1023-1032.

Best, P., Rademeyer, R., Burton, C., Ljungblad, D., Sekiguchi, K., Shimada, H., et al. (2003). The abundance of blue whales on the Madagascar Plateau, December 1996. *Journal of Cetacean Research and Management, 5*(3), 253-260.

Bordino, P., Albareda, D., & Fidalgo, G. (2004). *Abundance estimation of Franciscana dolphin Pontoporia blainvillei from boat surveys in Buenos Aires, Argentina. International Whaling Commission, Cambridge, UK, Scientific Committee Document SC/56/SM13.*

Bordino, P., Kraus, S., Albareda, D., Fazio, A., Palmerio, A., Mendez, M., et al. (2002). Reducing incidental mortality of Franciscana dolphin *Pontoporia blainvillei* with acoustic warning devices attached to fishing nets. *Marine Mammal Science, 18*(4), 833-842.

Bordino, P., & Wells, R. (2005). *Radiotracking of Franciscana Dolphins (Pontoporia Blainvillei) in Bahia Samborombon, Buenos Aires, Argentina.* Paper presented at the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, California (USA), 12-16 Dec 2005.

Bordino, P., Wells, R., & Stamper, M. (2008). *Satellite tracking of Franciscana Dolphins Pontoporia blainvillei in Argentina: preliminary information on ranging, diving and social patterns. Paper SC/53/IA32 presented to the IWC Scientific Committee, (unpublished).*

Branch, T., Stafford, K., Palacios, D., Allison, C., Bannister, J., Burton, C., et al. (2007). Past and present distribution, densities and movements of blue whales Balaenoptera musculus in the Southern Hemisphere and northern Indian Ocean. *Mammal Review, 37*(2), 116-175.

Brownell, R., & Ralls, K. (2008). Cetacean records from U. S. Commonwealth and Territories in the Pacific Ocean. PSRG-2008-15.

Brownell, R., Yamada, T., Mead, J., & Allen, B. (2006). *Mass strandings of melon-headed whales, Peponocephala electra: a worldwide review. SC/58/SM 8, 12 pp. (Available from IWC, The Red House, 135 Station Road, Impington, Cambridge C24 9NP, UK.)*.

Brownell, R., Yamada, T., Mead, J., & Van Helden, A. (2004). Mass strandings of Cuvier’s beaked whales in Japan: US Naval acoustic link. *Unpublished paper SC/56/ E, 37*.

Brownell, R., Yao, C., Lee, C., Wang, M., Yang, W., & Chou, L. (2009). Worldwide review of pygmy killer whales, Feresa attenuata, Mass Strandings Reveals Taiwan Hot Spot. *SC/61/SM1, 20 pp. (Available from IWC, The Red House, 135 Station Road, Impington, Cambridge C24 9NP, UK.)*.

Buckland, S., Anderson, D., Burnham, K., & Laake, J. (1993). *Distance sampling: Estimating abundance of biological populations*: Chapman & Hall London.

Buckland, S., Cattanach, K., & Miyashita, T. (1992). *Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys*.

Burtenshaw, J. C., Oleson, E. M., Hildebrand, J. A., McDonald, M. A., Andrew, R. K., Howe, B. M., et al. (2004). Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. *Deep Sea Research (Part II, Topical Studies in Oceanography), 51*(10-11), 967-986.

Böhm, E., Hopkins, T. S., Pietrafesa, L. J., & Churchill, J. H. Continental slope sea level and flow variability induced by lateral movements of the Gulf Stream in the Middle Atlantic Bight. *Progress In Oceanography, 70*(2-4), 196-212.

Böhm, E., Hopkins, T. S., Pietrafesa, L. J., & Churchill, J. H. (2006). Continental slope sea level and flow variability induced by lateral movements of the Gulf Stream in the Middle Atlantic Bight. *Progress In Oceanography, 70*(2-4), 196-212.

Calambokidis, J., Steiger, G., Cubbage, J., Balcomb, K., Ewald, C., Kruse, S., et al. (1990). *Sightings and movements of blue whales off central California 1986-88 from photo-identification of individuals*.

Calambokidis, J., Steiger, G., Ellifrit, D., Troutman, B., & Bowlby, C. (2004). Distribution and abundance of humpback whales(Megaptera novaeangliae) and other marine mammals off the northern Washington coast. *Fishery Bulletin, 102*(4), 563-580.

Campagna, C., Fedak, M., & McConnell, B. (1999). Post-breeding distribution and diving behavior of adult male southern elephant seals from Patagonia. *Journal of Mammalogy, 80*(4), 1341-1352.

Campagna, C., Le Boeuf, B., Blackwell, S., Crocker, D., & Quintana, F. (1995). Diving behaviour and foraging location of female southern elephant seals from Patagonia. *Journal of Zoology, 236*(1), 55-71.

Campagna, C., & Lewis, M. (1992). Growth and distribution of a southern elephant seal colony. *Marine Mammal Science, 8*(4), 387-396.

Campagna, C., Piola, A., Marin, M., Lewis, M., Zajaczkovski, U., & Fernández, T. (2007). Deep divers in shallow seas: Southern elephant seals on the Patagonian shelf. *Deep Sea Research Part I: Oceanographic Research Papers, 54*(10), 1792-1814.

Campagna, C., Piola, A., Rosa Marin, M., Lewis, M., & Fernández, T. (2006). Southern elephant seal trajectories, fronts and eddies in the Brazil/Malvinas Confluence. *Deep-Sea Research Part I, 53*(12), 1907-1924.

Campagna, C., Quintana, F., Le Boeuf, B., Blackwell, S., & Crocker, D. (1998). Diving behaviour and foraging ecology of female southern elephant seals from Patagonia. *Aquatic Mammals, 24*, 1-12.

Campagna, C., Rivas, A., & Marin, M. (2000). Temperature and depth profiles recorded during dives of elephant seals reflect distinct ocean environments. *Journal of Marine Systems, 24*(3-4), 299-312.

Carretta, J. V., Forney, K. A., Lowry, M. S., Barlow, J., Baker, J., Hanson, B., et al. (2008). *U.S. Pacific Marine Mammal Stock Assessments: 2008* (Report No. NOAA-TM-NMFS-SWFSC-434).

Carrillo, L., & Palacios-Hernandez, E. (2002). Seasonal evolution of the geostrophic circulation in the northern Gulf of California. *Estuarine, Coastal and Shelf Science, 54*(2), 157-173.

Cañadas, A., & Hammond, P. (2008). Abundance and habitat preferences of the short-beaked common dolphin Delphinus delphis in the southwestern Mediterranean: implications for conservation. *Endangered Species Research, 4*(3), 309.

Cañadas, A., Sagarminaga, R., De Stephanis, R., Urquiola, E., & Hammond, P. (2005). Habitat preference modelling as a conservation tool: proposals for marine protected areas for cetaceans in southern Spanish waters. *Aquatic Conservation: Marine and Freshwater Ecosystems, 15*(5), 495-521.

Cerchio, S., Andrianarivelo, N., Razafindrakoto, Y., Mendez, M., & Rosenbaum, H. (2009). *Coastal dolphin hunting in the southwest of Madagascar: status of populations, human impacts and conservation actions. In: Paper SC/61/SM15 presented to the IWC Scientific Committee, May 2009. 9pp.*

Cerchio, S., Ersts, P., Pomilla, C., Loo, J., Razafindrakoto, Y., Leslie, M., et al. (2009). *Updated estimates of abundance for humpback whale breeding stock C3 off Madagascar, 2000-2006. In: Paper SC/61/SH7 presented to the IWC Scientific Committee, May 2009 (unpublished). 23pp.*

Churchill, J., Levine, E., Connors, D., & Cornillon, P. (1993). Mixing of shelf, slope and Gulf Stream water over the continental slope of the Middle Atlantic Bight. *Deep Sea Research Part I: Oceanographic Research Papers, 40*(5), 1063-1085.

CIRVA. (1997). *Comite Internacional Para la Recuperacion de la Vaquita/International Committee for the Recovery of the Vaquita. Scientific Reports of: First Meeting, 25-26 January 1997.*

CIRVA. (1999). *Comite Internacional Para la Recuperacion de la Vaquita/International Committee for the Recovery of the Vaquita. Scientific Reports of the Second Meeting,7-11 February 1999.*

CIRVA. (2004). *Comite Internacional Para la Recuperacion de la Vaquita/International Committee for the Recovery of the Vaquita. Scientific Reports of the Third Meeting, 18-24 January 2004.*

Clapham, P., & Mattila, D. (1990). Humpback whale songs as indicators of migration routes. *Marine Mammal Science, 6*(2), 155-160.

Clapham, P., & Mattila, D. (1993). Reactions of humpback whales to skin biopsy sampling on a West Indies breeding ground. *Marine Mammal Science, 9*(4), 382-391.

Collins, T., Cerchio, S., Pomilla, C., Carvalho, I., Ngouessono, S., & Rosenbaum, H. (2008). Revised estimates of abundance for humpback whale breeding stock B1: Gabon. In: Paper SC/60/SH28 presented to the IWC Scientific Committee, May 2008 (unpublished). 17pp.

Collins, T., Ngouessono, S., & Rosenbaum, H. (2004). *A note on recent surveys for Atlantic humpback dolphins, Sousa teuszii (Kukenthal, 1892) in the coastal waters of Gabon*.

Craig, A., & Herman, L. (2000). Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. *Marine Ecology Progress Series, 193*, 209-216.

Crespo, E., Pedraza, S., Grandi, M., Dans, S., & Garaffo, G. (2004). *Abundance of franciscana dolphins, Pontoporia blainvillei, in the argentine coast, from aerial surveys. SC/56/SM9 Working paper submitted to the meeting of the International Whaling Commission, Sorrento, Italy, 29/6 to 10/7/04.*

Crespo, E., Pedraza, S., Grandi, M., Dans, S., & Garaffo, G. (2010). Abundance and distribution of endangered Franciscana dolphins in Argentine waters and conservation implications. *Marine Mammal Science, 26*(1), 17-35.

Croll, D. A., Marinovic, B., Benson, S., Chavez, F. P., Black, N., Ternullo, R., et al. (2005). From wind to whales: trophic links in a coastal upwelling system. *Marine Ecology Progress Series, 289*, 117-130.

D' Amico, A., Bergamasco, A., Zanasca, P., Carniel, S., Nacini, E., Portunato, N., et al. (2003). Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. *IEEE Journal of Oceanic Engineering, 28*(1), 29-43.

Danilewicz, D., Tavares, M., Moreno, I., Ott, P., & Trigo, C. (2009). Evidence of feeding by the humpback whale (Megaptera novaeangliae) in mid-latitude waters of the western South Atlantic. *Marine Biodiversity Records, 2*, e88.

De Forest, L., & Drazen, J. (2009). The influence of a Hawaiian seamount on mesopelagic micronekton. *Deep Sea Research Part I: Oceanographic Research Papers, 56*(2), 232-250.

DFO. (2007). *Recovery Potential Assessment Of Northern Bottlenose Whale, Scotian Shelf Population. Science Advisory Report 2007/011*.

Dolar, M. (1999). *Abundance, distribution and feeding ecology of small cetaceans in the eastern Sulu Sea and Tañon Strait, Philippines.* University of California, San Diego.

Dolar, M., Perrin, W., Taylor, B., Kooyman, G., & Alava, M. (2006). Abundance and distributional ecology of cetaceans in the central Philippines. *Journal of Cetacean Research and Management, 8*(1), 93.

DON. (2007a). *Navy OPAREA density estimates (NODE) for the Northeast OPAREAS: Boston, Narragansett Bay, and Atlantic. Naval Facilities Engineering Command, Atlantic; Norfolk, Virginia. Contract N62470-02-D-9997, Task Order 0045. Prepared by Geo-Marine, Inc., Plano, Texas*.

DON. (2007b). *Navy OPAREA Density Estimates (NODE) for the Southeast OPAREAS: VACAPES, CHPT, JAX/CHASN, and Southeastern Florida & AUTEC-Andros, Prepared for U.S. Fleet Forces Command, Norfolk, VA*.

Durbin, E., Campbell, R., Casas, M., Ohman, M., Niehoff, B., Runge, J., et al. (2003). Interannual variation in phytoplankton blooms and zooplankton productivity and abundance in the Gulf of Maine during winter. *Marine Ecology Progress Series, 254*, 81-100.

Ersts, P., & Rosenbaum, H. (2003). Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground. *Journal of Zoology, 260*(04), 337-345.

Falabella, V., Campagna, C., & Croxall, J. (2009). *Atlas del Mar Patagónico Especies y espacios, Wildlife Conservation Society Argentina. WCS*: Cambridge: BirdLife International.

Ferguson, M., & Barlow, J. (2001). *Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Admin. Rept*: LJ-01-04 available from the Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., La Jolla, CA 92037. 61pp.+ Addendum.

Ferguson, M., & Barlow, J. (2003). *Addendum: Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96*: Administrative Report LJ-01-04 (addendum), Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Ferguson, M., Barlow, J., Fiedler, P., Reilly, S., & Gerrodette, T. (2006). Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. *Ecological Modelling, 193*(3-4), 645-662.

Ferguson, M., Barlow, J., Reilly, S., & Gerrodette, T. (2006). Predicting Cuvier's (Ziphius cavirostris) and Mesoplodon beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. *Journal of Cetacean Research and Management, 7*(3), 287.

Fiedler, P., Reilly, S., Hewitt, R., Demer, D., Philbrick, V., Smith, S., et al. (1998). Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Research Part II, 45*(8-9), 1781-1801.

Findlay, K. (2001). A review of humpback whale catches by modern whaling operations in the Southern Hemisphere. *MEMOIRS-QUEENSLAND MUSEUM, 47*(2), 411-420.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X., & Aguilar, R. (2006). Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. *Marine Mammal Science, 10*(2), 137-150.

Forcada, J., Gazo, M., Aguilar, A., Gonzalvo, J., & Fernández-Contreras, M. (2004). Bottlenose dolphin abundance in the NW Mediterranean: addressing heterogeneity in distribution. *Marine Ecology Progress Series, 275*, 275-287.

Forcada, J., Notarbartolo di Sciara, G., & Fabbri, F. (1995). Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. *Mammalia, 59*(1), 127-140.

Forney, K. (2007). Preliminary estimates of cetacean abundance along the US west coast and within four National Marine Sanctuaries during 2005. US Department of Commerce. *NOAA Technical Memorandum NMFS-SWFSC-406. 27p*.

Frantzis, A., Swift, R., Gillespie, D., Menhennett, C., Gordon, J., & Gialinakis, S. (1999). Sperm whale presence off south-west Crete, Greece, eastern Mediterranean. *Eur Res Cet, 13*, 214-217.

Fujino, K. (1960). Immunogenetic and marking approaches to identifying sub-populations of the North Pacific whales. *Sci. Rep. Whales Res. Inst., Tokyo, 15*, 84-142.

Gabriele, C., Rickards, S., Yin, S., & Frankel, A. (2003). *Trends in Relative Distribution, Abundance and Population Composition of Humpback Whales, Megaptera novaeangliae, in Kawaihae Bay, Hawai'i 1988-2003. Final Report August 2003 for the Department of Land and Natural Resources, State of Hawai'I and the Hawaiian Islands Humpback Whale National Marine Sanctuary, National Marine Sanctuary Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.*

Gannon, D., Craddock, J., & Read, A. (1998). Autumn food habits of harbor porpoises, Phocoena phocoena, in the Gulf of Maine. *Fishery Bulletin, 96*(3), 428-437.

Garrison, L., Martinez, A., & Maze-Foley, K. ((in review)). Habitat and abundance of marine mammals in continental slope waters of the Southeastern U.S. Atlantic.

Garrison, L., Swartz, S., Martinez, A., Burks, C., Stamates, J., & Fisheries, N. (2003). A marine mammal assessment survey of the southeast US continental shelf: February-April 2002. *NOAA Technical Memorandum NMFS-SEFSC-492. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center*.

GBRMP. (2000). Whale and dolphin conservation in the Great Barrier Reef Marine Park: policy document. *B. a. WHG Species Conservation Team & Conservation, ed. Great Barrier Reef Marine Park Authority*, 69.

Genov, T., Kotnjek, P., Lesjak, J., Hace, A., & Fortuna, C. (2008). *Bottlenose dolphins (Tursiops truncatus) in Slovenian and adjacent waters (northern Adriatic Sea)*.

Gill, P. (2002). A blue whale (Balaenoptera musculus) feeding ground in a southern Australian coastal upwelling zone. *J. Cetacean Res. Manage, 4*(2), 179-184.

Gilles, A., Herr, H., Lehnert, K., Scheidat, M., & Siebert, U. (2008). Harbour porpoises abundance estimates and seasonal distribution patterns. *Marine mammals and seabirds in front of offshore wind energy. Wiesbaden: BG Teuber Verlag/GWV Fachverlage GmbH*, 19-36.

GOJ. (2007). Government of Japan website for Dall's porpoise abundance estimates., from http://kokushi.job.affrc.go.jp/H20/H20_46.pdf

Gutiérrez, O., Marinone, S., & Parés-Sierra, A. (2004). Lagrangian surface circulation in the Gulf of California from a 3D numerical model. *Deep Sea Research Part II: Topical Studies in Oceanography, 51*(6-9), 659-672.

Gómez de Segura, A., Crespo, E., Pedraza, S., Hammond, P., & Raga, J. (2006). Abundance of small cetaceans in waters of the central Spanish Mediterranean. *Marine Biology, 150*(1), 149-160.

Haley, N., & Read, A. (1993). Summary of the workshop on harbor porpoise mortalities and human interaction. *NOAA Tech. Mem. NMFS-F/NER, 5*.

Hamazaki, T. (2002). Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic ocean(from Cape Hatteras, North Carolina, U. S. A. to Nova Scotia, Canada). *Marine Mammal Science, 18*(4), 920-939.

Hansen, L., Mullin, K., Jefferson, T., & Scott, G. (1996). Visual surveys aboard ships and aircraft. *Distribution and abundance of marine mammals in the north-central and western Gulf of Mexico: Final report, 2*, 96-0027.

Hare, J., Churchill, J., Cowen, R., Berger, T., Cornillon, P., Dragos, P., et al. (2002). Routes and rates of larval fish transport from the southeast to the northeast United States continental shelf. *Limnology and Oceanography*, 1774-1789.

Hayano, A. e. a. (2004). *Life history and group composition of melon-headed whales based on mass strandings on the Japanese coast. In: the Seventeenth Biennial Conference on the Biology of Marine Mammals, Abstract, Society for Marine Mammalogy, Cape Town, South Africa.* Paper presented at the Seventeenth Biennial Conference on the Biology of Marine Mammals.

Hayano, A. e. a. (2007). *Life history and group composition of melon-headed whales based on mass strandings on the Japanese coast. In: the Seventeenth Biennial Conference on the Biology of*

Marine Mammals, Abstract, Society for Marine Mammalogy, Cape Town, South Africa. Paper presented at the Seventeenth Biennial Conference on the Biology of Marine Mammals.

Heimlich-Boran, J. R. (1993). *Social organization of the short-finned pilot whale, Globicephala macrorhynchus, with reference to the comparative social ecology of delphinids.* Cambridge University.

Holden, C. (2007). WHALE SENSING. *Science, 315*(5816), 1199d.

Hooker, S., Iverson, S., Ostrom, P., & Smith, S. (2001). Diet of northern bottlenose whales inferred from fatty-acid and stable-isotope analyses of biopsy samples. *Canadian Journal of Zoology, 79*(8), 1442-1454.

Hooker, S., Whitehead, H., & Gowans, S. (2002). Ecosystem consideration in conservation planning: energy demand of foraging bottlenose whales (Hyperoodon ampullatus) in a marine protected area. *Biological Conservation, 104*(1), 51-58.

Ichihara, T. (1957a). An application of linear discriminant function to external measurements of fin whale. *Scient. Rep. Whales Res. Inst., Tokyo, 12*, 127—189.

Ichihara, T. (1957b). An application of linear discriminant function to external measurements of fin whale. *Scient. Rep. Whales Res. Inst., Tokyo, 12*, 127—189.

IMO. (2007). *International Maritime Organization, Routing measures other than Traffic Separation Schemes. Ref. T2-OSS/2.7, SN.1/Circ.263,.*

Jaramillo-Legorreta, A., & Rojas-Bracho, L. (2008). *Passive acoustic assesment of vaquita. Paper SC/60/SM3 presented to the IWC Scientific Committee, 2008 (unpublished). 8pp.*

Jaramillo-Legorreta, A., Rojas-Bracho, L., Brownell, R., Read, A., Reeves, R., Ralls, K., et al. (2007). Saving the vaquita: immediate action, not more data. *Conservation Biology, 21*(6), 1653-1655.

Jaramillo-Legorreta, A., Rojas-Bracho, L., & Gerrodette, T. (1999). A new abundance estimate for vaquitas: first step for recovery. *Marine Mammal Science, 15*(4), 957-973.

Jefferson, T., Hung, S., Law, L., Torey, M., & Tregenza, N. (2002). Distribution and abundance of finless porpoises in Hong Kong and adjacent waters of China. *Raffles Bulletin of Zoology, 50*, 43-56.

Johnson, M., Madsen, P., Zimmer, W., De Soto, N., & Tyack, P. (2004). Beaked whales echolocate on prey. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 271*(Suppl 6), S383.

Johnson, S., Richardson, W., Yazvenko, S., Blokhin, S., Gailey, G., Jenkerson, M., et al. (2007). A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment, 134*(1), 1-19.

Johnston, D., McDonald, M., Polovina, J., Domokos, R., Wiggins, S., & Hildebrand, J. (2008). Temporal patterns in the acoustic signals of beaked whales at Cross Seamount. *Biology Letters, 4*(2), 208.

Johnston, D., Westgate, A., & Read, A. (2005). Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises Phocoena phocoena in the Bay of Fundy. *Marine Ecology Progress Series, 295*, 279-293.

Kahn, B. (2001). Komodo National Park cetacean surveys: A rapid ecological assessment of cetacean diversity, abundance, and distribution. Interim report - October 2001.

Kahn, B., Wawandono, N., & Subijanto, J. (2001). Positive identification of the rare pygmy Bryde's whale (*Balaenoptera edeni*) with the assistance of genetic profiling. Unpublished Unpublished contract report.

Kasuya, T., & Miyashita, T. (1988). Distribution of sperm whale stocks in the North Pacific. *Scientific Reports of the Whales Research Institute (Tokyo), 39*, 31-75.

Kasuya, T., & Miyashita, T. (1997). Distribution of Baird's beaked whales off Japan. *Report of the International Whaling Commission*, *47*, 963–968.

Kasuya, T., Miyashita, T., & Kasamatsu, F. (1988). Segregation of two forms of short-finned pilot whales off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst*, *39*, 77-90.

Kasuya, T., & Tai, S. (1993). Life history of short-finned pilot whale stocks off Japan and a description of the fishery. *Report of the International Whaling Commission*, 439-473.

Kato, H. (1992). *Body length, reproduction and stock separation of minke whales off northern Japan*.

Keller, C., Ward-Geiger, L., Brooks, W., Slay, C., Taylor, C., & Zoodsma, B. (2006). North Atlantic right whale distribution in relation to sea-surface temperature in the southeastern United States calving grounds. *Marine Mammal Science*, *22*(2), 426.

Kenney, R., Winn, H., & Macaulay, M. (1995). Cetaceans in the Great South Channel, 1979-1989: right whale (Eubalaena glacialis). *Continental Shelf Research*, *15*(4-5), 385-414.

Kenney, R., & Wishner, K. (1995). The South Channel Ocean Productivity EXperiment. *Continental Shelf Research, 15*(4-5), 373-384.

Kiszka, J., Berggren, P., Rosenbaum, H., Cerchio, S., Rowat, D., Drouot-Dulau, V., et al. (2009). *Cetaceans in the southwest Indian Ocean: a review of diversity, distribution and conservation issues. Paper SC/61/O18 presented to the IWC Scientific Committee, May 2009 (unpublished). 12pp.*

Koopman, H. (1998). Topographical distribution of the blubber of harbor porpoises (Phocoena phocoena). *Journal of Mammalogy, 79*(1), 260-270.

Kraus, S., Hamilton, P., Kenney, R., Knowlton, A., & Slay, C. (2001). Reproductive parameters of the North Atlantic right whale. *Journal of Cetacean Research and Management, 2*, 231-236.

Lasta, C. (1995). La Bahía Samborombón: zona de desove y cría de peces.

Lasta, C., & Acha, E. (1996). Cabo San Antonio: su importancia en el patrón reproductivo de peces marinos.[Cape San Antonio: its importance for reproductive pattern of marine fishes]. *Frente Marítimo, 16,* 39-45.

Leatherwood, S., Caldwell, D., Winn, H., Schevill, W., & Caldwell, M. (1976). Whales, dolphins, and porpoises of the western North Atlantic: a guide to their identification. from http://aquacomm.fcla.edu/1417/2/NOAA_Tech_Rpt_NMFS_CIRC-396.pdf

Lewis, T. (2010). *Preliminary abundance estimate of sperm whales in the SW Mediterranean from an acoustic line-transect survey. ACCOBAMS, 6th Meeting of the Scientific Committee, Casablanca, 11-13 January 2010. Document SC6-Inf 13. 8 p.*: ACCOBAMS.

Link, J., Overholtz, W., O'Reilly, J., Green, J., Dow, D., Palka, D., et al. (2008). The Northeast U.S. continental shelf Energy Modeling and Analysis exercise (EMAX): Ecological network model development and basic ecosystem metrics. *Journal of Marine Systems*, *74*(1-2), 453-474.

Lázaro, M., Lessa, E., & Hamilton, H. (2004). Geographic genetic structure in the franciscana dolphin (Pontoporia blainvillei). *Marine Mammal Science, 20*(2), 201-214.

MacLeod, C., & Mitchell, G. (2005). Key areas for beaked whales worldwide. *Journal of Cetacean Research and Management, 7*(3), 309.

Mahabub, E. (2008). *Minimum population size of Bryde's whale (Balaenoptera edeni) estimated using photo-identification techniques in the Swatch-of-No-Ground, Bangladesh, during winter seasons 2005-2008. Senior thesis project,.* Independent University, Bangladesh.

Mahakunlayanakul, S. (1996). *Species distribution and status of dolphins in the inner Gulf of Thailand. Ph.D. thesis, Chulalongkorn University, 130 pp.*

Mate, B. R., Gisiner, R., & Mobley, J. (1998). Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Canadian Journal of Zoology/Revue Canadien de Zoologie, 76*(5), 863-868.

Mattila, D., Clapham, P., Katona, S., & Stone, G. (1989). Population composition of humpback whales, Megaptera novaeangliae, on Silver Bank, 1984. *Canadian Journal of Zoology*, *67*(2), 281-285.

McDonald, M., Mesnick, S., & Hildebrand, J. (2006). Biogeographic characterization of blue whale song worldwide: using song to identify populations. *Journal of Cetacean Research and Management, 8*(1).

Meier, S., Yazvenko, S., Blokhin, S., Wainwright, P., Maminov, M., Yakovlev, Y., et al. (2007). Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. *Environmental monitoring and assessment*, *134*(1-3), 107.

Mendez, M., Rosenbaum, H., & Bordino, P. (2008). Conservation genetics of the franciscana dolphin in northern Argentina: population structure, by-catch impacts, and management implications. *Conservation Genetics*, *9*(2), 419-435.

Mendez, M., Rosenbaum, H., Yackulic, C., Subramaniam, A., & Bordino, P. (2010). Isolation by environmental distance in mobile marine species: molecular ecology of franciscana dolphins at their southern range. . *Molecular Ecology. In press.*

Merrick, R., & Cole, T. (2007). *Evaluation of northern right whale ship strike reduction measures in the Great South Channel of Massachusetts, NOAA Tech Memo NMFS NE 202*: National Oceanic and Atmospheric Administration.

Michels, K. H., Suckow, A., Breitzke, M., Kudrass, H. R., & Kottke, B. (2003). Sediment transport in the shelf canyon "Swatch of No Ground" (Bay of Bengal). *Deep Sea Research Part II: Topical Studies in Oceanography, 50*(5), 1003-1022.

Minoda, T. (1989). *Oceanographic and biomass changes in the Oyashio Current ecosystem in Kenneth Sherman and Lewis M. Alexander (eds.), Biomass Yields and Geography of Large Marine Ecosystems (Boulder: Westview) AAAS Selected Symposium 111.*

Miyashita, T. (1986). Abundance of Baird's beaked whales off the Pacific coast of Japan. *Rep. Int. Whal. Comm., 36*, 383-386.

Miyashita, T. (1993). *Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery*.

Miyashita, T. (2004). *Cruise report of the common minke whale sighting surveys in the Sea of Okhotsk in 2003*: Paper SC/56/RMP1, available from the International Whaling Commission, Cambridge, UK.

Miyashita, T., & Kato, H. (1993). Population estimate of Baird's beaked whales off the Pacific coast of Japan using sighting data collected by R/V SHUNYO MARU in 1991 and 1992. *IWC/SC/45/SM6*.

Miyashita, T., & Kato, H. (1998). *Recent data on the status of right whales in the NW Pacific Ocean*.

Miyazaki, N., & Amano, M. (1994). Skull morphology of two forms of short-finned pilot whales off the Pacific coast of Japan. *Rep. Int. Whaling Commn, 44*, 499-508.

Miyazaki, N., & Nakayama, K. (1989). Records of cetaceans in the waters of the Amami Islands. *Mem. Natn. Sci. Mus. Tokyo, 22*, 235-249.

Mobley, J., Bauer, G., & Herman, L. (1999). Changes over a ten-year interval in the distribution and relative abundance of humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. *Aquatic Mammals, 25*, 63-72.

Mobley, J., Spitz, S., Grotefendt, R., Forestell, P., Frankel, A., & Bauer, G. (2001). Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. *Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary, 26*.

Mori, S. (2005). *Distribution and residency of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in the waters of the Ogasawara (Bonnin) Islands, Japan. In: Sixteenth Biennial Conference on the Biology of Marine Mammals.* Paper presented at the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

Mullin, K., & Fulling, G. (2003). Abundance of cetatceans in the southern US North Atlantic Ocean during summer 1998. *FISHERY BULLETIN, 101*(3), 603-613.

Mullin, K., & Hoggard, W. (2000). Visual surveys of cetaceans and sea turtles from aircraft and ships. *Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations, 2*, 96-0027.

Mussi, B., Miragliuolo, A., & Bearzi, G. (2002). Short-beaked common dolphins around the island of Ischia, Italy (Southern Tyrrhenian Sea). *European Research on Cetaceans, 16*, 15.

Mustika, P. (2006). *Marine mammals in the Savu Sea (Indonesia): indigenous knowledge, threat analysis and management options.* James Cook University.

Nanbu, Y., Hirose, J., Kubo, N., Kishiro, T., & Shinomiya, A. (2006). Location and number of individuals of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in Kagoshima Bay [Japan]. *Memoirs of Faculty of Fisheries-Kagoshima University (Japan)*.

NMFS. (1994). *Designated Critical Habitat; Northern Right Whale. 59 Federal Register 28793-28834, June 3, 1994*.

NMS. (2009a, March 26, 2008). Cordell Bank Sanctuary: Seamounts And Banks. Retrieved September 2009, from http://www.sanctuarysimon.org/cordell/sections/seamounts/overview.php?sec=sm

NMS. (2009c, March 26, 2008). Gulf of the Farrallones Sanctuary. Retrieved September 2009, from http://www.sanctuarysimon.org/farallones/index.php

Northridge, S. (1996). Seasonal distribution of harbour porpoises in US Atlantic waters. *REPORT-INTERNATIONAL WHALING COMMISSION, 46*, 613-618.

Northrop, J., Cummings, W., & Thompson, P. (1967). 20 Hz signals observed in the central Pacific. *The Journal of the Acoustical Society of America, 42*, 1211.

Notarbartolo di Sciara, G. (2010). Personal Communication. Tethys Research Institute. Milano, Italy.

Notarbartolo-Di-Sciara, G., Zanardelli, M., Jahoda, M., Panigada, S., & Airoldi. (2003). The fin whale Balaenoptera physalus (L. 1758) in the Mediterranean Sea. *Mammal Review, 33*(2), 105-150.

Notarbotolo di Sciara, G., Venturino, M., Zanardelli, M., Bearzi, G., Borsani, F., & Cavalloni, B. (1993). Cetaceans in the central Mediterranean Sea: distribution and sighting frequencies. *Italian Journal of Zoology, 60*(1), 131-138.

O'Hern, J., & Biggs, D. (2009). Sperm Whale (Physeter macrocephalus) Habitat in the Gulf of Mexico: Satellite Observed Ocean Color and Altimetry Applied to Small-Scale Variability in Distribution. *Aquatic Mammals, 35*(3), 358-366.

Oleson, E., Calambokidis, J., Barlow, J., & Hildebrand, J. B. W. V. A. A. E. R. I. T. S. C. B. (2007). Blue whale visual and acoustic encounter rates in the Southern California Bight. *Marine Mammal Science, 23*(3), 574-597.

Omura, H., & Sakiura, H. (1956). Studies on the little piked whale from the coast of Japan. *Sci. Rep. Whales Res. Inst. Tokyo, 11*, 1-37.

Overholtz, W., & Link, J. (2007). Consumption impacts by marine mammals, fish, and seabirds on the Gulf of Maine–Georges Bank Atlantic herring (Clupea harengus) complex during the years 1977–2002. *ICES Journal of Marine Science, 64*, 83-96.

Pace, R. M., & Merrick, R. L. (2008). *Northwest Atlantic ocean habitats important to the conservation of North Atlantic right whales (Eubalaena glacialis). US Dept Commerce, Northeast Fish Sci Cent Ref Doc 08-07*. Retrieved from http://www.nefsc.noaa.gov/publications/crd/crd0807/crd0807.pdf.

Palka, D. (1995). *Preliminary cruise report of the spring distribution survey of harbor porpoises in the Mid-Atlantic. Available at NOAA/NMFS/NEFSC, Woods Hole, MA 02543. 7pp.*

Palka, D. (2006). Summer abundance estimates of cetaceans in US North Atlantic navy operating areas. *US Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc*, 06-03.

Palka, D., Orphanides, C., & Warden, M. (2009). Summary of harbor porpoise (Phocoena phocoena) bycatch and levels of compliance in the northeast and mid-Atlantic gillnet fisheries after the implementation of the Take Reduction Plan: 1 January 1999-31 May 2007. *NOAA Technical Memorandum NMFS NE, 212*(89), 02543-01026.

Palka, D., Read, A., Westgate, A., & Johnston, D. (1996). *Summary of current knowledge of harbour porpoises in US and Canadian Atlantic waters. Rep. Int. Whal. Commn 46: 559-565.*

Panigada, S., & Azzellino, A. (2009). *Determinazione degli habitat critici delle specie di cetacei presenti nell'area del Santuario Pelagos (porzione occidentale), ai fini della gestione. Rapporto finale.* : Istituto Tethys.

Panigada, S., Burt, L., Lauriano, G., Pierantonio, N., & Donovan, G. (2009). Winter abundance of striped dolphins (Stenella coeruleoalba) in the Pelagos Sanctuary (north-western Mediterranean Sea) assessed through aerial survey. *Journal of Cetacean Research Management*(SC/61/SM7), 1-10.

Panigada, S., Notarbartolo di Sciara, G., Panigada, M., Airoldi, S., Borsani, J., & Jahoda, M. (2005). Fin whales (Balaenoptera physalus) summering in the Ligurian Sea: distribution, encounter rate, mean group size and relation to physiographic variables. *Journal of Cetacean Research Management, 7*(2), 137-145.

Paterson, R., & Paterson, P. (1984). A study of the past and present status of humpback whales in east Australian waters. *Biological Conservation, 29*(4), 321-343.

Payne, P., & Heinemann, D. (1993). The distribution of pilot whales (Globicephala spp.) in shelf/shelf-edge and slope waters of the Northeastern United States, 1978-1988 In: Biology of Northern Hemisphere Pilot Whales-Reports of the International Whaling Commission, Special issue 14. *IWC, Cambridge, UK*, 51-68.

Pegau, W., Boss, E., & Martínez, A. (2002). Ocean color observations of eddies during the summer in the Gulf of California. *Geophysical Research Letters, 29*(9), 9-1.

Perrin, W., Dolar, M., Amano, M., & Hayano, A. (2003). Cranial Sexual Dimorphism And Geographic Variation In Eraser's Dolphin, Lagenodelphis Hosei. *Marine Mammal Science, 19*(3), 484-501.

Perrin, W., & Hohn, A. (1994). Pan tropical spotted dolphin Stenella attenuata. *Handbook of marine mammals: The first book of dolphins*, 71.

Pet-Soede, L. (2002). *The Solor and Alor islands: Expedition results, data collected during 2 reconnaissance trips; 9-12 September 2001 and 7-19 May, 2002. Report of a joined activity by The Nature Conservancy Southeast Asia Center for Marine Protected Areas and World Wide Fund for Nature Wallacea Bioregional Program.*

Pomilla, C., & Rosenbaum, H. (2005). Against the current: an inter-oceanic whale migration event. *Biology Letters, 1*(4), 476.

Read, A. (1999). Harbour porpoise Phocoena phocoena (Linnaeus, 1758). *Handbook of marine mammals, 6*, 323-355.

Reeves, R., Mckenzie, M., & Smith, T. (2006). History of Bermuda shore whaling, mainly for humpback whales. *Journal of Cetacean Research and Management, 8*(1), 33.

Reilly, S., & Thayer, V. (1990). Blue Whale (Balaenoptera-Musculus) Distribution In The Eastern Tropical Pacific. *Marine Mammal Science, 6*(4), 265-277.

Rendell, L., Cañadas, A., & Mundy, C. (2005). *Scientific Report Balearics Sperm Whale Project 2003-2005*: The Nando Peretti Foundation, One World Wildlife.

Rice, D. (1998). Marine Mammals of the World: Systematics and Distribution, Special Publication Number 4, The Society for Marine Mammalogy: Allen Press, USA. ix+ 231pp.

Rojas-Bracho, L., & Taylor, B. (1999). Risk factors affecting the vaquita (Phocoena sinus). *Marine Mammal Science, 15*(4), 974-989.

Romero, S., Piola, A., Charo, M., & Garcia, C. (2006). Chlorophyll-a variability off Patagonia based on SeaWiFS data. *Journal of Geophysical Research, 111*(C5), C05021.

Rosa, S., Milinkovitch, M., Van Waerebeek, K., Berck, J., Oporto, J., Alfaro-Shigueto, J., et al. (2005). Population structure of nuclear and mitochondrial DNA variation among South American Burmeister's porpoises (Phocoena spinipinnis). *Conservation Genetics, 6*(3), 431-443.

Rosenbaum, H., & Collins, T. (2006). The Ecology, Population Characteristics and Conservation Efforts for Humpback Whales (Megaptera novaeangliae) on Their Wintering Grounds in the Coastal Waters of Gabon. *Bulletin of the Biological Society of Washington*, 425-433.

Rosenbaum, H., Pomilla, C., Mendez, M., Leslie, M., Best, P., Findlay, K., et al. (2009). Population Structure of Humpback Whales from Their Breeding Grounds in the South Atlantic and Indian Oceans.

Rosenbaum, H., Walsh, P., Razafindrakoto, Y., Vely, M., & Desalle, R. (1997). First description of a humpback whale wintering ground in Baie d'Antongil, Madagascar. *Conservation Biology, 11*(2), 308-314.

Rossman, M. (2009). Estimated Bycatch of Small Cetaceans in Northeast US Bottom Trawl Fishing Gear during 2000-2005. *J. Northw. Atl. Fish. Sci., 42*, 77-101.

Rugh, D., Shelden, K., & Schulman-Janiger, A. (2001). Timing of the southbound migration of gray whales. *J. Cetacean Res. Manage, 3*(1), 31-39.

Rutenko, A., Borisov, S., Gritsenko, A., & Jenkerson, M. (2007). Calibrating and monitoring the western gray whale mitigation zone and estimating acoustic transmission during a 3D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment, 134*(1), 21-44.

Saraceno, M., Provost, C., & Piola, A. (2005). On the relationship between satellite-retrieved surface temperature fronts and chlorophyll a in the western South Atlantic. *Journal of Geophysical Research-Oceans, 110*(C11), C11016.

Sarin, M., Krishnaswami, S., Dilli, K., Somayajulu, B., & Moore, W. (1989). Major ion chemistry of the Ganga-Brahmaputra river system: Weathering processes and fluxes to the Bay of Bengal. *Geochimica et Cosmochimica Acta, 53*(5), 997-1009.

Scheidat, M., Gilles, A., Kock, K., & Siebert, U. (2008). Harbour porpoise Phocoena phocoena abundance in the southwestern Baltic Sea. *Endangered species research*, 1-9.

Scheninin, A., Kerem, D., & Goffman, O. (2010). Personal Communication. University of Haifa.

Secchi, E., Danilewicz, D., & Ott, P. (2003). Applying the phylogeographic concept to identify franciscana dolphin stocks: implications to meet management objectives. *Journal of Cetacean Research and Management, 5*(1), 61-68.

Selzer, L., & Payne, P. (1988). The distribution of white-sided dolphins (Lagenorhynchus acutus) and common dolphins (Delphinus delphis) vs. environmental features of the continental shelf of the northeastern United States. *Mar. Mammal Sci, 4*, 141-153.

Sergeant, D. (1962). *The biology of the pilot or pothead whale Globicephala melaena (Traill) in Newfoundland waters*: Fisheries Research Board of Canada under the control of the honourable the Minister of Fisheries, Ottawa.

Shirakihara, M., Shirakihara, K., Tomonaga, J., & Takatsuki, M. (2002). A resident population of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in Amakusa, western Kyushu, Japan. *Marine Mammal Science, 18*(1), 30-41.

Siebert, U., Gilles, A., Lucke, K., Ludwig, M., Benke, H., Kock, K., et al. (2006). A decade of harbour porpoise occurrence in German waters--Analyses of aerial surveys, incidental sightings and strandings. *Journal of Sea Research, 56*(1), 65-80.

Smith, B., Ahmed, B., Mowgli, R., & Strindberg, S. (2008). Species occurrence and distributional ecology of nearshore cetaceans in the Bay of Bengal, Bangladesh, with abundance estimates for Irrawaddy dolphins Orcaella brevirostris and finless porpoises Neophocaena phocaenoides. *The Journal of Cetacean Research and Management, 10*(1), 45-58.

Smith, B., Jefferson, T., Ho, D., Leatherwood, S., Thuoc, C., Andersen, M., et al. (1995). Marine mammals of Vietnam: a preliminary checklist. *Tuyen Tap Nghien Cuu Bien (Collection of Marine Research Works), 6*, 147-176.

Somayajulu, Y., Murty, V., & Sarma, Y. (2003). Seasonal and inter-annual variability of surface circulation in the Bay of Bengal from TOPEX/Poseidon altimetry. *Deep Sea Research Part II: Topical Studies in Oceanography, 50*(5), 867-880.

Sparks, T. (1997). *Distributions of sperm whales along the continental slope in the northwestern and central Gulf of Mexico as determined from an acoustic survey*. Texas A& M University.

Stafford, K., Nieukirk, S., & Fox, C. (2001). Geographic and seasonal variation of blue whale calls in the North Pacific. *Journal of Cetacean Research and Management, 3*(1), 65-76.

Steele, J. H., Collie, J. S., Bisagni, J. J., Gifford, D. J., Fogarty, M. J., Link, J. S., et al. (2007). Balancing end-to-end budgets of the Georges Bank ecosystem. *Progress In Oceanography, 74*(4), 423-448.

Stone, G., Katona, S., & Tucker, E. J. B. C. (1987). History, migration and present status of humpback whales Megaptera novaeangliae at Bermuda. *42*(2), 133-145.

Strindberg, S., Ersts, P., Collins, T., Sounguet, G., & Rosenbaum, H. (In Press). Line Transect Estimates of Humpback Whale Abundance and Distribution on their Wintering Grounds in the Coastal Waters of Gabon. *Journal of Cetacean Research and Management.*

Subrahmanyam, V., Krishna, K., Ramana, M., & Murthy, K. (2008). Marine geophysical investigations across the submarine canyon (Swatch-of-No-Ground), northern Bay of Bengal. *Current Science, 94*(4), 507-513p.

Tomilin, A. (1967). Mammals of the USSR and adjacent countries. *Vol. IX. Cetacea. Moscow, Soviet Union (English translation, 1967, Israel Program for Scientific Translations, Jerusalem, Israel)*.

Townsend, C. (1935). The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, 19*(1), 1-50.

Tyack, P., & Whitehead, H. (1982). Male competition in large groups of wintering humpback whales. *Behaviour*, 132-154.

Van Waerebeek, K., Barnett, L., Camara, A., Cham, A., Diallo, M., Djiba, A., et al. (2004). Distribution, Status, and Biology of the Atlantic Humpback Dolphin, Sousa teuszii (Kukenthal, 1892). *Aquatic Mammals, 30*(1), 56-83.

Vella, A. (2005). Common dolphin *Delphinus delphis* research and conservation requirements in the Central Mediterranean around the Maltese Islands. In K. Stockin, A. Vella, P.G.H. Evans. Common dolphins: current research, threats and issues. *ECS Newsletter N. 45, Special Issue July 2005,* 4-12.

Verfuß, U., Honnef, C., Meding, A., Dähne, M., Mundry, R., & Benke, H. (2007). Geographical and seasonal variation of harbour porpoise (Phocoena phocoena) presence in the German Baltic Sea revealed by passive acoustic monitoring. *Journal of the Marine Biological Association of the UK, 87*(01), 165-176.

Vigness-Raposa, K., Kenney, R., Gonzalez, M., & August, P. (2009). Spatial patterns of humpback whale (Megaptera novaeangliae) sightings and survey effort: Insight into North Atlantic population structure. *Marine Mammal Science, 26*(1), 161-175.

Wada, S. (1988). Genetic differentiation between two forms of short-finned pilot whales off the Pacific coast of Japan. *Sci Rep Whales Res Inst, 39*, 91-101.

Walsh, P., Fay, J., Gulick, S., & Sounguet, G. (2000). Humpback whale activity near Cap Lopez, Gabon. *Journal of Cetacean Research and Management, 2*(1), 63-68.

Wang, J., & Yang, S. (2007). *An identification guide to the dolphins and other small cetacean of Taiwan.*: Jen Jen Publishing Co., Ltd.

Wang, P. (1999). Chinese cetaceans. *Hong kong: Ocean Enterprises Ltd*.

Waring, G., Josephson, E., Fairfield-Walsh, C., & Maze-Foley, K. (2009). US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments--2008. *NOAA Tech Memo NMFS NE 210, 210*(440), 02543-01026.

Watkins, W., Daher, M., Reppucci, G., George, J., Martin, D., DiMarzio, N., et al. (2000). Seasonality and distribution of whale calls in the North Pacific. *OCEANOGRAPHY-WASHINGTON DC-OCEANOGRAPHY SOCIETY-, 13*(1), 62-67.

WCS. (2010). Wildlife Conservation Society, Antongil Bay Seascape, Madagascar. Retrieved September 14, 2010, 2010, from http://www.wcs.org/saving-wild-places/ocean/antongil-bay-seascape.aspx

Weir, C. (2006a). First confirmed records of Clymene dolphin, Stenella clymene (Gray, 1850), from Angola and Congo, south-east Atlantic Ocean. *African Zoology, 41*(2), 297-300.

Weir, C. (2006b). Short Communication Sightings of beaked whales (Cetacea: Ziphiidae) including first confirmed Cuvier's beaked whales Ziphius cavirostris from Angola. *African Journal of Marine Science, 28*(1), 173-175.

Weir, C. (2007). Occurrence and distribution of cetaceans off Northern Angola, 2004/05. *The Journal of Cetacean Research and Management, 9*(3).

Whitehead, H., Gowans, S., Faucher, A., & McCarrey, S. (1997). Population analysis of northern bottlenose whales in the Gully Nova Scotia. *Marine Mammal Science, 13*(2), 173-185.

Whitehead, H., & Moore, M. (1982). Distribution and movements of West Indian humpback whales in winter. *Canadian Journal of Zoology, 60*(9), 2203-2211.

Wimmer, T., & Whitehead, H. (2004). Movements and distribution of northern bottlenose whales, Hyperoodon ampullatus, on the Scotian Slope and in adjacent waters. *Canadian Journal of Zoology, 82*(11), 1782-1794.

Winn, H. (1982). A characterization of marine mammals and turtles in the Mid-and North Atlantic areas of the US outer continental shelf. *Final report. Sponsored by the Bureau of Land Management under contract AA551-CT8-48. 450pp*.

Yamada, T. (2009). *Balaenpotera omurai Wada, Oishi & Yamada, 2003. Pages 330-331, In: The Wild Mammals of Japan.* Kyoto: Shoukadoh Book Sellers.

Yen, P. P. W., Sydeman, W. J., & Hyrenbach, K. (2004). Marine bird and cetacean associations with bathymetric habitats and shallow- water topographies: implications for trophic transfer and conservation. *Journal of Marine Systems, 50*(1-2), 79-99.

Yoshida, H., Shirakihara, K., Kishino, H., & Shirakihara, M. (1997). A population size estimate of the finless porpoise, Neophocaena phocaenoides, from aerial sighting surveys in Ariake Sound and Tachibana Bay, Japan. *Researches on Population Ecology, 39*(2), 239-247.

Zhou, K. (2002). Marine mammal research and conservation in China. *Fisheries Science, 68*((Supplement 1)), 244-247.

Zhou, K. (2004). Cetacea Carnivora: Phocoidea, Sirenia. Fauna Sinica, Mammal 9:vi, 326.

Zhou, K., Leatherwood, S., & Jefferson, T. (1995). Records of small cetaceans in Chinese waters: a review. *Asian Marine Biology, 12*, 119-139.

APPENDIX D-8: MAP FIGURES OF FINAL SURTASS LFA SONAR MARINE MAMMAL OBIAS, APRIL 2011

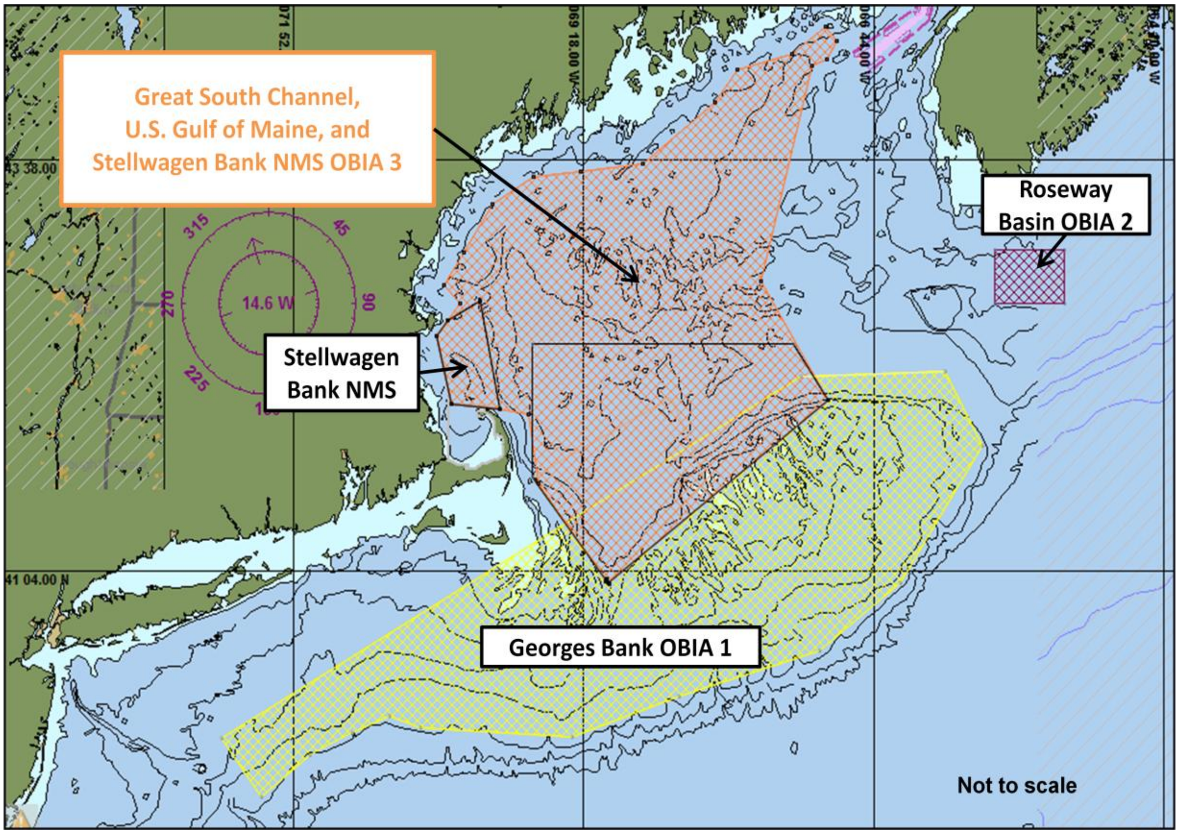
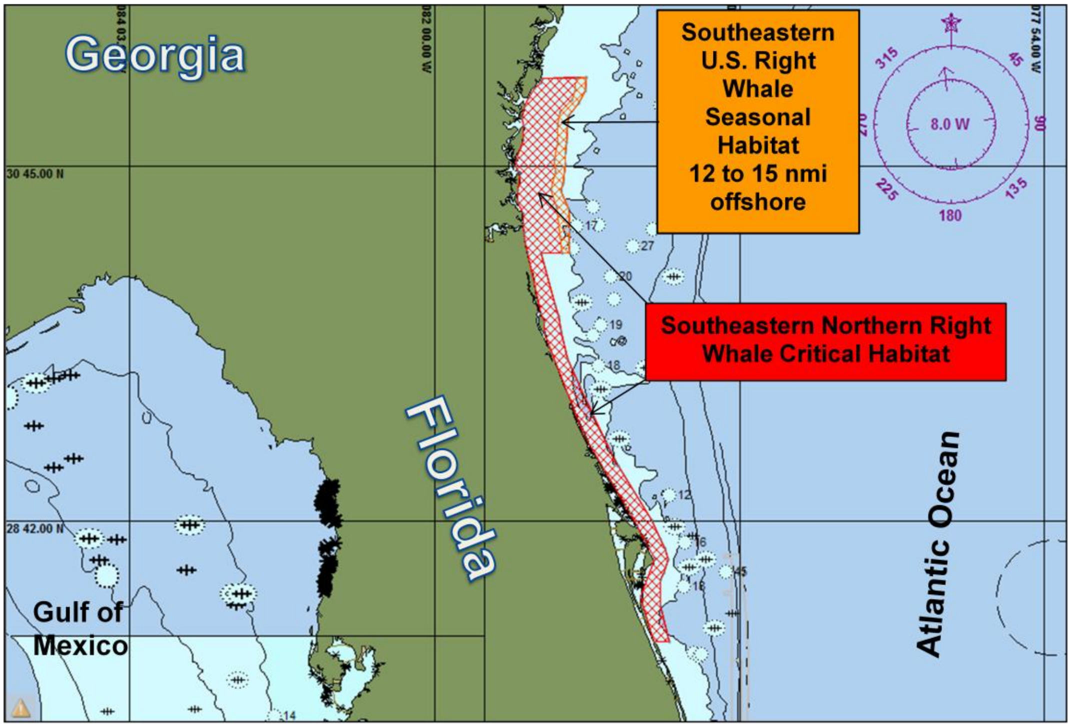
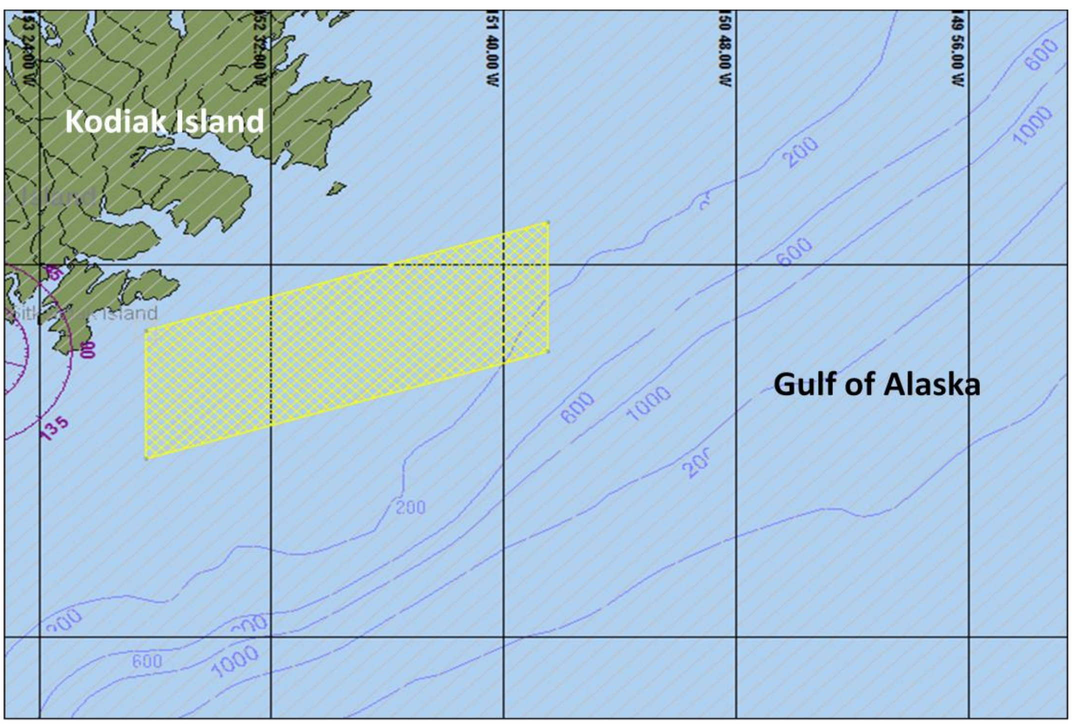


Figure D-1. OBIA Area Number 1: Georges Bank OBIA Area Number 2: Roseway Basin Right Whale Conservation Area OBIA Area Number 3: Great South Channel/U.S. Gulf of Maine/Stellwagen Bank NMS



Not to Scale

Figure D-2. OBIA 4: Southeastern U.S. right whale seasonal habitat.



Not to Scale

Figure D-3. OBIA 5: North Pacific right whale critical habitat (Gulf of Alaska only).

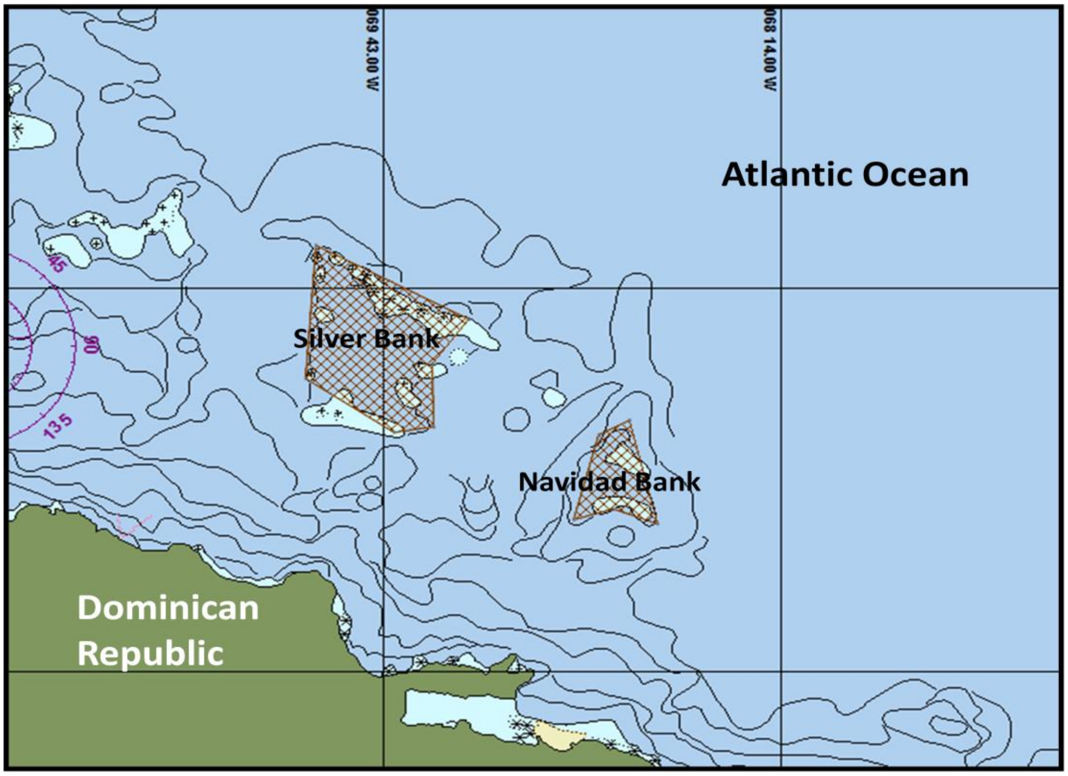


Figure D-4. OBIA 6: Silver and Navidad Banks.

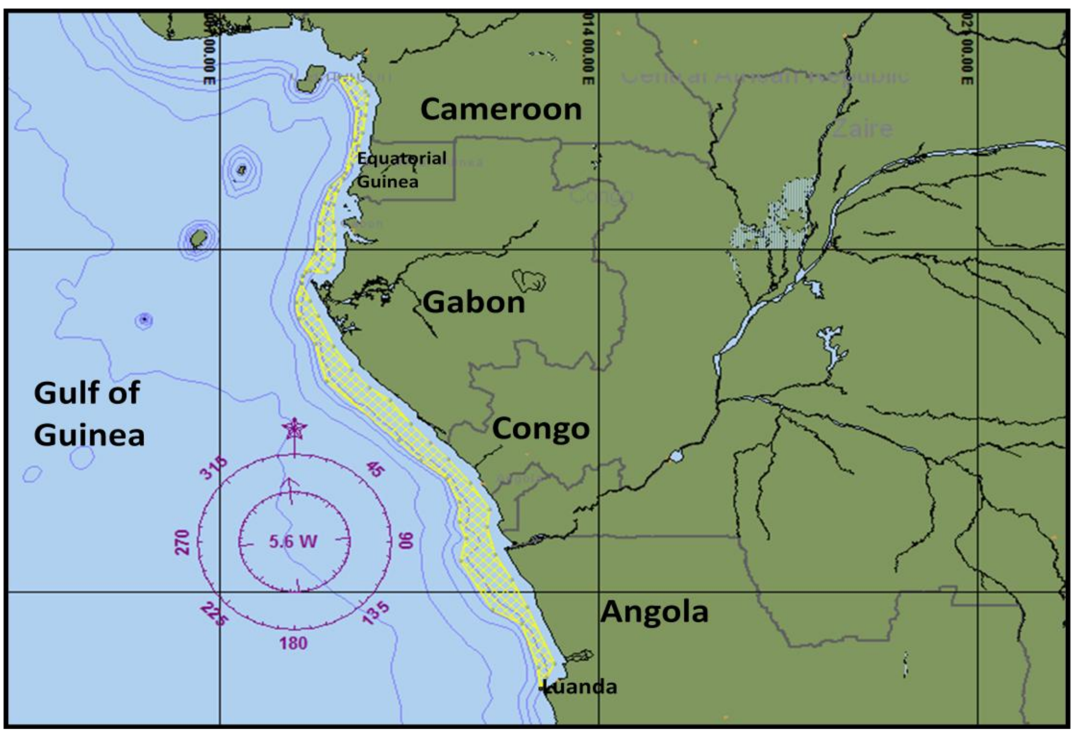


Figure D-5. OBIA 7: Coastal waters of Gabon, Congo, and Equatorial Guinea.

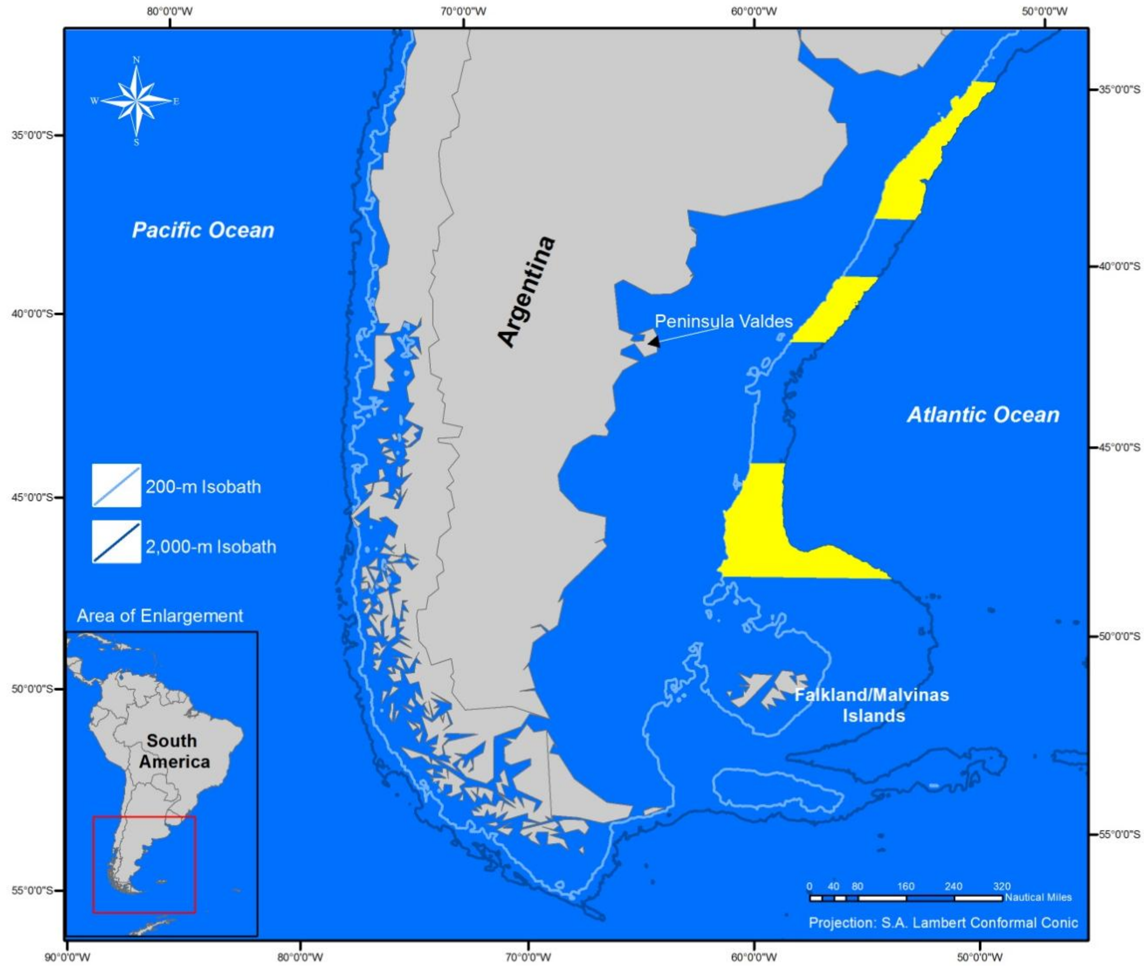
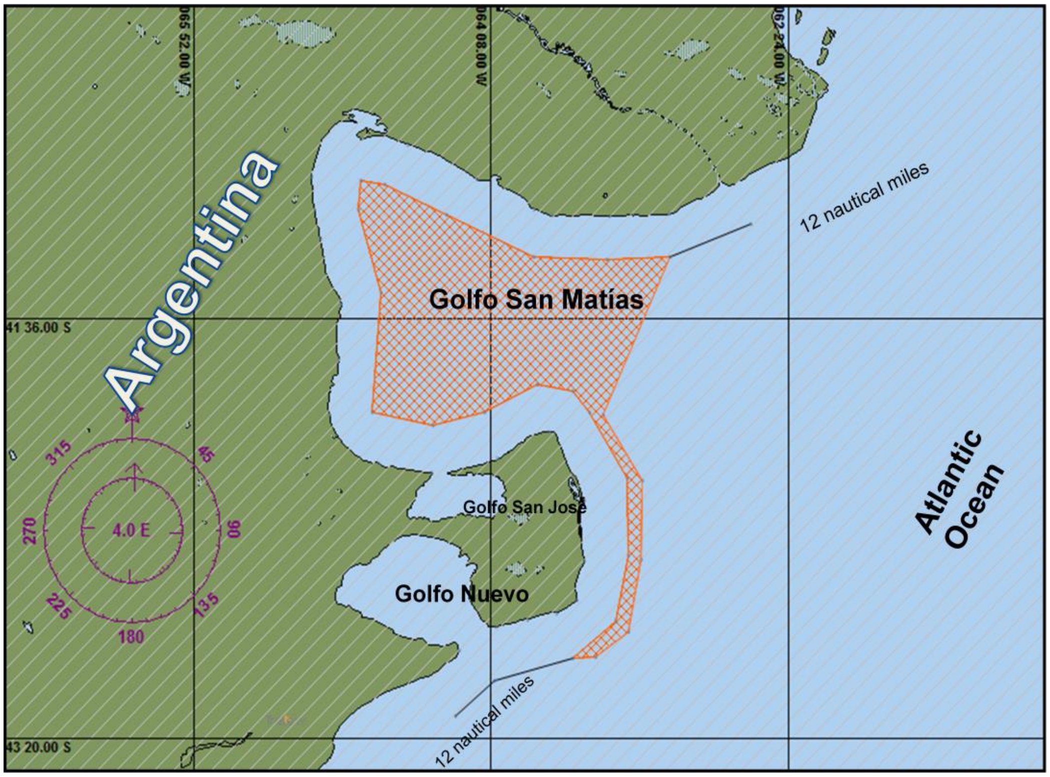


Figure D-6. OBIA 8: Patagonian shelf break.



Not to Scale

Figure D-7. OBIA 9: Southern right whale seasonal habitat.

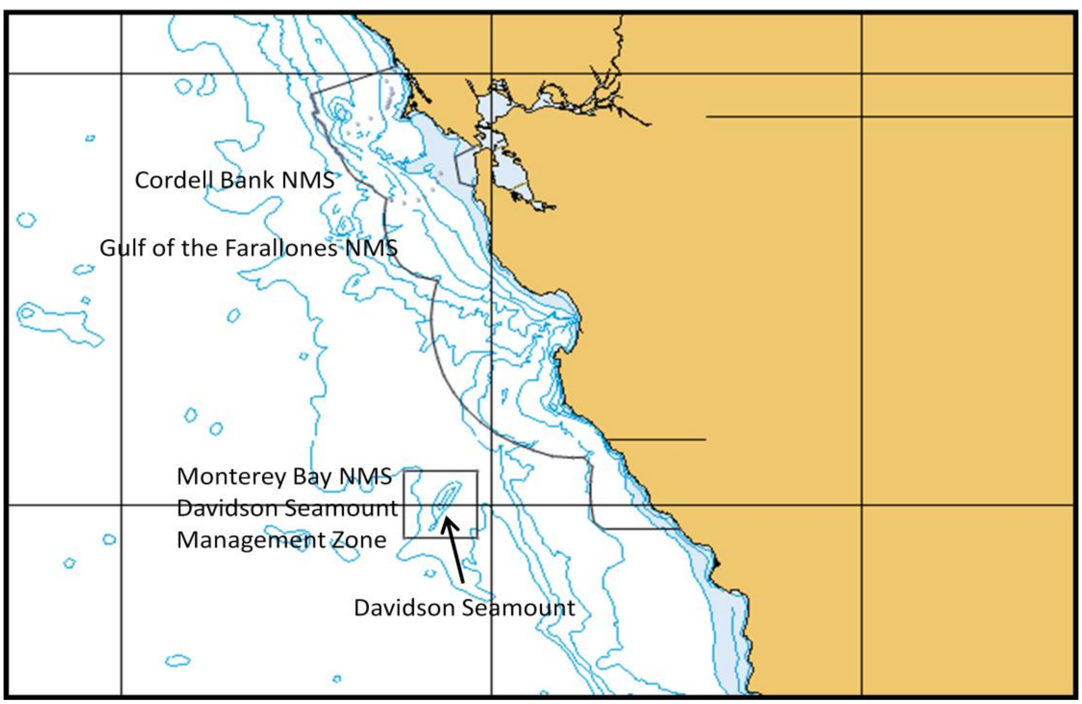


Figure D-8. OBIA 10: Central California National Marine Sanctuaries.

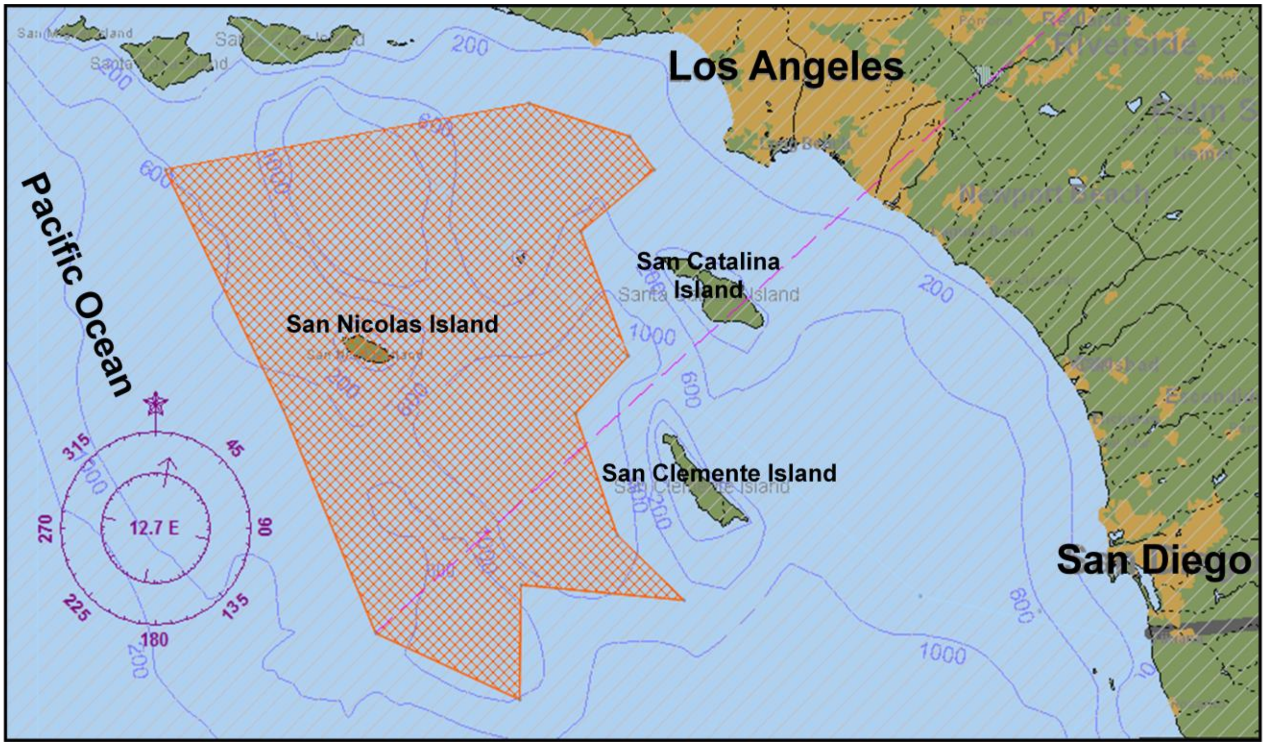


Figure D-9. OBIA 11: Southern California Bight.

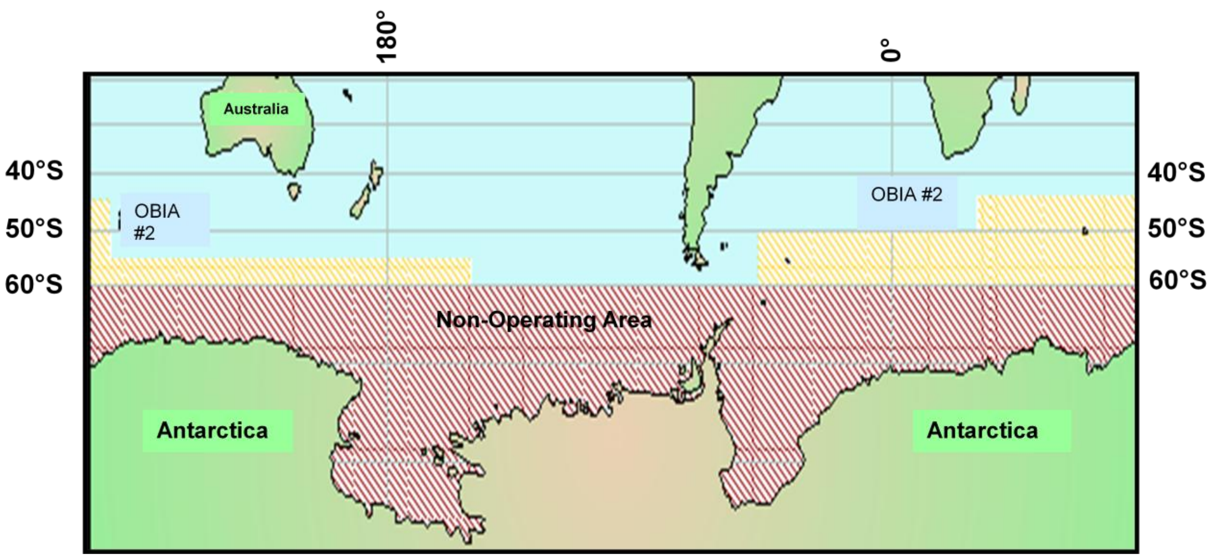


Figure D-10. OBIA 12: Antarctic Convergence Zone.

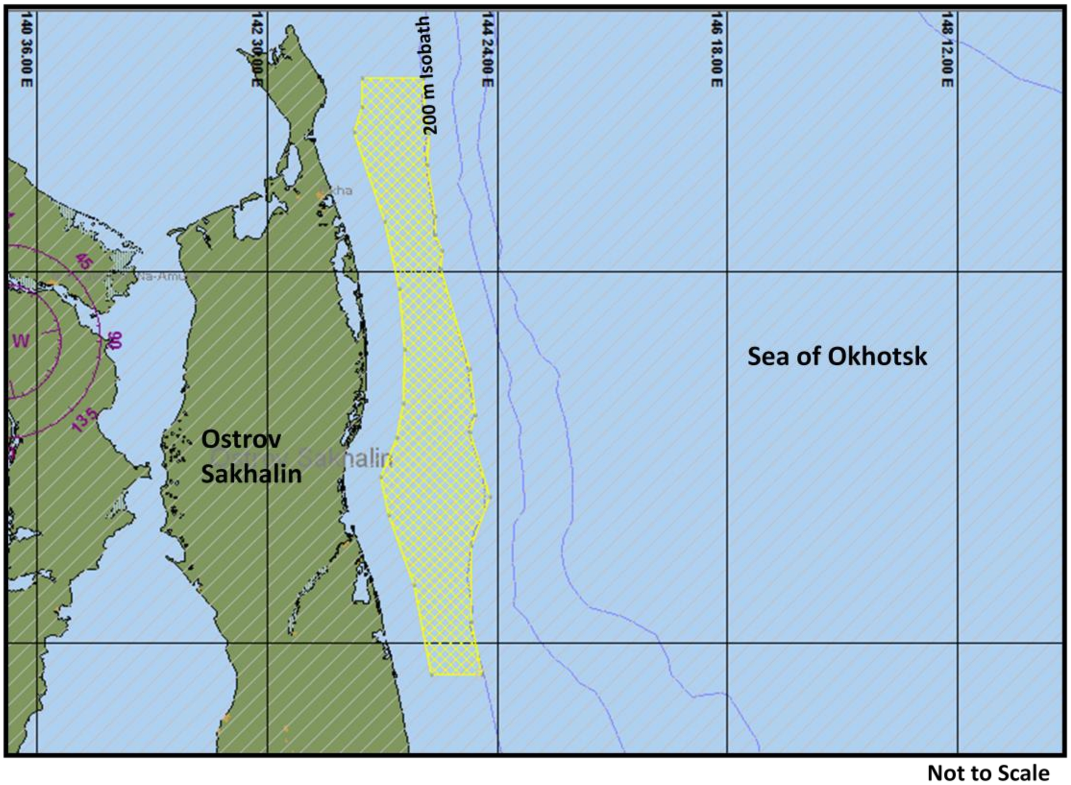


Figure D-11. OBIA 13: Piltun and Chayvo offshore feeding grounds—Sea of Okhotsk.

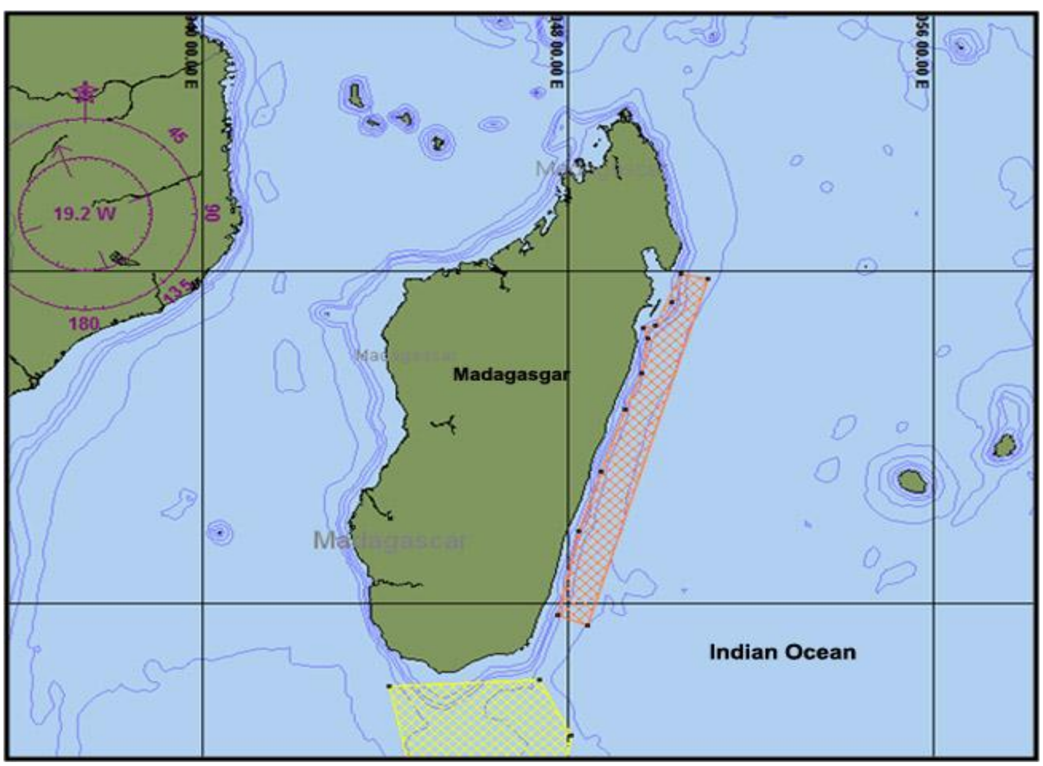


Figure D-12. OBIA 14: Coastal waters off Madagascar.

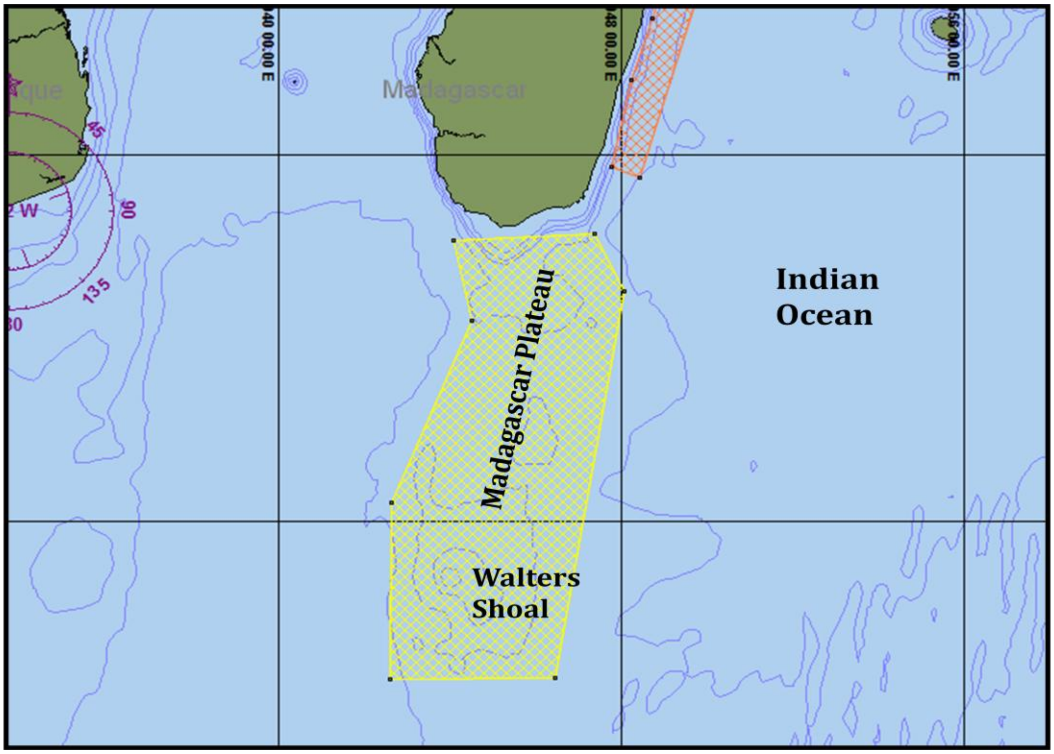


Figure D-13. OBIA 15: Madagascar Plateau, Madagascar Ridge, and Walters Shoal.

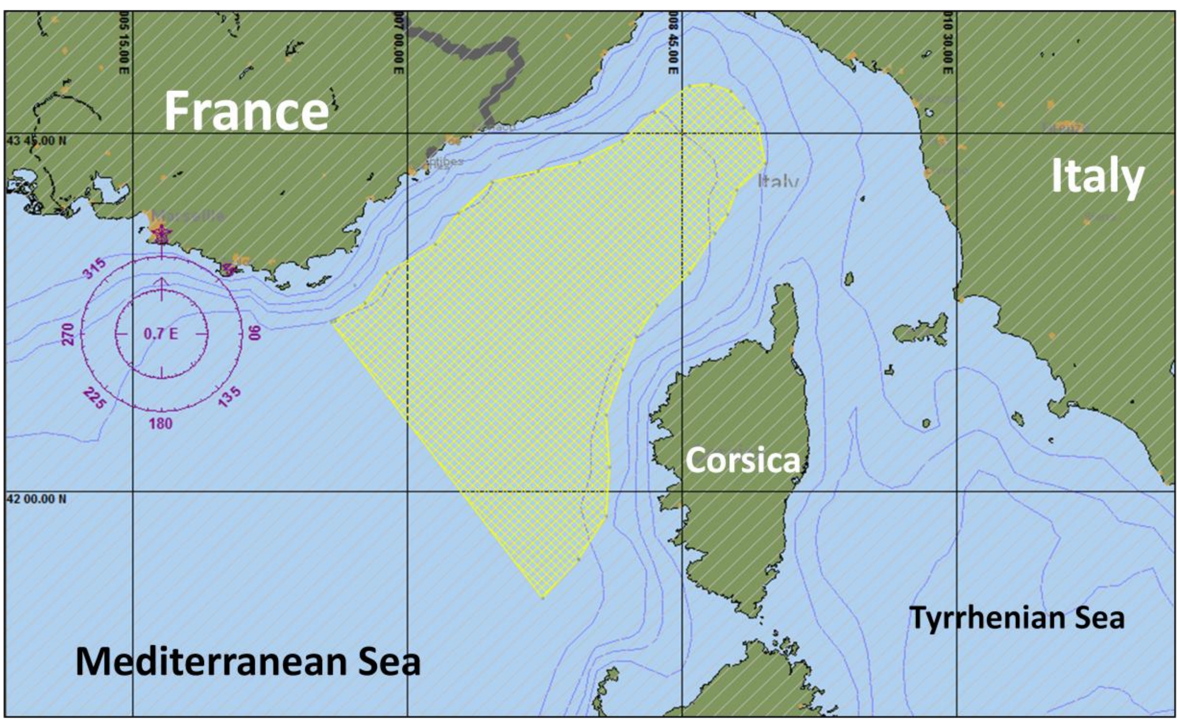


Figure D-14. OBIA 16: Ligurian-Corsican-Provençal Basin and Western Pelagos Sanctuary.

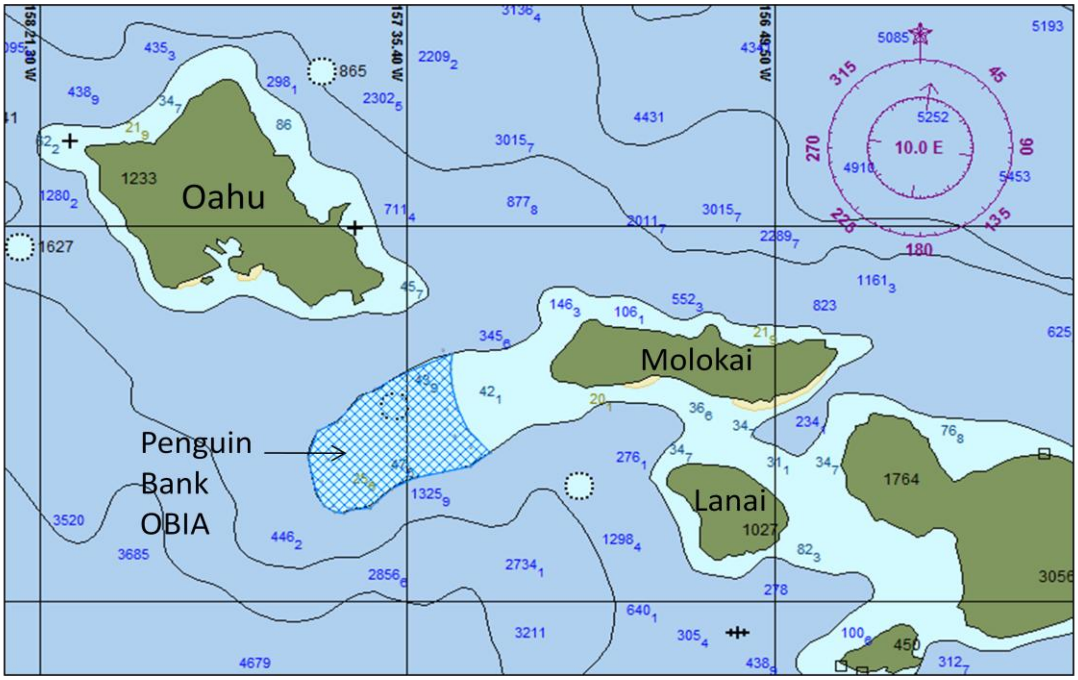


Figure D-15. OBIA 17: Penguin Bank, Hawaiian Island Humpback Whale National Marine Sanctuary.

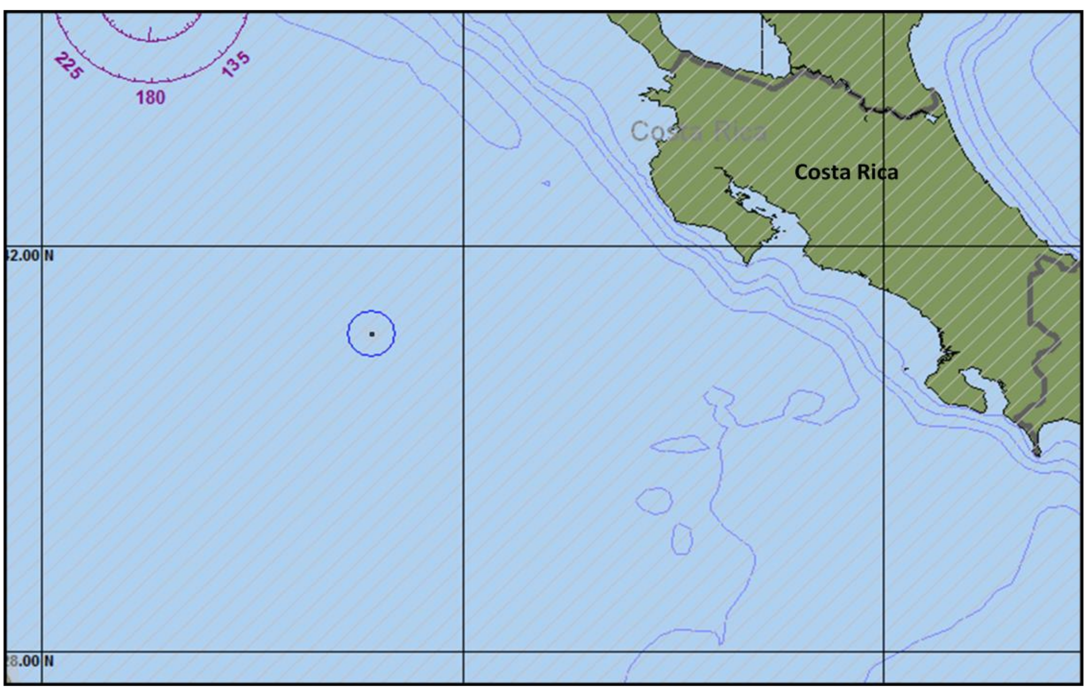


Figure D-16. OBIA 18: Costa Rica Dome.

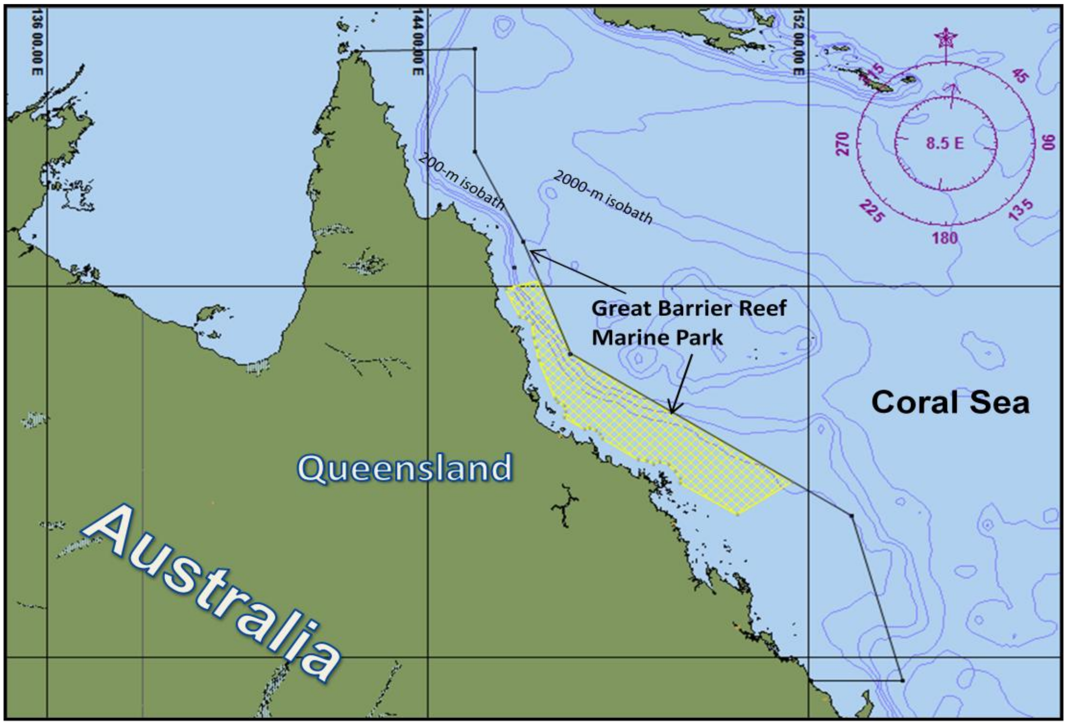


Figure D-17. OBIA 19: Great Barrier Reef between 16°S and 21°S.

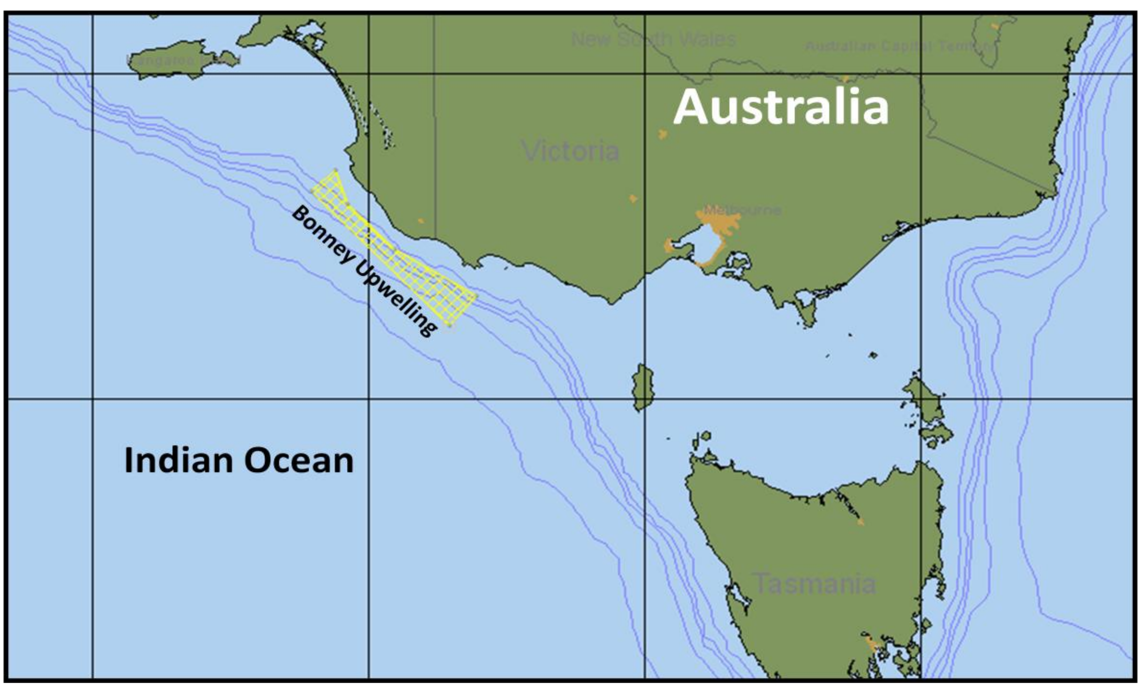


Figure D-18. OBIA 20: Bonney Upwelling.

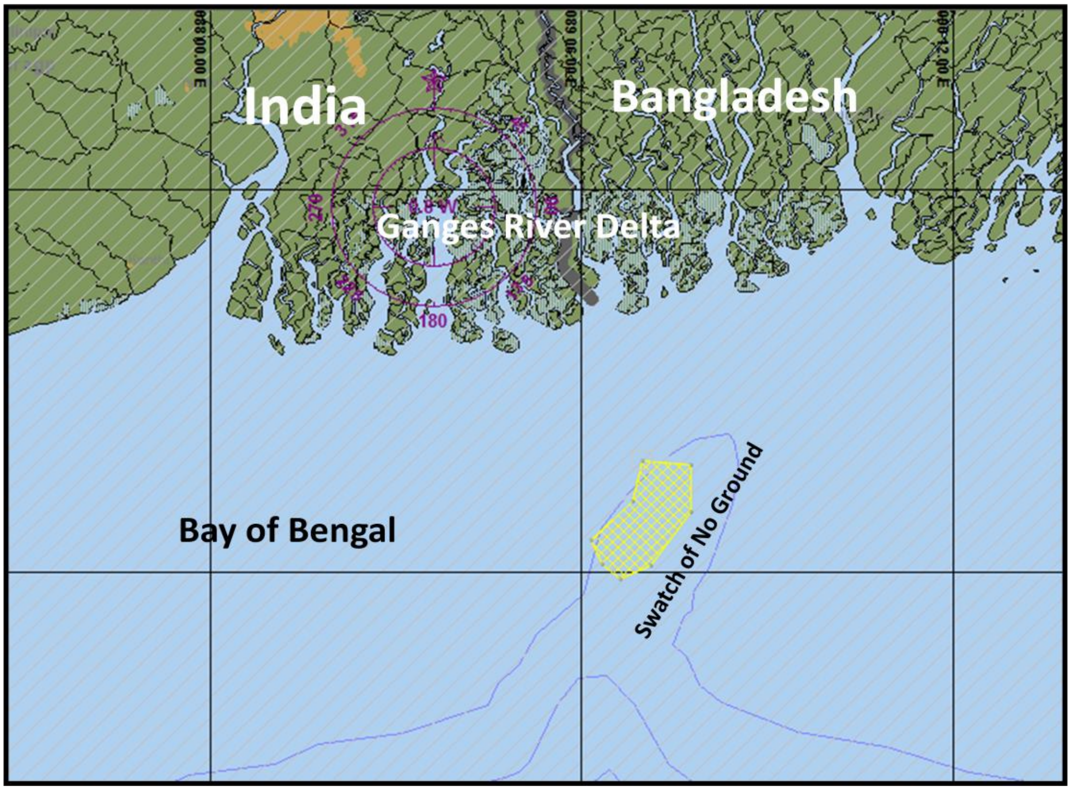


Figure D-19. OBIA 21: Head of Swatch-of-No-Ground (SoNG), Northern Bay of Bengal.

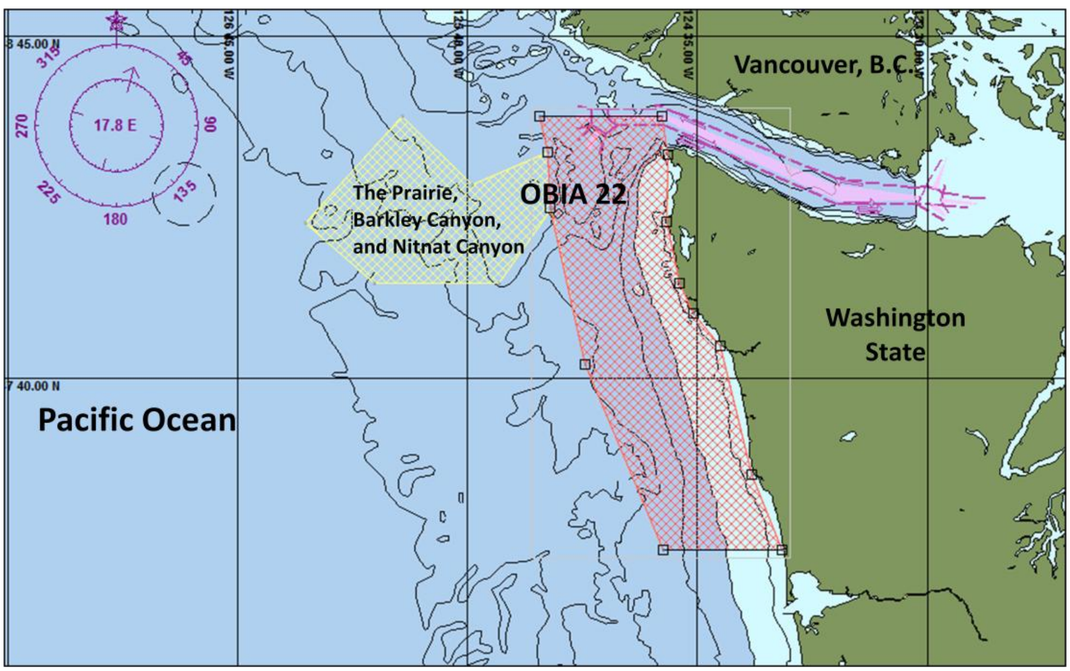


Figure D-20. OBIA 22: Olympic Coast and the Prairie, Barkley, and Nitnat Canyons.

APPENDIX E—

DETAILED ANALYSIS FOR POTENTIAL MMPA LEVEL B EFFECTS FROM THE CUMULATIVE EFFECTS OF CONCURRENT LFA AND MFA SONAR OPERATIONS

THIS PAGE IS INTENTIONALLY LEFT BLANK

E-1 DISCUSSION OF THE PROBLEM AND POSSIBLE APPROACHES TO THE SOLUTION

This appendix provides more information on the analyses the Navy conducted regarding the potential effects when SURTASS LFA sonar and MFA sonar (AN/SQS-53C) may be operating concurrently. The question of whether the effects of two active sonar systems with different operating characteristics (i.e., frequency, pulse length, waveforms, etc.) operating concurrently is greater than the effects from each system operating individually is complex given the multitude of environments and conditions possible in the oceans of the world. The variables that can influence how the two sonar transmissions could combine and thus influence their potential for effects on marine mammals include:

- Each sonar's frequency, transmitted source level, the water depth of the source, the transmitted beam pattern, waveform type, transmission duration, and interval between transmissions, etc.;
- The location of each source and the course and speed of the source's vessel over the duration of the evolution or exercise;
- The underwater sound propagation paths present in the area, their extent and variability (including diurnal patterns and other short-term variations as well as seasonal and other, longer-term variations, [such as El Niño], local weather, tides, and the general variability of the water mass due to currents, ocean fronts, eddies, and etc.);
- The variability of the ocean surface (i.e., wave heights) and seafloor characteristics throughout the area;
- The animal species potentially present in the area, their distribution, abundance and density;
- The activities those species are involved in, which influences the depths where they are found in the water column, and how they are moving through the area (i.e., migrating, searching for food, feeding, searching for mates, breeding, etc.);
- The hearing sensitivity for these species in the frequencies transmitted by each of the sources; and
- The other noise present across the frequencies of interest, such as naturally-occurring noise from high wind conditions, rain and/or lightning storms, and earthquakes, as well as man-made noise such as shipping noise, explosions and seismic airgun operations.

For the purposes of analyzing potential effects of SURTASS LFA sonar and MFA sonar, these complexities can be better managed, because some of the variables are known, and others can be simplified through use of reasonable and conservative assumptions:

- To simplify the analysis, with negligible loss of accuracy, a single representative frequency for each sonar system was used.
- Actual source depths for SURTASS LFA sonar (122 m [400 ft]) and for the MFA sonar (8 m [26.2 ft]) were used.
- Because analyzing all of the potential operation areas where overlapping SURTASS LFA sonar and MFA sonar transmissions could occur is infeasible, representative areas in the North Pacific Ocean were used. These areas were chosen because they represent areas where concurrent SURTASS LFA and MFA sonar operations are most probable in the near term and convergence zone (CZ)

sound propagation[1] is most prominent. Analysis of other oceanic areas where CZ propagation is most prominent would be expected to yield negligible differences in results from those presented here.

- A reasonable estimation of risk from concurrent operations of LFA and MFA sonars can be derived from the LFA risk continuum curve (see Figure 4.7-2). Generally conservative values were used for most of the sonar operating parameters for both systems (i.e., source level, waveform type, transmission duration, interval between transmissions, etc.). For example, maximum source level for particular sonar operating modes, longer duration transmissions and shorter intervals between transmissions were used, all of which should notionally increase the potential for effects.
- The widest and most volume-ensonifying beam patterns for each source were used. For the MFA sonar, an omni-directional beam pattern (i.e., 360 degrees in 3D) was assumed, although in fact a significant volume of the beam pattern is blocked by the ship's hull. For LFA sonar, an omni-directional beam pattern in the horizontal plane was assumed, with the narrow sonar beam vertically-steered a nominal ±10 degrees from the horizontal. The ensuing ensonified area can be likened to a flat disk centered on the LFA source array, which is mounted on a vertical line array beneath the ship. The differences in the beam patterns for the two sonars are due primarily to differences in their construction, with LFA sonar being deployed below the ship and MFA sonar being mounted on the forward hull of the ship.

Existing LFA and MFA sonar analytical methodologies are dissimilar (e.g., the LFA sonar risk continuum uses a 60-sec transmission, while MFA sonar uses a 1-sec transmission). Because the LFA sonar risk continuum allows for the addition of acoustic energy from multiple underwater sound sources and provides an estimated animal exposure level as if that energy comes from a single source, it was used for this analysis.

It should be noted that there is a lack of scientific data on analytical methodologies to address whether or not (or under what circumstances) an animal will behave differently in the presence of two or more sources. Therefore, it was necessary to make the reasonable and conservative assumptions stated above, and to recognize the limitations of the available analysis techniques.

Based on the above assumptions and discussion, the potential effects from concurrent MFA and LFA sonar operations were analyzed using two distinct approaches as defined in Subchapter 4.7.4.1.2:

- Parametric analysis (Section E-2.0; and
- Acoustic Integration Model analyses (Section E-3.0)

E.2 PARAMETRIC ANALYSIS

Typically, in dimensional analyses[2] the complexity and number of the dimensions or quantities acting on the variables is such that several dimensionless parameters/numbers are ultimately used to understand and visualize how the variables react under varying conditions (an example of this will be presented below). However, for this acoustic analysis, a single parameter (i.e., the range between a receiver location and the source locations, which acoustically equates to the transmission loss [TL] as a function of range and depth) will ultimately control how the variable (i.e., potential acoustic impacts to a species) is

1 A convergence zone is a region in the deep ocean where sound rays, refracted from the depths, arrive at the surface in successive intervals of 55 to 64 km (30 to 35 nmi). The repeated occurrence of these zones to several hundred miles from the sound source depends on the refraction of sound at depth and the reflection of these rays at the surface.

2 Dimensional analysis defined by Avallone et al. (1987) as "the mathematics of dimensions and quantities and provides procedural techniques whereby the variables that are assumed to be significant in a problem can be formed into dimensionless parameters, the number of parameters being less than the number of variables."

affected. Thus, this dimensional analysis will be simplified into a single dimensional analysis, or a "parametric analysis[3]."

Technically, the sound propagation is a function of both the receiver (animal) depth and the range of that receiver (animal) from the sound source. However, there are other ways to quantify a sound propagation type (at least approximately). For example, sound propagation via a CZ can be quantified by the range to the CZ annulus[4] (i.e., the distance from the sound source to the point where the CZ returns to the ocean surface [typically 30 to 35 nmi in the North Pacific Ocean]). Effectively, the range to a CZ's annulus is therefore a "critical acoustic parameter;" in this case the "critical acoustic distance" which can be used to characterize the sound propagation for the modeled water volume. Additionally, since the distance between the sound sources determines the range from each modeled location and the TL from each sound source to that location, the distance between the sound sources is a variable, which will change the average risk per modeled location in the modeled water volume. Thus, when these factors are combined, a dimensionless parameter consisting of their ratio is produced.

$$\frac{\text{Distance between the sound sources (km or nmi)}}{\text{Critical acoustic distance (km or nmi)}} = \text{Dimensionless Parameter} \qquad (1)$$

The critical acoustic distance will be different for each type of sound propagation condition encountered. For example, for ducted sound propagation, it will still be a constant, but related to the depth of the duct, which in turn identifies which sound frequencies will be trapped in the duct. Regardless of what the critical acoustic distance is, the examination of the above dimensionless number (equation [1]) will provide insight into how the variable (i.e., average risk per modeled location) will change as a function of the dimensionless parameter. Since it appears that this analysis can be performed through the use of a single dimensionless parameter (i.e., the dimensionless ratio of equation [1]), coupled with the resulting effects on marine animals in the region of overlap of the LFA and MFA sonar sound fields, this dimensional analysis has been simplified to a "parametric analysis," and will be identified as such for the remainder of this appendix. Finally, since the critical acoustic distance is a fixed value (i.e., a constant) for a modeled sound propagation condition (for this CZ propagation condition it is about 60 km or 32.4 nmi), the dimensionless value of the distance between the sound sources can also be applied during this analysis. To do this entails the additional step of dividing that distance by the critical acoustic distance in order to "normalize" the relationship and represent the data as a function of the dimensionless parameter.

E-2.1 Initial Analyses Assumptions and Approach

Given that the critical acoustic distance is the significant parameter, the remaining factor needed to quantify the underwater sound fields is the underwater sound propagation, or TL between the sound sources and the modeled locations surrounding each sound source.

Underwater sound propagation and the sound speed profiles[5] (SSPs) of the North Pacific Ocean have been studied and reported on for decades (Podezwa, 1976; NAVOCEANO, 1982; Kerr et al., 1994; JASA, 2005) and are fairly well known and documented in the existing acoustic databases (OAML, 2002). Based on these reports, and the modeling efforts using these databases, the deep-water (waters not on either a continental shelf or slope) sound propagation in the North Pacific Ocean can be characterized into three general categories: 1) surface duct[6] or half-channel[7]; 2) convergence zone (CZ); and 3) bottom-

---

3 Parametric analysis is a methodology to describe and examine the relationship between different parameters, (e.g., in this case acoustic transmission loss as a function of range and depth) and the variable (e.g., potential acoustic impact to marine mammals) that it/they influence or affect.

4 The CZ annulus is the sea surface areal extent of the sound energy that has traveled from the sound source via the CZ propagation path. The annulus width is nominally about 10% of the distance from the sound source to the CZ annulus.

5 Sound speed profile (SSP) is a plot of underwater sound speed as a function of water depth.

6 In underwater acoustics, a zone below the sea surface where sound rays are refracted toward the surface and then reflected. The rays alternately are refracted and reflected along the duct out to relatively long distances from the sound source.

limited[8]. Most of the surface duct or half-channel sound propagation occurs north of latitude 45°N for the eastern North Pacific Ocean and north of about 42°N for the western North Pacific Ocean. The remainder of the North Pacific Ocean typically shows CZ propagation if the water is deep enough to allow the sound rays to bend at their deepest point without striking the bottom. Otherwise, the initial CZ-like sound propagation encounters the ocean bottom and is reflected off it (hence, it would be bottom-limited). It varies somewhat by season, but approximately 90% of the North Pacific Ocean, between 20°N and the ducted northern regions, supports CZ sound propagation. Thus, CZ sound propagation is a reasonable initial representative for deep-water propagation in the North Pacific Ocean. To simplify this analysis, and because it reflects the most probable water depths for concurrent LFA and MFA sonar operations, this parametric analysis will focus on deep water and CZ sound propagation.

Sample SSPs from approximately 30°N/155°E (i.e., in the Philippine Sea) were extracted from the Generalized Digital Environmental Model (GDEM[9]) database and used for the CZ modeling. This SSP generates a characteristic CZ for a shallow (i.e., about 8 m [26.2 ft] deep) MFA sonar at a range of between about 60 to 64 km (32.4 to 34.6 nmi), or a 4.1-km (2.2–nmi) CZ annulus when calculated using the Comprehensive Acoustic Simulation System/Gaussian Ray Bundle (CASS/GRAB[10]) model (Weinberg et al., 2001). The deeper LFA source (122 m [400 ft]) has a slightly wider CZ annulus of 5.9 km (3.2 nmi), at about 57 to 63 km (30.8 to 34.0 nmi) distance from the sound source. Using the source operational characteristics that were identified in Chapter 4 (Table 4.7-1), the TL for both the MFA and LFA sonars were derived and plotted (Figure E-1). For the purpose of this analysis, a nominal 60 km (32.4 nmi) range to the CZ annulus for both LFA and MFA was used.

Since the range from each source to its CZ annulus is approximately 60 km (32.4 nmi), it was decided to begin by using a separation distance between the sources of 130 km (70.2 nmi) in order to ensure that no portion of the LFA or MFA sonar CZ annuli would be overlapping at the outset. An examination of Figure E-1 will show that at 65 km (35 nmi) (i.e., the halfway point between the sources when they are 130 km apart) from each source, the MFA transmission has incurred at least 85 dB of TL, while the LFA transmission shows about 78 dB of TL. This is equivalent to maximum received levels at the mid-point of about 150 dB for both MFA and LFA transmissions. Therefore, this starting distance between the sources ensures that all possible modeled locations that could receive about 150 dB or higher have been examined. Additionally, based on the LFA Risk Continuum curve (Figure 4.7-2) all possible sites with greater than 2.5% (or 0.025) risk have been examined.

In the initial geometric arrangement of the two sources, the initial range was the maximum distance between the sources (130 km [70.2 nmi]) (Figure E-2). The parametric analysis needed to vary the distance between the sources (i.e., the variable portion of the dimensionless number or the variable parameter) to examine how potential levels of effects on marine mammals change as a function of that parameter. Since the critical acoustic parameter for this CZ propagation case has been identified and fixed at 60 km (32.4 nmi), the only method to adjust or vary the dimensionless parameter of equation (1) was to change the distance between the sound sources. This is represented in Figure E-2 by the

7 In underwater acoustics, an upward-refracting condition where the sound-speed gradient is positive from the surface all the way to the bottom. In a half channel, sound waves behave as if in a very thick surface duct.

8 Bottom-limited sound propagation indicates that the sound rays interact with the bottom in some way, particularly through the sound being absorbed and reflected by the bottom, and the sound being refracted through the surface layer of the bottom. A bottom-limited condition is the cause that generates the effect of bottom bounce sound propagation.

9 GDEM, developed by the U.S. Naval Oceanographic Office, derives vertical profiles of temperature and salinity in 30'x30' latitude-longitude grid elements and employs these data to calculate sound speed profiles. The temperature-salinity profiles are derived from quality-screened data from the Master Oceanographic Observation Data Set maintained by the Fleet Numerical Oceanography Center in Monterey, California.

10 CASS/GRAB is the Navy standard model for active and passive range-dependent acoustic propagation, reverberation and signal excess. Frequency range is 600 Hz to 100 kHz.

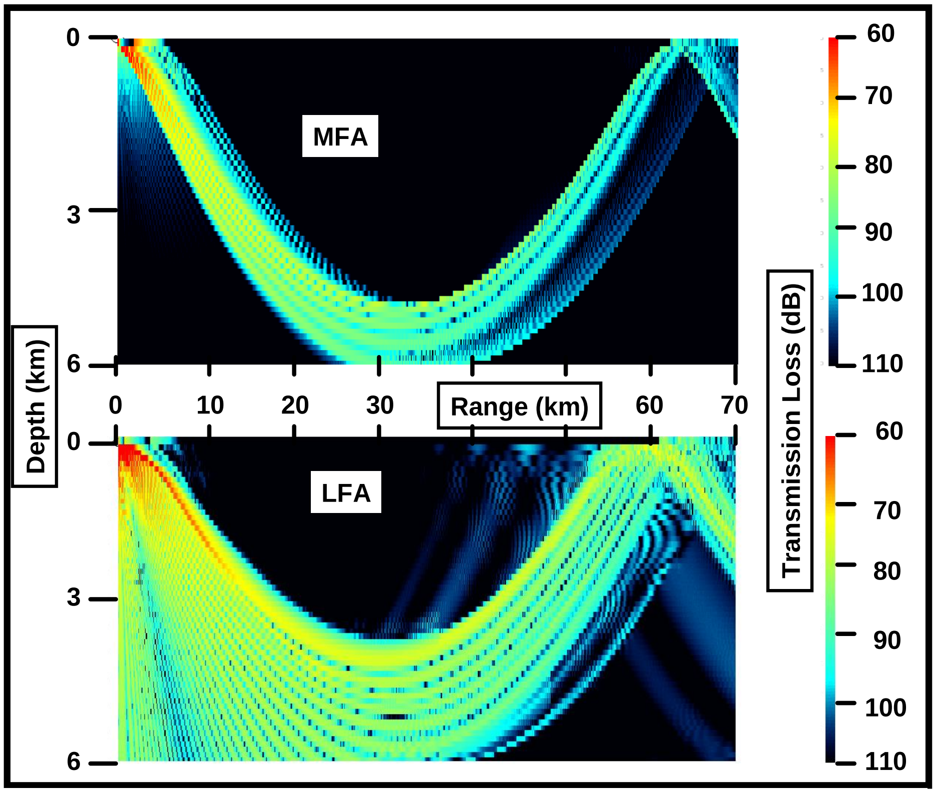


Figure E-1. TL Plots for MFA and LFA used in the analysis.

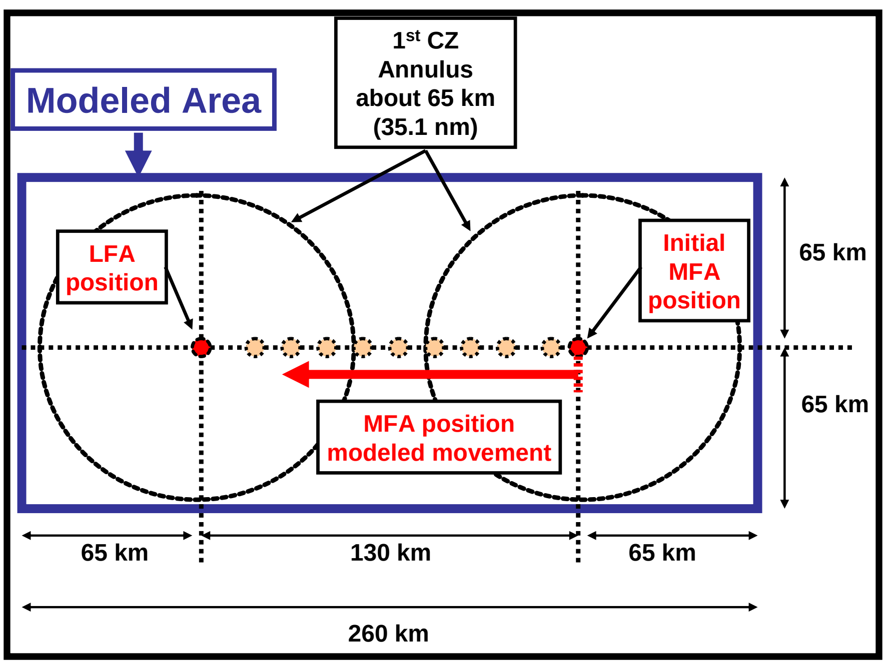


Figure E-2. Geometry of the modeled area used for the parametric analysis.

movement of the MFA sonar to the left (i.e., decreasing the range between the sources) for each subsequent run of the underwater acoustic propagation model. Before this modeling could be accomplished, some additional modeling decisions were necessary.

E-2.2 ADDITIONAL ANALYSES ASSUMPTIONS

Two additional general decisions needed to be made in order to complete the parametric analysis. The first was the selection of the acoustic propagation modeling resolution (i.e., the size of individual increments of water space to be analyzed) and the related need to identify the step increment for the ranges between the sound sources (i.e., how many distances between the sound sources would be examined). The second decision was to identify a metric for the potential changes to the effects on marine mammals.

E-2.2.1 Modeling Resolution and Step Sizes

For this analysis, a resolution of 50 m (164 ft) in the X and Y directions and 100 m (328 ft) for depth (Z direction) was used for both the acoustic model and the gridding of receiver locations in the analysis volume. This allowed the examination of over 6.3 million RL locations during each run (i.e., range step) of the analysis. These values are a reasonable compromise that allowed adequate resolution of the acoustic sound fields and timely completion of the calculations of the overlapping sound fields.

A preliminary analysis showed little variation in the average risk for each modeled location for a range step of 0.1 km (0.054 nmi) (i.e., the amount of distance between the LFA and MFA sources changed each time the model was rerun). There was concern that a range step of 1.0 km (0.54 nmi) might miss details of the results. Thus, a compromise of 0.5 km (0.27 nmi) was decided on as the appropriate range step size.

E-2.2.2 Effects Metric

Prior to deciding on the effects metric, some care must be taken to correctly identify how these two different sonar transmissions can add to each other at the receiver locations modeled in the parametric analysis. The combined transmission of an LFA and MFA sonar has a maximum addition of 3 dB if the RLs of the two transmissions are equal, but as one transmission grows stronger than the other because of the receiver location and the TL of the transmissions to that location, the contribution of the weaker transmission decreases accordingly (Figure E-3). Thus if the weaker transmission is 5 dB less than the stronger, the additional energy only adds 1.2 dB, and by the time the difference is 10 dB, the addition is only about 0.4 dB. Therefore, for each transmission to contribute significantly (i.e., greater than 0.4 dB) when combined, the RLs for the transmissions must be within about 10 dB of each other.

For the purposes of this transmission addition discussion, it was assumed that the transmissions arrived at the receiver location at the same time. As discussed in Subchapter 4.7.4, however, this kind of exact overlap of LFA and MFA sonar sound would only occur at each receiver location (i.e., modeled grid location) for approximately 2 seconds every 10 minutes or so, due to the nominal 60-second duration of the LFA sonar transmission approximately every 10 minutes, and the nominal one-second MFA transmission every 30 seconds or so. The period of overlapping transmissions (0.32 percent of the time that both sonars are operating) is the only time and place that could possibly contribute to the combined effects (i.e., other times and locations will only have one transmission present at the most). Hence, the model was designed to ignore the transmission travel times and assume that for each receiver location the two transmissions arrived “simultaneously” after incurring the appropriate TL as their sound propagated to that location.

Because it is impossible to know what marine mammals, if any, are present at the time and place when the LFA and MFA sonar transmissions overlap, it was assumed that all the receiver locations have an equal number of marine mammals. These two assumptions (i.e., that the transmissions arrive

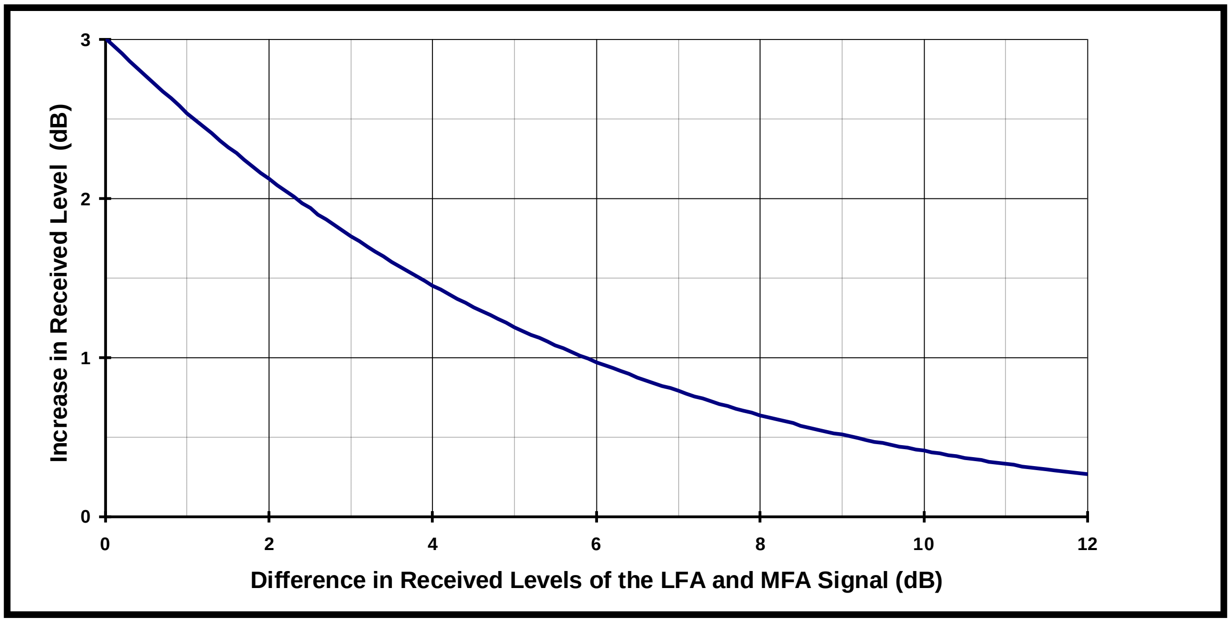


Figure E-3. Net increase in received level of the combined transmission, based on the difference in individual transmissions at these frequencies.

simultaneously at all locations, and that all locations have an equal number of marine mammals) further facilitated the examination of potential effects from: 1) the LFA sonar alone; 2) the MFA sonar alone; and 3) the combined LFA and MFA sonars operating concurrently.

The simplest way to identify a combined effects metric that includes the modeling discussed above and allows for the application of the SURTASS LFA sonar risk continuum is to apply that risk continuum to each modeled location, and then sum the total risk for the entire modeled water volume. This was done for the three transmission reception cases (i.e., the LFA sonar transmission alone, the MFA sonar transmission alone, and the combined LFA and MFA sonar transmissions). The effects from the two independent cases (i.e., the LFA sonar transmission alone, the MFA sonar transmission alone) were then added and compared to the combined case, for the modeled separation range between the two sources. Then the sources were moved closer together based on the 0.5-km (0.27-nmi) range step size, and the model was rerun again for the new source range difference. The process was repeated multiple times to create Figure E-4, which graphically represents the percent change in risk per modeled location.

E-2.2.3 Discussion of the Parametric Analysis Results

First, all of the results of the analyses show a change in risk percentage of zero or less (Figure E-4). In other words, there is actually less risk where the MFA and LFA sonar transmissions overlap than there is from simply combining the risk from the transmissions from the sonars operating independently, and the larger the volume of the overlapping transmissions (i.e., when the sources are less than 10 km apart), the greater the reduction in risk. This counter-intuitive result is discussed further in Section E-2.4.

The second message from Figure E-4 is the correlation between the “dips” in the curves and real-world conditions. As the labels in the figure explain, the three black arrows correspond to the particular configurations of the sonars and the CZ annuli (Figures E-5, E-6, and E-7). Note that when the sources’ CZs intersect, the dark green areas indicate where there would be an expected increase in Level B volumes.

Essentially, the three “dips” in the separation ranges shown in Figure E-4 reinforce the conclusion that as more of the volume has overlapping transmissions of similar received level, the overall risk is decreased.

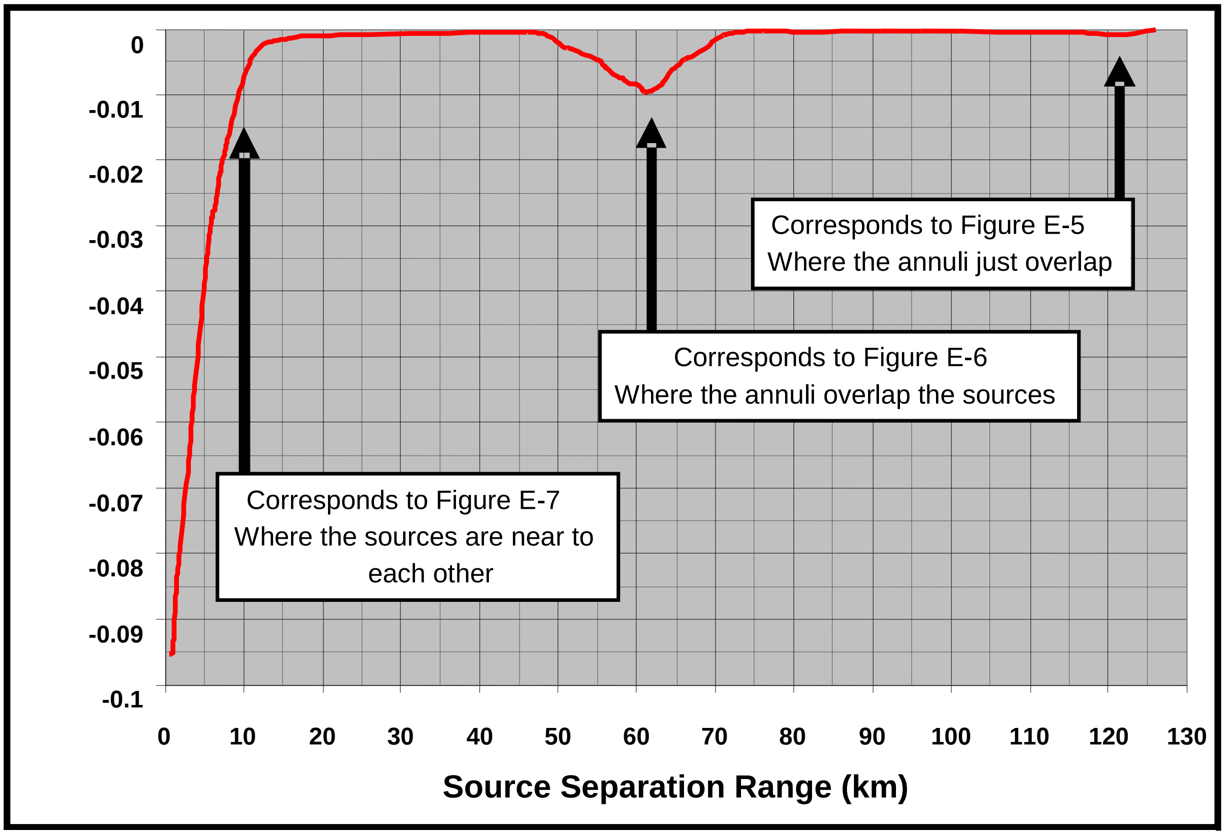


Figure E-4. Percent change in risk as a function of source separation distance.

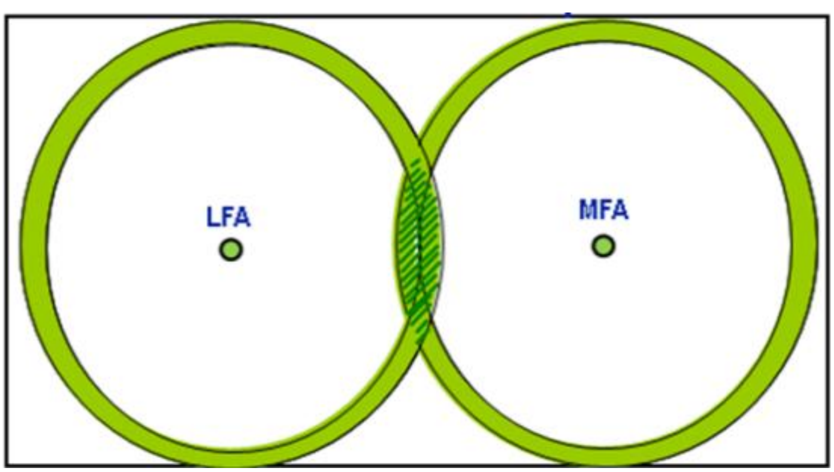


Figure E-5. Source separation distance of about 120 km, where the CZ annuli are just overlapping.

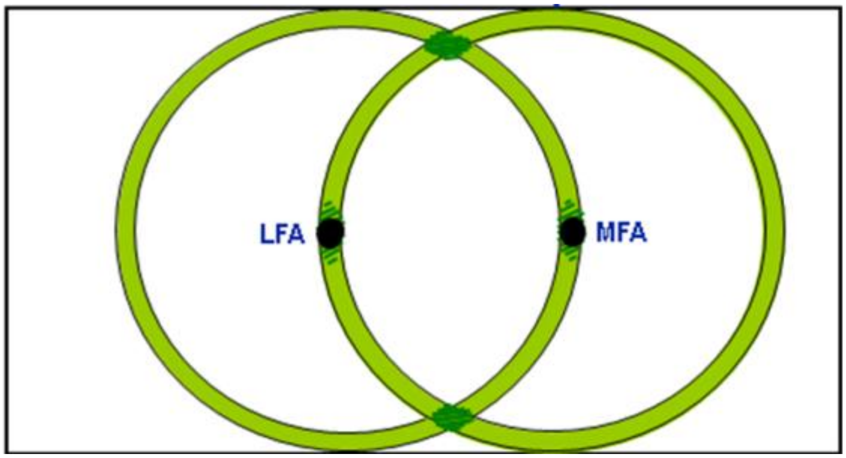


Figure E-6. Source separation distance of about 60 km, where the CZ annuli are just overlapping the LFA and MFA sources.

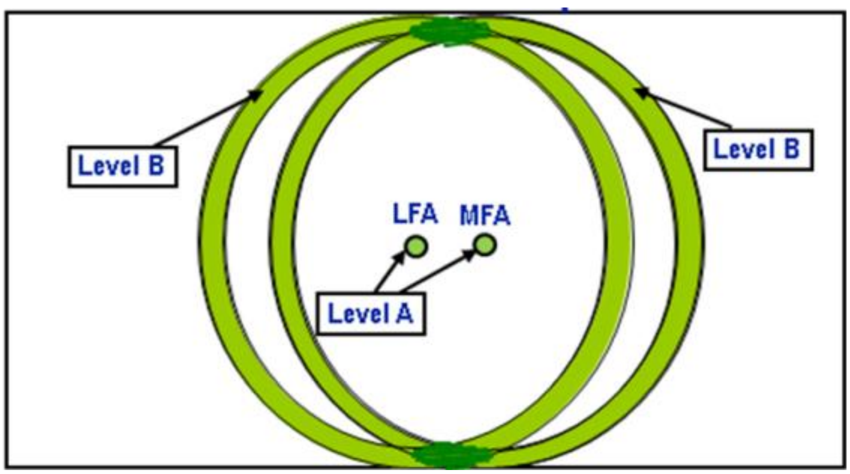


Figure E-7. Source separation distance of 10 km or less, where the LFA and MFA sources are in proximity.

By covering the full gamut of MFA/LFA sonar separation distances where the parametric analysis indicated that there might be changes to the risk, the realistic combinations of the critical parameter (i.e., sonar separation range) were examined and found to have no increase (and often exhibit a decrease) in risk when the sonars operate concurrently, as compared to when they operate independently. The analysis has covered all realistic configurations of the MFA and LFA sonars for the CZ case revealing that, regardless of what the source ship tracks and speeds are, the change in risk between MFA and LFA sonars operating independently as opposed to concurrently will be zero or less. Thus, there is no possibility of increased effects from the addition of LFA and MFA sonar transmissions when operating concurrently, beyond the risk associated with the systems operating independently.

Essentially, the three "dips" in the separation ranges shown in Figure E-4 reinforce the conclusion that as more of the volume has overlapping transmissions of similar received level, the overall risk is decreased. By covering the full gamut of MFA/LFA sonar separation distances where the parametric analysis indicated that there might be changes to the risk, the realistic combinations of the critical parameter (i.e., sonar separation range) were examined and found to have no increase (and often exhibit a decrease) in risk when the sonars operate concurrently, as compared to when they operate independently. The analysis has covered all realistic configurations of the MFA and LFA sonars for the CZ case revealing that, regardless of what the source ship tracks and speeds are, the change in risk between MFA and LFA sonars operating independently as opposed to concurrently will be zero or less. Thus, there is no possibility of increased effects from the addition of LFA and MFA sonar transmissions when operating concurrently, beyond the risk associated with the systems operating independently.

Further, even though this analysis was conducted for the CZ case, the results can be considered to be germane to the other two deep-water acoustic propagation modes that may be encountered in the North Pacific Ocean and other potential SURTASS LFA sonar operating areas. For example, the ducted and half-channel propagation situations produce a RL volume originating near the sources and extending outward undergoing cylindrical spreading, which has less TL than the typical spherical spreading expected at these ranges. This volume will therefore have higher RLs for both the LFA and MFA sonar transmissions than the CZ case above. This greater RL volume would translate to greater “dips” or reductions in average risk for modeled locations. Similarly, the bottom-limited case (i.e., where the transmitted sound rays reflect off the ocean bottom before they refract or bend upward as they would in a CZ) would also have more RL volume with strong received transmissions, because the bottom reflections would ensonify a greater portion of the volume of the ocean than just that volume in the CZ path. Thus, this case would also have higher RLs for both the LFA and MFA sonar transmissions and corresponding decreases in risk for MFA/LFA sonar concurrent operations.

E-2.2.4 Explanation of the Results of the Parametric Analysis

The risk decreases when the LFA and MFA sonar’s CZ annuli overlap with each other, or with the sources themselves, because in many locations throughout the RL volume of the two overlapping MFA/LFA sonar sound fields, one sonar transmission dominates or overshadows the other transmission, and minimizes its contribution to the total risk experienced at each modeled location. This risk value is slightly larger than either of the individual risk values viewed separately, but it is less than the risk of the two independent risk values added together. Indeed, for most of the modeled locations throughout the modeled volume, one of two cases occurs: a) one of the RLs is significantly higher (i.e., greater than 10 dB) than the other RL; or b) both RLs are below the 120-dB RL of the risk continuum where risk is considered zero.

For case (a) the higher RL dominates in both the combined RL value and in the contribution of its individual risk (Figure E-8); so, the difference between the “combined risk” (dark blue [source A] and yellow [source B]) and their “combined energy” (green case) ends up being negligible. Only when RL locations have similar or close RLs for sources A and B (i.e., in case [b]) do slightly larger decreases in risk occur to the total risk throughout the sound field (Figure E-9). As the number of these locations increases (i.e., when the CZ annuli overlap), so does the change in total risk become noticeable, as in Figure E-4. However, it never results in an increase in the risk experienced from the addition of independent risks from the MFA and LFA sonars.

In a case when two RLs are about equal, two RLs for sources A and B, respectively, are shown for a RL location where both RLs are about 135 dB (shown as the dark blue and yellow circles, respectively) (Figure E-9). The individual risk for each of these single RLs, if treated separately, is shown as the dark blue and yellow rectangles on the vertical or “risk” axis of the figure (assume 0.020 for source A and 0.023 for source B). If the energy for the two RLs is combined, the resulting RL (shown as the green circle) is a maximum of approximately 3 dB higher than the larger of RLs of source A or source B (i.e., 3 dB higher than RL B which is 135 dB—thus, it is 138 dB). The corresponding risk for the combined energy case is the green rectangle—at about 0.035 on the vertical axis.

By contrast, a simple addition of the risk for the two individual sources (i.e., the dark blue and yellow rectangles), shown as a dark blue and yellow striped rectangle, carries a risk value of approximately

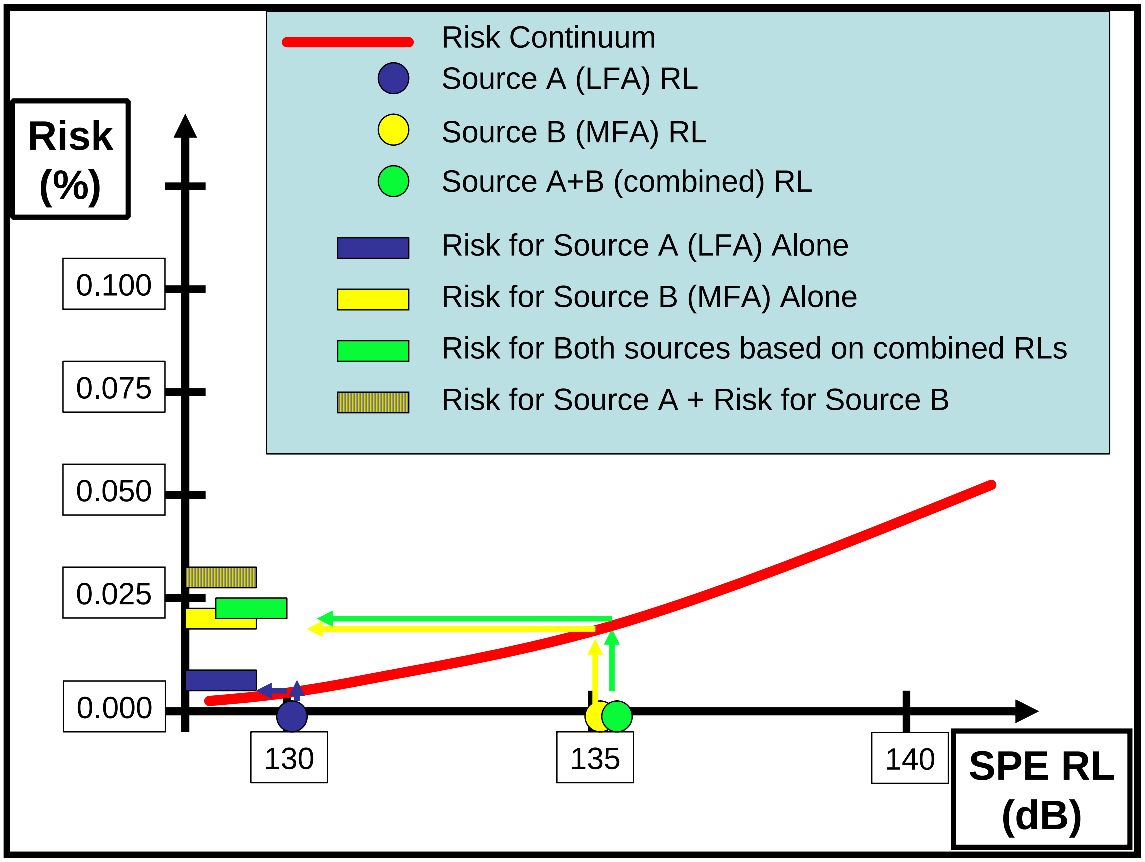


Figure E-8. Graphic representation of the calculation for combined risk for two separate sources for the case of dissimilar received levels.

0.043 (i.e., the risk from A and B separately added: 0.020 + 0.023 = 0.043). The risk of the combined transmissions (green) is therefore less than that of the two transmissions treated separately, specifically about -0.008 less (0.035 – 0.043 = – 0.008).

In the parametric analysis, this slight difference in risk can occur at many points throughout the overlapping sound fields of the modeled RL volume, with each sonar transmission. It is the addition of reduced risk provided by many modeled locations that slowly accumulates and results in the overall risk reduction that appears in Figure E-4.

In most real-world cases the two received transmissions will not be equal (i.e., the blue and yellow circles will not be at about the same level); in fact, one transmission may be as much as 10 dB or so below the other but only contribute slightly to the overall risk. An example of a case where the difference in RL is 5 dB (Figure E-8), where the green circle, representing the combined RL, while slightly higher than the larger of the yellow and blue circles, is significantly closer to the larger of those two than was the case in Figure E-9. In this example, the individual risk values are 0.006 for source A (blue circle) and 0.022 for source B (yellow circle), with the combined (green rectangle) risk being 0.024, and the summed risk being 0.028. Thus, the change or decrease in risk for this case is about 0.004 (i.e., 0.024 – 0.028 = – 0.004). This is about half of the risk reduction for the case where the RLs are nearly equal.

E-2.2.5 Parametric Analysis Summary

In summary, the results of this parametric analysis, which utilized the SURTASS LFA sonar risk continuum approach, show that the potential risk for Level B harassment from MFA and LFA sonar

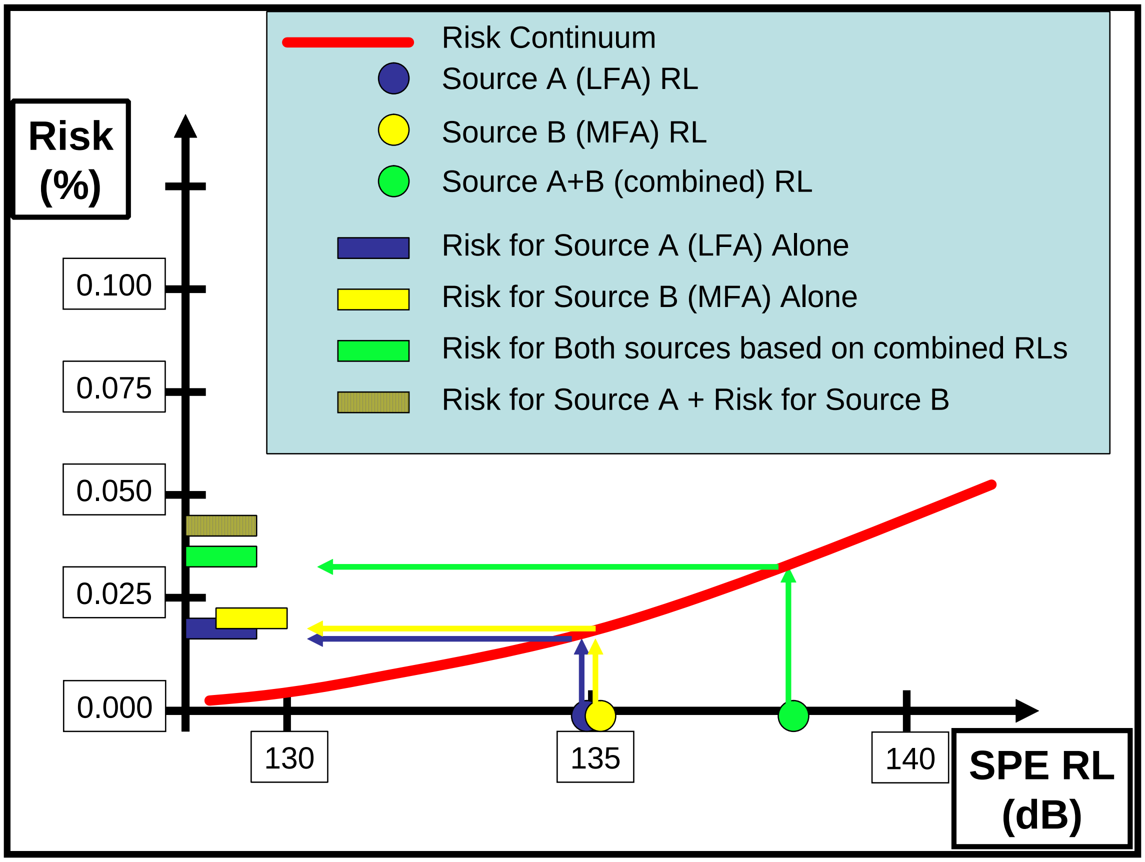


Figure E-9. Graphic representation of the calculation for combined risk for two separate sources for the case of similar received levels.

concurrent operations is not greater than the sum of the individual risks from each of the MFA and LFA sonar sources operating independently.

E-3 ACOUSTIC INTEGRATION MODEL (AIM) ANALYSIS

The model analysis presented here is an attempt to create a simulation of a representative concurrent operation with one LFA sonar and one MFA sonar. Actual waypoints representing plausible ship courses are input into the model, as are the source characteristics of each vessel (Table E-1). Each modeled vessel produces a sonar ping according to the programmed sonar plan for the vessel. A population of representative marine mammals is placed in the simulation around the vessels. These simulated animals, referred to as “animats,” are programmed to move in four dimensions, with movement parameters derived from actual animals. The acoustic propagation from the ships to each animat is modeled with the Ocean and Atmospheric Master Library (OAML[11])-approved Parabolic Equation (PE[12]) model (Zingareli et al.,

11 The Chief of Naval Operations (CNO) established OAML in 1984. The OAML suite consists of Navy-standard core-models, algorithms and databases that support the Department of the Navy, Department of Defense, research and development laboratories and Joint and NATO activities.

12 Parabolic Equation (PE) 5.0 is a robust and capable model that incorporates one of the fastest and most accurate acoustic models, the Range-dependent Acoustic Model (RAM). For the most part, both the ocean acoustics R&D community and the Navy operational community are using the same PE model.

Table E-1. Source characteristics used for AIM modeling.

SOURCE	LOW-FREQUENCY ACTIVE SONAR	MID-FREQUENCY ACTIVE SONAR
Source Level	Typical Operational	Typical Operational
Frequency	250 Hz	3500 Hz
Duty Cycle	60 second transmission every ten minutes	1 second transmission every 30 seconds
Beam Pattern	Normal LFA beam pattern	Normal omni-directional transmission, vertically beamformed

1999) for the LFA ship and the ray-based BELLHOP[13] model (Porter, 1992) for the MFA source (because BELLHOP is better suited to the acoustic parameters of MF sources than PE). The received level (RL) at each animat can therefore be predicted. These predicted RLs are then analyzed using the standard methods as described in Subchapter 4.4.1 of the SURTASS LFA Sonar Final SEIS (Department of the Navy (DoN, 2007). One additional calculation is needed to sum MFA and LFA transmissions that arrive simultaneously, which is discussed in Section E.3.2 below.

E-3.1 DESCRIPTION OF AIM

The concern for underwater acoustic impacts to marine mammals has been growing since the 1990s. Because of the complexity of underwater acoustic propagation, acoustic exposure of marine animals is a function of the animal's depth as much as its range from the source. Therefore, the accurate prediction of acoustic exposure of free-ranging animals requires the consideration of animal movement as well as physical environmental conditions. The Acoustic Integration Model (AIM) was developed to address this requirement. Furthermore, any impact analysis model needs to be able to fully address: 1) changing and variable acoustic thresholds; 2) the scarcity of data on marine mammal densities, distribution and their behavioral responses to underwater sound; 3) constantly improving and expanding environmental data bases and propagation model capabilities; and 4) the requirement from both federal regulators and the public to use the best available science for any impact analysis process. AIM has been at the forefront of these issues and has attempted to properly address them since its development in the late 1990s. It was first applied to the U.S. Navy's SURTASS LFA Sonar EIS/OEIS (DoN, 2001), which was the first EIS prepared for a Navy operational system. Since then it has been used for other acoustic sources, including seismic profilers, underwater explosives, over-water sonic booms, and numerous active sonar applications. Today it is an open architecture coalition of candidate models and databases. The component of AIM that remains actively involved in all AIM executions is the animat movement engine, which creates the sound sources and animats of interest, moves them in 3D in the ocean volume, and facilitates tracking the estimated sound exposure on each modeled marine mammal.

---

13 BELLHOP computes underwater acoustic transmission paths via beam (ray) tracing. Ray tracing is a method for calculating the path of sonar beams through water with regions of varying propagation conditions, absorption characteristics, and reflecting surfaces. Under these circumstances, sonar beam may bend, change direction, or reflect off the water surface or seafloor, complicating analysis. Ray tracing solves the problem by repeatedly advancing idealized narrow beams called *rays* through the water by discrete amounts. Simple problems can be analyzed by propagating a few rays using simple mathematics. More detailed analyses can be performed by using a computer to propagate many rays.

Because the exact underwater positions of sources and receivers cannot be known, multiple runs of realistic predictions are used to provide statistical validity. The movement and/or behavioral patterns of sources and receivers can be known, and these data are incorporated into the model. Accurate representation of the movements of sources and receivers is necessary for realistic predictions. Each source and/or receiver is modeled via the animat concept. Each animat has parameters that control its speed and direction in three dimensions. Thus, it is possible to recreate the type of diving pattern that an animal shows in the real world. Furthermore, the movement of the animat can be programmed to respond to environmental factors, such as water depth and sound level. In this way, species that normally inhabit specific environments can be constrained in the model to stay within that habitat.

Once the behavior of the animats has been programmed, the model is run. AIM proceeds forward in time, with all features following the same master clock; the source produces a sound, the transmitted sound level at all ranges and depths is calculated using the propagation loss model, the range and depth of each animat at that time is noted and the respective RL for that animat is noted and retained with that animat's record. Then each animat and the source move ahead in time to the next source transmission, and the process is repeated. This continues until all source transmissions have been completed. After all the programmed runs are complete, each animat's full record of exposure levels is analyzed and a risk assessment is assigned, both to individual animals, as well as the resident population.

E-3.2 DESCRIPTION OF THE MODELING EFFORT

In this analysis, an approach similar to that used for estimating the potential environmental effects from real-world operations of SURTASS LFA sonar was used. Courses and speeds for both LFA and MFA vessels, and the LFA and MFA sonar acoustic characteristics were input into AIM. Each of three potential operational scenarios was then populated with marine mammals around the LFA and MFA vessels (see Sections E-3.2.3, E-3.2.4 and E-3.2.5 below). The model was then run to predict the sound source exposure history for individual animals in each MFA/LFA concurrent operations exposure scenarios.

E-3.2.1 Selection of the Scenarios to be Modeled

The ship movement scenarios selected were designed to address both intentional (clearing) and incidental (closing or parallel courses) interactions between LFA and MFA vessels. The clearing exercise scenario was designed as a possible sweep of an MFA ship around an LFA ship to detect any nearby submarines. The parallel course scenario is set up so that the LFA and MFA source ships start at approximately two CZs apart, with animals between them. The overtaking scenario starts with the MFA source ship approximately two CZs behind the LFA source ship, and then overtaking the LFA ship because of its greater speed. This scenario places the source ships much closer than would ever occur in actual LFA/MFA concurrent operations, but attempts to place an upper bound on potential risk.

E-3.2.2 Technical Approach

To estimate the acoustic exposure that an animal is likely to receive while the sources are transmitting, the movement of animals and the acoustic fields to which they would be exposed are modeled. The sound fields around each source are estimated based on details of the proposed acoustic sources using the Navy's standard PE model 5.0 for low-frequency sources (SURTASS LFA sonar) to a range of 150 km (81 nmi), and BELLHOP for mid-frequency sources (AN/SQS-53C) to a range of 100 km (54 nmi). AIM is used to simulate the acoustic exposure for each marine mammal species from the nominal transmissions of the MFA and LFA acoustic sources. Analyses were performed using generic animal species behavior, and each model run involved two 5-hour simulations (one for LFA and one for MFA), with animal 3D movement replicated.

To estimate the risk of harassment from each acoustic source, the individual acoustic exposures an animal receives were converted to single ping equivalent (SPE), using established SURTASS LFA sonar procedures (i.e., 5LogN, where N = number of exposures). This SPE is input into the SURTASS LFA

AIM Input Parameters

- Animat species was a generic baleen whale, based on blue and fin whale movement parameters.
- Animat density = 0.1 animats/sq km (this is the model density)
- Animal density = 0.001 animals/sq km (this is predicted density of real animals)
- MFA ship speed 18.5 km/hr (10 kt)
- LFA ship speed 6 km/hr (3.2 kt)
- Feller risk continuum curve parameters:
  - Basement (B) = 120 dB (same as baseline LFA case)
  - Transition Point (K) = 45 dB (same as baseline LFA case)
  - Slope Parameter (A) = 10 (as in the single LFA, single MFA, or combined effects LFA and MFA analysis).

sonar risk continuum to estimate Level B harassment (Figure 4.7-2). The SPE RLs are then evaluated for each source three ways: 1) separately; 2) additive (i.e., the two separate values added together); and 3) combined by summing the pressure of the two waveforms, a procedure that accounts for difference in frequency between the two transmissions.

Three nominal operational scenarios were analyzed:

- A “clearing” exercise scenario, analyzed for both CZ and surface duct underwater sound propagation;
- A “parallel courses” exercise scenario, with the LFA and MFA vessels two CZs apart, and the animals between the vessels, analyzed for both CZ and surface duct underwater sound propagation; and
- An “overtaking” exercise scenario, where the MFA vessel starts two CZs behind the LFA vessel, and by its greater speed, overtakes and passes the LFA vessel, analyzed for both CZ and surface duct underwater sound propagation.

The following AIM analyses could not be done for the whole world, so the overlapping SURTASS LFA sonar and MFA sonar operating areas have been localized to areas of the North Pacific Ocean for convergence zone (CZ) sound propagation conditions and the Gulf of Alaska for duct sound propagation conditions. The North Pacific should be considered the most probable scenario for concurrent SURTASS LFA and MFA sonar operations. Analysis of other oceanic areas where CZ propagation is most prominent would be expected to yield negligible differences in results from those presented here. For the duct sound propagation scenarios, the Gulf of Alaska region should be considered the most probable area for concurrent SURTASS LFA and MFA sonar operations where duct sound propagation conditions would exist. Likewise, analysis of other oceanic areas where duct propagation could occur would be expected to yield negligible differences from those presented here. Doing this for specific cases (e.g., MFA and LFA source ships one and two CZs apart) will also allow the testing of the fidelity of the parametric analytic approach by using a dynamic case with 3D animal movement. It should be noted that the risk values presented here do not take into account any effect of the mitigation measures required for either SURTASS LFA or MFA sonar, which would lessen any risk analyzed here.

E-3.2.3 "Clearing" Exercise Scenario

A "clearing" scenario consists of an MFA vessel "clearing" all sectors around the LFA vessel, starting in the rear port quadrant, moving forward, then starboard, then aft, to check all quadrants for possible submarines (Figure E-10). The results from the AIM model runs for the "clearing" exercise scenario, for both a CZ and duct sound propagation environment, are presented below[14].

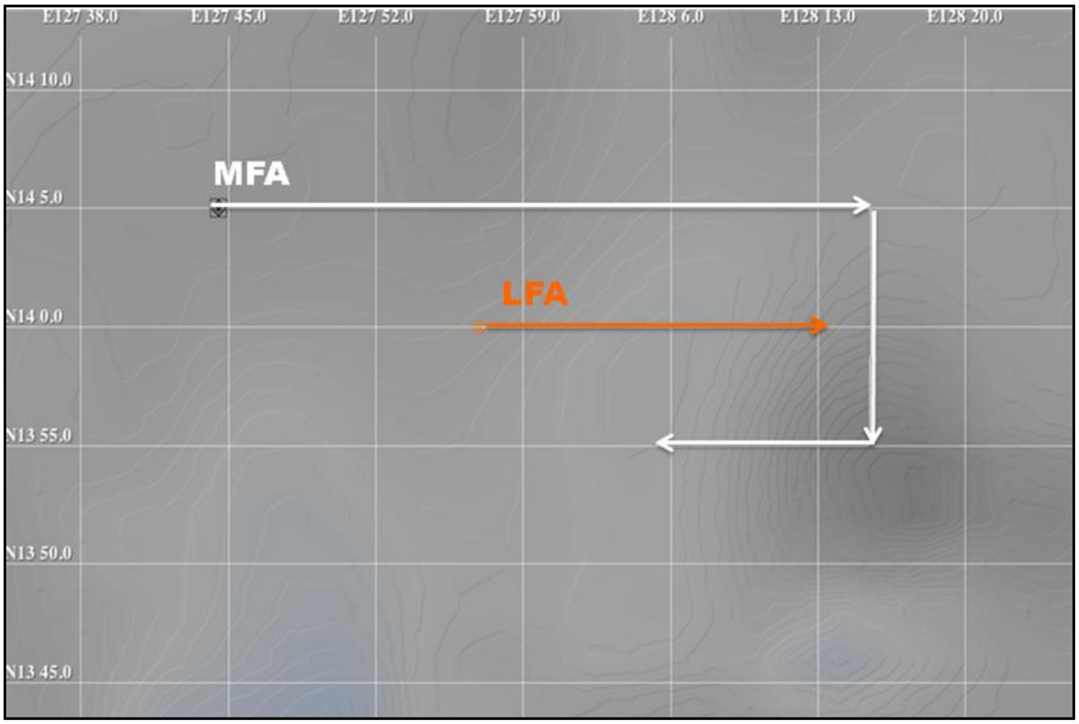


Figure E-10. Geographical set-up for model analysis—"clearing" exercise scenario. Note: each square is approximately 9 km (5 nmi) on a side.

Acoustic Analysis for "Clearing" Exercise Scenario Results (CZ Sound Propagation)
Total risk for 1919 animats, as derived from the SURTASS LFA sonar risk continuum: • LFA risk alone = 0.0716 • MFA risk alone = 0.0626
Additive risk = 0.1342 (LFA risk alone + MFA risk alone)
Combined risk (calculated) for concurrent LFA and MFA sonar operations considering frequency and duty cycle differences = 0.1340
Risk for concurrent LFA and MFA sonar operations = difference between additive and combined risk values (combined minus additive) = 0.1340 – 0.1342 = -0.0002
Conclusion: Result of concurrent MFA/LFA sonar operations is zero increase in risk, over that from summing the risk of the two sources operating independently.

14 Mathematical values shown to the 4th decimal place are for illustrative purposes, and are necessary to show the differences among the calculated values.

Acoustic Analysis—“Clearing” Exercise Scenario Results (Duct Sound Propagation)
Total risk for 1349 animats as derived from the SURTASS LFA sonar risk continuum: • LFA risk alone = 0.07893 • MFA risk alone = 0.07971
Additive risk = 0.1586 (LFA risk alone + MFA risk alone)
Combined risk (calculated) for concurrent LFA and MFA sonar operations considering frequency and duty cycle differences = 0.1448
Risk for concurrent LFA and MFA sonar operations = difference between additive and combined risk values (combined minus additive) = 0.1448 – 0.1586 = -0.0138
Conclusion: Result of concurrent MFA/LFA sonar operations is zero increase in risk, over that from summing the risk of the two sources operating independently.

E-3.2.4 “Parallel Course” Exercise Scenario

The results from the AIM model runs for the “parallel course” exercise scenario (Figure E-11), for both a CZ and duct sound propagation environment, are presented below.

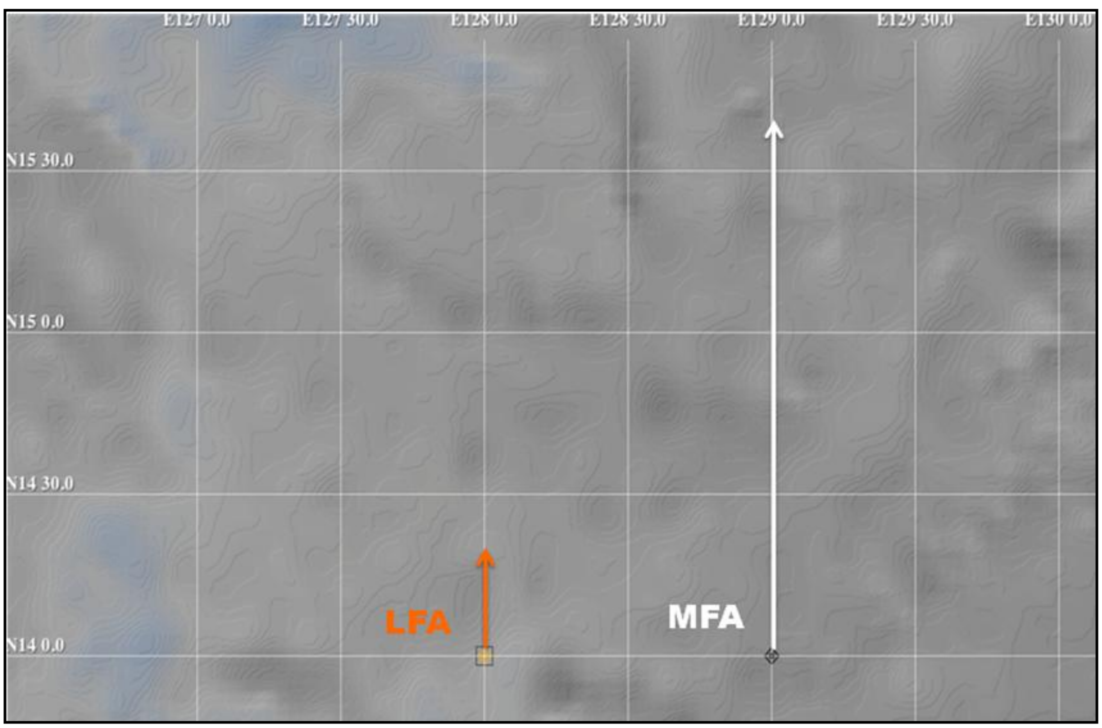


Figure E-11. Geographical set-up for model analysis—“parallel course” exercise scenario.

Acoustic Analysis—"Parallel Course" Exercise Scenario Results (CZ Sound Propagation)
Total risk for 2532 animats as derived from the SURTASS LFA sonar risk continuum: • LFA risk alone = 0.0666 • MFA risk alone = 0.0954
Additive risk = 0.1620 (LFA risk alone + MFA risk alone)
Combined risk (calculated) for concurrent LFA and MFA sonar operations considering frequency and duty cycle differences = 0.1613
Risk for concurrent LFA and MFA sonar operations = difference between additive and combined risk values (combined minus additive) = 0.1613 – 0.1620 = - 0.0007
Conclusion: Result of concurrent MFA/LFA sonar operations is zero increase in risk, over that from summing the risk of the two sources operating independently.

Acoustic Analysis—"Parallel Course" Exercise Scenario Results (Duct Sound Propagation)
Total risk for 7839 animats as derived from the SURTASS LFA sonar risk continuum: • LFA risk alone = 0.9195 • MFA risk alone = 0.2659
Additive risk = 1.1854 (LFA risk alone + MFA risk alone)
Combined risk (calculated) for concurrent LFA and MFA sonar operations considering frequency and duty cycle differences = 1.1002
Risk for concurrent LFA and MFA sonar operations = difference between additive and combined risk values (combined minus additive) = 1.1002 - 1.1854 = -0.0852
Conclusion: Result of concurrent MFA/LFA sonar operations is zero increase in risk, over that from summing the risk of the two sources operating independently.

E-3.2.5 "Overtaking" Exercise Scenario

The results from the AIM model runs for the "overtaking" exercise scenario (Figure E-12), for both a CZ and duct environment, are presented below.

Acoustic Analysis—"Overtaking Course" Exercise Scenario Results (CZ Sound Propagation)
Total risk for 3024 animats as derived from the SURTASS LFA sonar risk continuum: • LFA risk alone = 0.0669 • MFA risk alone = 0.0948
Additive risk = 0.1617 (LFA risk alone + MFA risk alone)
Combined risk (calculated) for concurrent LFA and MFA sonar operations considering frequency and duty cycle differences = 0.1557
Risk for concurrent LFA and MFA sonar operations = difference between combined and additive risk values (combined minus additive) = 0.1557 – 0.1617 = - 0.0060
Conclusion: Result of concurrent MFA/LFA sonar operations is zero increase in risk, over that from summing the risk of the two sources operating independently.

Acoustic Analysis—"Overtaking Course" Exercise Scenario Results (Duct Sound Propagation)
Total risk for 5340 animats as derived from the SURTASS LFA sonar risk continuum: • LFA risk alone = 0.9623 • MFA risk alone = 0.2235
Additive risk = 1.1858 (LFA risk alone + MFA risk alone)
Combined risk (calculated) for concurrent LFA and MFA sonar operations considering frequency and duty cycle differences = 1.0263
Risk for concurrent LFA and MFA sonar operations = difference between additive and combined risk values (combined minus additive) = 1.0263 - 1.1858 = -0.1595
Conclusion: Result of concurrent MFA/LFA sonar operations is zero increase in risk, over that from summing the risk of the two sources operating independently.

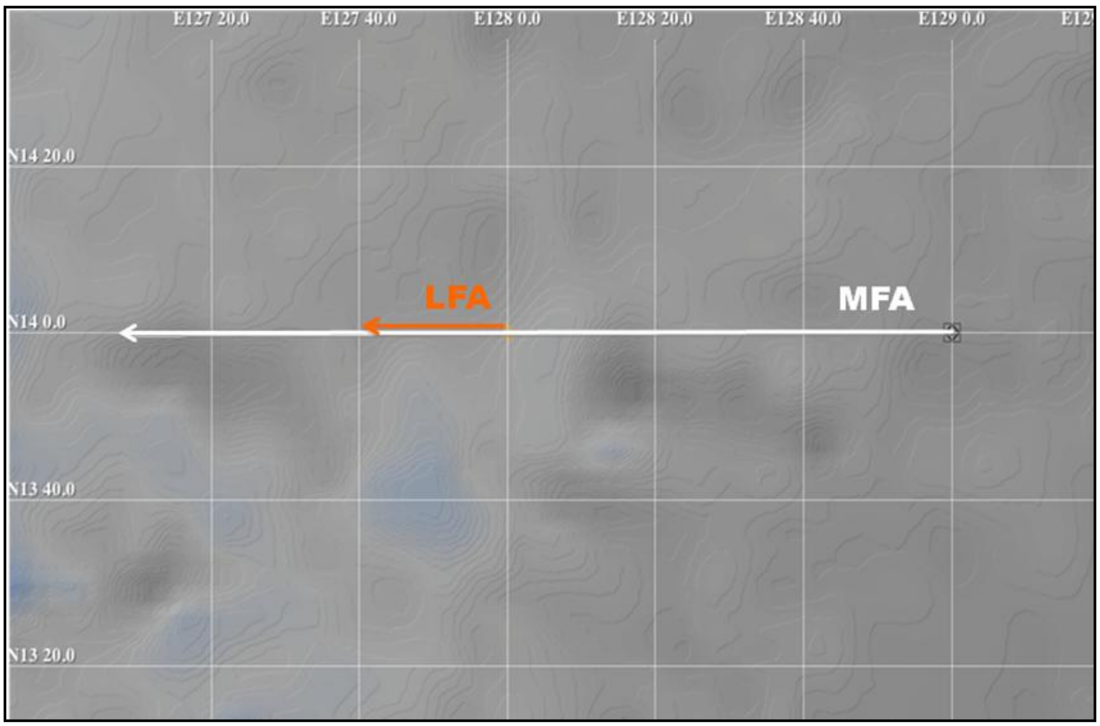


Figure E-12. Geographical set-up for model analysis—"overtaking" exercise scenario.

E-3.3 FINDINGS OF AIM ANALYSIS

In all six modeled scenarios, this model analysis, which utilizes AIM and the SURTASS LFA sonar risk continuum approach, shows that the concurrent operation of the LFA and MFA sources provided a slightly lower risk than the combined risk of each source operating independently. In summary, the relative differences between additive risk and combined risk for concurrent MFA and LFA operations range from -0.0002 to -0.0060 for CZ sound propagation conditions, and from -0.0138 to -0.1595 for duct sound propagation conditions. However, the relative differences between the two analyses are very small and for many cases are essentially zero. Given that the sequential operation analysis (i.e., separate analysis) produces the slightly larger risk values, summing the individual risk values of the two sources operating independently is the more conservative approach.

E-4 CONCLUSION

Two separate analytic approaches (parametric analysis and AIM analysis), performed independently, have concluded that there is no potential increase in risk for Level B harassment from concurrent MFA and LFA sonar operations, over that from summing the risk of the two sources operating independently.

E-5 LITERATURE CITED

Avallone, E.A., and T. Baumeister III, eds. 1987. Marks' standard handbook for mechanical engineers. Ninth Edition. New York, New York: McGraw-Hill Book Company.

Bishop, G.C., W.T. Ellison, and L.E. Mellberg. 1987. A simulation model for high-frequency under-ice reverberation. Journal of the Acoustical Society of America 82(1)**:**275-285.

DoN (U.S. Department of the Navy). 2001. Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Washington, D.C.: Chief of Naval Operations.

DoN (U.S. Department of the Navy). 2007. Final supplemental environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Washington, D.C: Department of the Navy, Chief of Naval Operations.

JASA (Journal of the Acoustical Society of America). 2005. Special issue on the North Pacific Acoustic Laboratory. Journal of the Acoustical Society of America 117(3, Part 2):1499-1673.

Kerr, G.A., and G.P. Cloy. 1994. Northern hemisphere shallow-water acoustic ducts. Naval Research Laboratory Technical Report NRL/MR/7182—94-7540. Stennis Space Center, Mississippi: Naval Research Laboratory.

NAVOCEANO (Naval Oceanographic Office). 1982. Typical expendable bathythermograph (TXBT) data base, Pacific Ocean. Naval Oceanographic Office reference publication RP-42B. STL Station, Bay St. Louis, Mississippi: Commanding Officer Naval Oceanographic Office.

OAML (Oceanographic and Atmospheric Master Library). 2002. Oceanographic and atmospheric master library. Stennis Space Center, Mississippi: Commander, Navy Meteorology and Atmospheric Command.

OAML (Oceanographic and Atmospheric Master Library). 2000. Database description for the General Digital Environmental Model—Variable Resolution (GDEM-V), version 2.5. Stennis Space Center, Mississippi: Commander, Navy Meteorology and Atmospheric Command.

Podezwa, E.M. 1976. Sound speed profiles of the North Pacific Ocean. NUSC Technical Document 5271. New London, Connecticut: Naval Underwater Systems Center.

Porter, M.B. 1992. The KRAKEN normal mode program. Naval Research Laboratory.

Sonntag, R.M., W.T. Ellison, C.W. Clark, D.R. Corbit, and B.D. Krogman. 1986. A description of a tracking algorithm and its application to bowhead whale acoustic location data collected during the spring migration near Point Barrow, Alaska 1984-85. Report of the International Whaling Commission 36**:** 299-310.

U.S. Department of Commerce. 2001. 2-minute Gridded Global Relief Data (ETOPO2) National Oceanic and Atmospheric Administration, National Geophysical Data Center.

Weinberg, H., D.L. Deavenport, E.H. McCarthy, and C.M. Anderson. (2001). Comprehensive Acoustic System Simulation (CASS) reference guide. NUWC-NPT TM 01-016.Newport, Rhode Island: Naval Undersea Warfare Center, Division, Newport.

Zingareli, R., D. King, L. Gainey, and E. Holmes. 1999. Software test dDescription for the parabolic equation/finite element parabolic equation model, version 5.0.

APPENDIX F—
ADDITIONAL ANALYSIS RECORD FOR OBIAS FOR SURTASS LFA SONAR: CONTINUED ANALYSIS FOR LOW-FREQUENCY HEARING SPECIALISTS

THIS PAGE IS INTENTIONALLY LEFT BLANK

Additional Analysis Record for Offshore Biologically Important Areas (OBIAs) for the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

Continued analysis for low-frequency hearing specialists.

National Marine Fisheries Service
Office of Protected Resources
May 28, 2012

Table of Contents

Table 1 – NMFS' Classification Methodology for OBIA Analysis

Level	Level Description for High Density, Foraging, Breeding/Calving, Migration, or Small Distinct Populations
0	Information presented does not meet NMFS' definition of the corresponding OBIA criteria or the OBIA criteria are not applicable.
1	Clear justification (qualitative or quantitative) for corresponding OBIA criteria is not available; or there is not sufficient detail for our criterion evaluation; or for high density specifically, there is strong abundance/presence information, but without the comparative information that supports *high* density.
2	Designation inferred from analyses conducted for purposes other than quantifying the corresponding OBIA criteria. Designation inferred from habitat suitability models (non-peer reviewed), expert opinion, regional expertise, or gray literature.
3	Designation inferred from peer-reviewed analysis, habitat suitability models (peer-reviewed), or a survey specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented from a single source or is generally imprecise (e.g., CV => 30%).
4	Designation inferred from peer-reviewed analyses or surveys specifically aimed at investigating and supporting the corresponding OBIA criteria. Information presented is from multiple sources or is generally precise (e.g., CV < 30%).

IUCN Marine Region 3: Mediterranean Sea

Alboran Sea MPA and Specially Protected Areas of Mediterranean Importance (SPAMI)

Basis:	(Hoyt, 2011) and Subject Matter Expert	
Criteria Reviewed:	Foraging Area	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	1
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation of the entire Central Alborán Sea as a known, defined foraging area at this time. Not enough information to support designation of a known, defined foraging area outside of the 12 nmi buffer around Alborán Island at this time.	

Area reviewed previously in the 2011 DSEIS.

2A – High Density

- Canadas et al. (2005) conducted habitat preference modeling for cetaceans in southern Spanish Mediterranean waters. Using 11 years of data, they provide predictions of relative density for cetacean species occurring off southern Spain. Their findings did not identify areas of higher relative density for fin whales or other low-frequency hearing specialists (Cañadas et al., 2005).

2B - Foraging

- De Stephanis et al. (2001) suggested that the central part of the Alborán Sea could be a feeding ground based on their analysis of fin whale sightings from 1994 to 2000.
- De Stephanis et al. (2001) state that in their analysis of other areas, only in one occasion, did they sight fin whales feeding in the Bay of Algeciras. This sighting was made in conjunction with a bloom of euphausiids in the Bay (De Stephanis et al., 2001).

Wintering Grounds (*Note: Portions of the Alborán Basin are within 22 km/12 nmi of Alborán Island*).

- Castellote et al. (2010) analyzed fin whale calls from seafloor recorders in the western Mediterranean Sea, Strait of Gibraltar and in adjacent Atlantic waters during 2006-2009. In a total of 29.822 hours of recording they detected 103.664 fin whale 20 Hz pulses from the Northeast North Atlantic (NENA) population off northern Morocco, crossing the Strait of Gibraltar and wintering in the southwestern Mediterranean basin (Alborán Sea).
- Castellote et al. (2010) also noted the presence of fin whale songs in the Columbretes archipelago area in fall and their absence in the Ibiza Channel in summer is in accordance with the well documented seasonal concentration of fin whales in their primary feeding ground in Liguria during summer.
- The acoustic features of the fin whales in the Alborán Basin and Strait of Gibraltar in fall and winter match those obtained in songs recorded in other studies in the northeast North Atlantic Ocean. Their results suggest that the whales detected in Alborán Basin and Strait of Gibraltar in fall and winter correspond to a northeast North Atlantic population of fin whales Castellote et al. (2010).

Straight of Sicily MPA (Outside of 22 km/12 nmi of Any Coastline)

Basis:	(Hoyt, 2011) and Subject Matter Expert	
Criteria Reviewed:	Foraging Area Breeding / Calving	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	1
	Breeding / Calving	1
	Foraging	1
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation of a known, defined foraging area outside of the 12 nmi buffer around Lampedusa Island at this time.	

Area reviewed previously in the 2011 DSEIS.

2B - Foraging:

- Marini *et al*. (1996) reported on a March survey around Lampedusa Island and noted a high density of animals around the island. They reported sighting females with calves, and relatively high numbers of animals demonstrating feeding behavior. However, Marini *et al*. (1996) did not provide density or abundance estimates.
- In 2004, Canese *et al*. (2006) conducted a 14-day boat survey in the waters surrounding the island of Lampedusa, where fin whales occur at this time of the year. They encountered a total of 20 fin whale groups (average group size two animals). In each encounter the animals were engaged in surface feeding activity. From plankton samples and underwater video, the prey species identified was the Euphausiid, *Nyctiphanes couchi*.
- Canese *et al*. (2006) note that the information obtained suggests that this area may be an important winter feeding ground for fin whales.

2B – Breeding / Calving

- Information is lacking to suggest localized calving grounds in the Mediterranean (Notarbartolo di Sciara, Zanardelli, Jahoda, Panigada, & Airoldi, 2003).
- Marini et al. (1992) suggested that fin whales during winter migrate to the southern part of the Mediterranean to give birth and to mate.
- The wide geographical distribution of the overall record of neonate fin whales in the Mediterranean argues against any precise calving location for fin whales in the Mediterranean Sea (Notarbartolo di Sciara et al., 2003).

Eratosthenes Seamount SPAMI (Proposed)

Basis:	(Hoyt, 2011) and Subject Matter Expert	
Criteria Reviewed:	High Density	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support high density designation at this time.	

Area reviewed previously in the 2011 DSEIS.

2A – High Density:

- The saline, warm and ultra-oligotrophic Levantine Basin holds little promise for sustaining an abundance and a diverse assemblage of top predators and may not be able to sustain the feeding requirements of large rorquals (Kerem et al., 2012)
- The relative regional scarcity is evident from the very low stranding rate: 0.22 strandings/100 km coastline/year in Israel (Kerem et al., 2012).

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Seco de los Olivos Seamount SAC (Proposed)

Basis:	(Hoyt, 2011) and Subject Matter Expert	
Criteria Reviewed:	High Density	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support high density designation at this time.	

Area reviewed previously in the 2011 DSEIS.

2A – High Density

- Canadas et al. (2005) conducted habitat preference modeling for cetaceans in southern Spanish Mediterranean waters. Using 11 years of data, they provide predictions of relative density for cetacean species occurring off southern Spain. Their findings did not identify areas of higher relative density for fin whales or other low-frequency hearing specialists (Cañadas et al., 2005).
- Canadas et al. (2005) noted that with respect to other cetacean species, their modeling predicts that the area is important for striped and Risso's dolphins, long-finned pilot, beaked and sperm whales and particularly short-beaked common dolphins.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Delta del Ebro-Columbretes SAC (Proposed)

Basis:	(Hoyt, 2011) and Subject Matter Expert	
Criteria Reviewed:	High Density	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support high density designation at this time.	

Area reviewed previously in the 2011 DSEIS.

2A – High Density

- Canadas et al. (2005) conducted habitat preference modeling for cetaceans in southern Spanish Mediterranean waters. Using 11 years of data, they provide predictions of relative density for cetacean species occurring off southern Spain. Their findings did not identify areas of higher relative density for fin whales or other low-frequency hearing specialists (Cañadas et al., 2005).
- Canadas et al. (2005) noted that with respect to other cetacean species, their modeling predicts that the area is important for striped and Risso's dolphins, long-finned pilot, beaked and sperm whales and particularly short-beaked common dolphins.

Wintering Grounds (*Note: Does not meet the Geographic Criterion*).

- Castellote et al. (2010) analyzed fin whale calls from seafloor recorders in the western Mediterranean Sea, Strait of Gibraltar and in adjacent Atlantic waters during 2006-2009. In a total of 29.822 hours of recording they detected 103.664 fin whale 20 Hz pulses from the NENA population off northern Morocco, crossing the Strait of Gibraltar and wintering in the southwestern Mediterranean basin (Alborán Sea**).**
- Castellote et al. (2010) also noted the presence of fin whale songs in the Columbretes archipelago area in fall and their absence in the Ibiza Channel in summer is in accordance with the well documented seasonal concentration of fin whales in their primary feeding ground in Liguria during summer.
- The acoustic features of the fin whales in the Alborán Basin and Strait of Gibraltar in fall and winter match those obtained in songs recorded in other studies in the northeast North Atlantic Ocean. Their results suggest that the whales detected in Alborán Basin and Strait of Gibraltar in fall and winter correspond to a northeast North Atlantic population of fin whales (Castellote et al., 2010).

IUCN Marine Region 4: Northwest Atlantic

Southeast Shoal of the Grand Bank MPA (Proposed)

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Foraging	
Species:	Fin whale (*Balaenoptera physalus*) Humpback whale (*Megaptera novaeangliae*) Minke whale (*Balaenoptera acutorostrata*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	3
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Information supports designation as a foraging area.	

2B – Foraging (June and July)

- Piatt et al. (1989) studied baleen whales feeding in Witless Bay, Newfoundland during and reported correlations between whale abundance and capelin (*Mallotus villosus*) concentrations. They noted that abundance of all whale species was strongly correlated with abundance of capelin through each season and between years.
- Piatt et al. (1989) reported that when capelin were locally abundant, whales concentrated in areas preferred by schooling capelin (e.g., near headlands; at the Ledge, a shoal between Gull and Green islands; and at Whale Deep, a trough between Green and Great islands).
- In 1982, Whitehead & Glass (1985) studied humpback whales on the Southeast Shoal of the Grand Bank of Newfoundland from a 13-m ketch during the months of June and July. They reported that the whales concentrated on the central part of the shoal most likely following spawning capelin. However, the humpbacks and prey traces dispersed as the season progressed. Apart from forming very large coordinated groupings early in the studies, when the prey was most concentrated, the feeding and grouping behavior of the humpbacks was similar to that in the inshore waters off Newfoundland.
- The primary purpose of the designation for this MPA is to conserve representative biodiversity of species and habitat, protect juvenile fish, investigate the effectiveness of a large-scale closure on depleted fish stocks and establish a precedent for open-ocean high seas protected areas (Fuller & Myers, 2004).

Areas of Increased Awareness in the 2008 AFAST FEIS/OEIS

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	All Criteria	
Species:	North Atlantic Right whale (*Eubalaena glacialis*); Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	2
	Breeding / Calving	2
	Foraging	2
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Several of the AIAs are within OBIAs 1, 2, 3 and 4 which include the North Atlantic right whale critical habitat areas as well as areas in the Gulf of Maine, the Great South Channel, Georges Bank, and the Roseway Basin. Some of the AIAs are within 22 km (14 mi; 12 nmi) of a coastline and are protected by the requirement that the Navy limit the SURTASS LFA sonar sound field so that it does not exceed 180 dB re: 1 µPa.	

In the 2008 Atlantic Fleet Active Sonar Training FEIS/OEIS, the Navy considered the designation of areas of increased awareness for marine mammals while using of mid-frequency active sonar technology during Atlantic Fleet training exercises, maintenance, and research, development, test, and evaluation activities.

Alternative 3 of the 2008 AFAST FEIS/OEIS analyzed not conducting mid-frequency active sonar activities in *designated areas of increased awareness* located offshore of the U.S. East Coast and within the Gulf of Mexico to the extent allowable while meeting operational requirements.

The 2008 AFAST FEIS/OEIS defined *designated areas of increased awareness* as environmentally sensitive areas that typically indicate higher concentrations of marine species and include the following features:

- Bathymetric features such as canyons, steep walls, and seamounts
- Areas of persistent oceanographic features
- North Atlantic right whale critical habitat areas
- River and bay mouths
- Areas of high marine mammal density
- Designated National Marine Sanctuaries (i.e., Monitor, Gray's Reef, Stellwagen Bank, Florida Keys, and Flower Garden Banks)

Areas of Increased Awareness are protected by the geographic restriction where we require the Navy to limit the SURTASS LFA sonar sound field so that it does not exceed 180 dB re: 1 µPa within 22 km (14 mi; 12 nmi) of any coastline.

IUCN Marine Region 5: Northeast Atlantic Ocean

Charlie–Gibbs Fracture Zone – High Seas

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	High Density Foraging	
Species:	Sperm whale (*Physeter macrocephalus*) Sei whale (*Balaenoptera borealis*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	1
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

2A – High Density

- The 2004 Mid-Atlantic Ridge (MAR)-ECO expedition on the R.V. G.O. *Sars* provided the first opportunity to correlate oceanic distributions of cetaceans with synoptic acoustic (ADCP to 700m depth, multi-beam echosounders) measurements of high-resolution, three-dimensional (3D) potential habitat (spatial scale < 100 km) (Skov et al., 2008).

2B –Foraging

- Skov et al. (2008) suggested aggregations of sperm and sei whales along the MAR are primarily associated with fine-scale frontal processes interacting with the topography in the upper 100 m of the water column just north of the Sub-Polar Front (SPF) and the Charlie–Gibbs Fracture Zone (CGFZ) (Skov et al., 2008).
- The authors suggested further studies were needed to evaluate the importance of the bio-physical coupling, and the significance of small-scale frontal processes in the surface and subsurface waters north of the SPF for the transfer of energy to higher trophic levels in the North Atlantic (Skov et al., 2008).

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Tête de Canyon du Cap Ferret SPA – France

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	All	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	1
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

2A – High Density

- The shelf break in the Bay of Biscay includes the presence of two deep canyons, Cap Ferret and Cap Breton (Certain, Ridoux, Van Canneyt, & Bretagnolle, 2008). In a strip-transect study of cetacean populations in the Bay of Biscay, almost 50% of the aerial sightings were unidenti fied small delphinids (Certain et al., 2008).
- The stranding record for other types of cetaceans is limited. Santos et al., (2006) noted one stranding record of a male pygmy sperm whale (*Kogia breviceps*) at Cap Ferret in 1999. Also, the short-beaked common dolphin the most common cetacean bycatch in the Bay of Biscay, mainly from December to March (d'Andrade, 2008).
- In a 2008 Master's thesis, d'Andrade (2008) modeled cetacean presence from three most sighted species (fin whale, common and striped dolphins) with environmental predictors using CODA survey data. The resulting spatial segregation showed that dolphins were distributed in the inner part of the Bay and fin whales around the Galician Bank. However, the data represents summer distribution surveyed during a single year and requires additional data to cover a broader temporal scale and to define the regions of typically high and predictable probability of occurrence.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

El Cachucho MPA (Le Danois Bank) – Spain

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	All	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	1
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

2A – High Density

- In a 2008 Master's thesis, d'Andrade (2008) modeled cetacean presence from three most sighted species (fin whale, common and striped dolphins) with environmental predictors using CODA survey data. The resulting spatial segregation showed that dolphins were distributed in the inner part of the Bay and fin whales around the Galician Bank. However, the data represents summer distribution surveyed during a single year and requires additional data to cover a broader temporal scale and to define the regions of typically high and predictable probability of occurrence.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Cañón de Avilés SAC (Proposed)

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	All	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

2A – High Density

- In 2010, the team from CEMMA conducted the first maritime campaign in the Canyon of Aviles for the LIFE+ INDEMARES project. They conducted a total of 597.7 km line transects and with a total of 15 sightings of cetaceans, 11 of which were systematic and 3 were opportunistic. The species observed were: common bottlenose dolphin (*Tursiops truncatus*), long-finned pilot whale (*Globicephala melas*), striped dolphin (*Stenella coeruleoalba*), Cuvier's beaked whale (*Ziphius cavirostris*), Sowerby's beaked whale (*Mesoplodon bidens*), unidentified dolphins and an unidentified cetacean (INDEMARES, 2010b).
- In the same study, the CEMMA team also reported a possible acoustic recording of a sperm whale (*Physeter macrocephalus*), a species that was not observed (INDEMARES, 2010b).

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Banco de Galicia SAC (Proposed)

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	All	
Species:	Fin whale (*Balaenoptera physalus*)	
Classification Rank:	High Density	1
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

The Galician Bank is a large submarine mountain located some 200 km west of the Galician coast. The shallower area is of about 6,250 km^2, and a 2,500 m deep channel divides the Bank from the continental platform (INDEMARES, 2010a).

The information about Galician Bank and its ecosystems is rather scarce, and there have been few biological investigations made onsite (INDEMARES, 2010a).

2A – High Density

- Rebull et al. (2006) monitored the presence of fin whales in the Galicia Basin by deploying ocean bottom seismometers 250 km from the NW coast of Iberia in the Galicia Margin, NE Atlantic Ocean for one month. They reported a large variety of signals, including fin whale vocalizations identified by their specific acoustic signature. With this information, the authors were able to assess the presence of fin whales in the Galicia Margin, NE Atlantic.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Dogger Bank SAC (Proposed)

Basis:	(Hoyt, 2005, 2011) and NMFS	
Criteria Reviewed:	High Density Foraging	
Species:	Minke whale (*Balaenoptera acutorostrata*) Harbor porpoise (*Phocoena phocoena*)	
Classification Rank:	High Density	1
	Breeding / Calving	0
	Foraging	3
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Information supports designation as a foraging area.	

Area reviewed previously in the 2011 DSEIS.

2A – High Density

- In 2010, the Joint Nature Conservation Committee re-evaluated Dogger Bank according to the Habitats Directive selection criteria and guiding principles in response to scientific questions on site justification for harbor porpoises. They concluded that the data indicated that there is no difference in occurrence of harbor porpoise within the Dogger Bank SAC (identified for its sandbank habitat) compared to outside the SAC (JNCC, 2010). They concluded that there is not "good population density (in relation to neighboring areas and that the Dogger Bank SAC cannot be considered a "clearly identifiable area essential to the life and reproduction" of harbor porpoise, and that therefore the species should not be a qualifying feature for the site (JNCC, 2010).

2B – Foraging

- The Dogger Bank is a large sand bank where at times, a front develops which is characterized by relatively high primary productivity, particularly during May and the summer months (Clark, Dolman, & Hoyt, 2010).
- From March 28 to July 2, 2007 de Boer et al. (2010) conducted platform of opportunity and line transect surveys during a geophysical (seismic) survey to investigate the distribution and abundance of minke whales northeast of the Dogger Bank. They suggested that the slopes of the Dogger Bank offer foraging sites for minke whales, particularly during spring when they exploit local sandeel (*Ammodytes sp.*) aggregations.
- de Boer et al. (2010) estimated that the peak density of minke whales was estimated to be 0.029 whales km^2 (minimum estimate, 95% CI: 0.012 to 0.070) in May. During peak abundance, the minke whales temporarily congregated in the area, suggesting that the whales were taking advantage of the local spring abundance of sandeels. They also reported a high relative abundance (2.04 whales $100km^{-1}$) in water depths ranging between 50 and 59 m.
- However, the distribution and abundance of minke whales on feeding grounds will ultimately depend on the distribution of their prey and underlying primary production (de Boer, 2010). Early spring plankton at the Dogger Bank is patchily distributed, and sandeels only emerge from the seabed when feeding conditions are optimal (de Boer, 2010).

North East Scotland Marine Reserve and Cetacean Critical Habitat Network (Proposed)

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Foraging	
Species:	Minke whale (*Balaenoptera acutorostrata*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	2
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Areas noted for foraging are within 22 km of the coastline. Not enough information to support designation of a known, defined foraging areas outside of the 22 km coastal restriction at this time.	

The Whale and Dolphin Conservation Society (WDCS) identified key areas in need of protection including the southern coast of the Outer Moray Firth for minke whales (Clark et al., 2010). This area is within 22 km of the coastline.

2B – Foraging

- Tetley (2004) studied the distribution and habitat preference of the North Atlantic minke whale in the southern outer Moray Firth over a five-year period (2000-2004) during the months of May through September and observed that the areas of highest minke whale encounter frequency occurred in regions characterized by shallow depths, steep slopes, northerly facing aspects and sandy gravel sediment types.
- Tetley (2004) reported that the majority of minke whales were encountered close to the coast with encounter frequency decreasing with distance from the shore. Two areas in particular seemed to have high numbers of encounters: a strip of the coastline lying between Portknockie and Whitehills; and Aberdour Bay, located between Gardenstown and Rosehearty. Overall, minke whale distribution and encounter frequency were highly variable both spatially and temporally within the survey area (Tetley, 2004).
- Another study hypothesized that the inter-annual variability observed by Tetley (2004) could be accounted for by the respective distribution of schooling mackerel (*Scomber scombrus*) which may perform the role of compacting targeted sandeel (*Ammodytes spp.*) prey into concentrated bait balls upon which the minke whales opportunistically feed (Robinson & Tetley, 2007).

IUCN Marine Region 7: Wider Caribbean

Mississippi and De Soto Canyons, Breton Spur, Gulf of Mexico

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	High Density Breeding/Calving Small Distinct Population	
Species:	Sperm whale (*Physeter macrocepbalus*) Bryde's whale (*Balaenoptera edeni*)	
Classification Rank:	High Density	1
	Breeding/Calving	1 for Mississippi Canyon, 0 for other areas
	Foraging	N/A
	Migration Corridor	0
	Small Distinct Population	1
Analysis Result:	Not enough information to support designation to support designation at this time.	

All three areas are located outside of 22 km from the shoreline.

Biggs et al. (2005) concluded that summer-to-summer variability in the intensity and geographic location of Loop Current eddies, warm slope eddies, and areas of cyclonic circulation over the middle slope region of the northern Gulf forced striking year-to-year differences in the locations along the 1000-m isobath where there was on-margin and off-margin flow, and in locations where sperm whales were encountered along the 1,000-m isobath.

2A -High Density (Rank 1 for each area):

- The interannual variability of the Mississippi River discharge itself may also have significant impact on sperm whale distributions along the 1,000-m isobath between Mississippi Canyon and De Soto Canyon (Jochens et al., 2008).
- Ship-based transect surveys of the northern Gulf of Mexico from 1996-97 and 1999 to 2001 reported sightings of 19 species of marine mammals (Mullin & Fulling, 2004). The most commonly sighted species were pantropical spotted dolphin, *Stenella attenuata*; sperm whale, *Physeter macrocepbalus*; dwarf pygmy sperm whale, *Kogia simal/breviceps*; Risso's dolphin, *Grampus griseus*; and bottlenose dolphin, *Tursiups truncatus*. The only large whales sighted were *P. macrocephalus* and Bryde's whale, *Balaenoptera edeni*. The most abundant species were the pantropical spotted, Clymene, spinner, and striped dolphins (Mullin & Fulling, 2004).
- The Mullin and Fulling study (2004) conducted twice as much survey effort per unit area in the NE slope stratum (*i.e.*, waters 200-2,000 m deep between 83°55.0′ and 88°30.0′ W, which includes DeSoto Canyon) than the NW slope (*i.e.*, waters 200-2,000 m deep west of 88°30.0′ W, which includes Mississippi Canyon) or the abyssal strata in the northern Gulf of Mexico. They observed that sperm whales, *Kogia*, and Risso's and pantropical spotted dolphins were widely distributed and reported that sperm whale densities were lower (0.15/100 km^2) in the NE slope stratum than in the NW slope (0.43/100 km^2) (Mullin & Fulling, 2004).
- Conversely, the bottlenose dolphin had the highest densities in the NE slope stratum and the group's distribution extended seaward of the shelf edge (Mullin & Fulling, 2004).
- All baleen or mysticete whales, other than the Bryde's whales, potentially occurring in the Gulf of Mexico are considered extralimital to the Gulf (Jefferson & Schiro, 1997; Waring, Josephson,

Fairfield-Walsh, & Maze-Foley, 2009). Although occurring only rarely, the Bryde's whale is the most frequently sighted baleen species in the Gulf (DON, 2010) .

- Bryde's whales occur in both coastal and pelagic waters and are often sighted in shelf break waters or near topographic features such as the De Soto Canyon or Florida Escarpment (Davis, Evans, & Wursig, 2000; Davis et al., 2002).

2B –Breeding/Calving (Rank: 1 for Mississippi Canyon; 0 for De Soto Canyon and Breton Spur:)

- In a 1991 report on cetaceans on the upper continental slope in the north-central Gulf of Mexico, Mullins et al. (1991) observed that sperm whale sightings in the Breton Spur, south of the Louisiana Fan, were concentrated near the 900 m isobath.
- The basic unit of sperm whale social organization is the breeding or mixed herd consisting of mature females, juveniles of both sexes, and calves. Aggregations of female and mixed juvenile/calf groups were commonly sighted around the Mississippi Canyon in summer 2004 (Thomsen et al., 2011). Conversely, in summer 2005, Jochens et al. (2008) observed lone/bachelor males around the Mississippi Canyon did not observe any mixed herds (Thomsen et al., 2011).
- Regarding the interannual differences in sighting between the two surveys, Jochens et al. (2008) further notes that they observed no members of the mixed groups "core population" which could be caused by changing oceanographic conditions between the two surveys. The Mississippi River's 2005 discharge was 59% of the average summer monthly outflow.
- The Bryde's whale does not have a well-defined breeding season in most areas and locations of specific breeding areas are unknown (DON, 2010).
- Based upon the best available information in screening this area as a potential OBIA, NMFS and the Navy rank this area as a 1 for Breeding/Calving area.

2B –Small, Distinct Population (Rank 1 - for all areas)

- The genetic analyses indicate that the sperm whale population in the Gulf is unique from populations in the North Atlantic Ocean, Mediterranean Sea, and North Sea. They also indicate site fidelity of females to specific areas (Jochens et al., 2008). Jochens et al. (2008) report that the sperm whale population off the Mississippi River Delta likely has a core size of about 140 individuals, 88 of which may be females.
- Based upon the NMFS 2010 Final Recovery Plan for the Sperm Whale (NMFS, 2010), the existing knowledge of the population structure of sperm whales is insufficient to support the small distinct population criterion.
- Bryde's whales have displayed considerable local variation world-wide, and analysis of skin biopsy samples could determine whether the northern Gulf stock of Bryde's whales is restricted geographically and genetically isolated from animals in the Atlantic Ocean (Davis et al., 2000; Wursig, 2001). However, there but there is no information on stock differentiation (Waring et al., 2009).

Agoa Marine Mammal Sanctuary in the French Antilles

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Migration Breeding / Calving	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding/Calving	2
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Areas noted for breeding are within 22 km of the coastline. Not enough information to support designation of a known, defined calving areas outside of the 22 km coastal restriction at this time.	

2A – High Density

- We did not find supporting information for this criterion at this time.

2B -Migration:

- The humpback whales migrate annually more than 3,000 miles between NOAA's Stellwagen Bank National Marine Sanctuary off the Massachusetts coast and Agoa Marine Mammal Sanctuary in the Caribbean's French Antilles (NOAA, 2011).

2B – Breeding / Calving

- SC/63/E9 provided a synoptic overview and preliminary update of the marine mammals of the Dutch Caribbean EEZ based on 279 cetacean sighting and stranding records. The windward sector stands out for its large number of humpback whale sightings (45% of records) and may form part of it former (or current) calving grounds. This species remains relatively rare in the leeward sector (5% of records) (Debrot, Witte, & Scheidat, 2011)
- In 2011, the St. Maarten Nature Foundation conducted a marine mammal census project February through May in St. Maarten territorial waters and the Man of War Shoal Marine Park both of which are within the Agoa Sanctuary. They reported that the most abundant species present was the humpback whale (33 individuals, including calves) and the route taken was generally in a southerly direction and the most common activity observed was breaching. March saw the highest density recorded (NF, 2011).

Florida Keys/Dry Tortugas

Basis:	(Hoyt, 2011) and NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	High Density	
Species:	Sperm whale (*Physeter macrocepbalus*) Bryde's whale (*Balaenoptera edeni*)	
Classification Rank:	High Density	0
	Breeding/Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

2A – High Density

- Ship-based transect surveys of the northern Gulf of Mexico from 1996-97 and 1999 to 2001 reported sightings of 19 species of marine mammals (Mullin & Fulling, 2004). The most commonly sighted species were pantropical spotted dolphin, *Stenella attenuata*; sperm whale, *Physeter macrocepbalus*; dwarf pygmy sperm whale, *Kogia simal/breviceps*; Risso's dolphin, *Grampus griseus*; and bottlenose dolphin, *Tursiups truncatus*. The only large whales sighted were *P. macrocephalus* and Bryde's whale, *Balaenoptera edeni*. The most abundant species were the pantropical spotted, Clymene, spinner, and striped dolphins (Mullin & Fulling, 2004).
- The Mullin and Fulling study (2004) conducted twice as much survey effort per unit area in the NE slope stratum (*i.e.*, waters 200-2,000 m deep between 83°55.0′ and 88°30.0′ W, which includes DeSoto Canyon) than the NW slope (*i.e.*, waters 200-2,000 m deep west of 88°30.0′ W, which includes Mississippi Canyon) or the abyssal strata in the northern Gulf of Mexico.
- They observed that sperm whales, *Kogia*, and Risso's and pantropical spotted dolphins were widely distributed and reported that sperm whale densities were lower (0.15/100 km^2) in the NE slope stratum than in the NW slope of the Gulf of Mexico (0.43/100 km^2) (Mullin & Fulling, 2004).

IUCN Marine Region 8: West Africa

Tristan da Cunha Cetacean Sanctuary

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Breeding	
Species:	Southern right whale (*Eubalaena australis*)	
Classification Rank:	High Density	0
	Breeding/Calving	1
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

2B – High Density

- The only available information is derived from aerial surveys conducted on a single day in each of the years 1985-89. Although the daily surveys were fairly comprehensive in terms of their coverage of the three islands, they were subject to factors such as poor weather conditions (IWC, 2001).

2B – Breeding / Calving

- The population that breeds off Argentina also uses Tristan da Cunha as breeding grounds (IWC, 2001). However, The maximum number of cow-calf pairs seen on any of the days surveyed was two, suggesting that the total number of reproductive females in this population over this period was very low (IWC, 2001).
- Best et al. (1993) reported long-range movements of southern right whales between Gough Island and South Africa, and between Argentina and Tristan da Cunha, southern Brazil through matching of six photo-identified individuals.
- Best et al. (1993) also noted that on 14 October 1989, two adult right whales and a calf were photographed in Dead Man's Bay, Tristan da Cunha (37"09'S, 12"17.67'W).

2B – Foraging

- The location of feeding grounds is not known with certainty but the IWC has identified Tristan da Cunha (40º S.) as a feeding area (IWC, 2001).

IUCN Marine Region 9: South Atlantic

Albrohos Bank off the Brazilian Coast

Basis:	NMFS	
Criteria Reviewed:	Breeding / Calving	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding/Calving	3
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Information supports designation as a breeding/calving area.	

The Albrohos Bank region is an extension of the Brazilian continental shelf that rarely exceeds depths of 40 m and reaches a maximum distance from shore of approximately 245 km (Freitas, Kinas, Martins, & Coitinho, 2004). Humpback whales occupy this region from May to December with peak abundance between late August and early September.

2B – Breeding / Calving

- In the Southwestern Atlantic Ocean, humpback whales migrate every winter to the Brazilian coast for breeding and calving in the Abrolhos Bank (Engel et al., 2008; Martins et al., 2001; Ward, Zerbini, Kinas, Engel, & Andriolo, 2006).
- The Brazilian coast is recognized as a southern hemisphere humpback whale wintering ground (IWC breeding stock ‘A’). Breeding stock ‘A’ is one of the least known and corresponds to whales wintering off Brazil (Zerbini et al., 2004).
- Zerbini et al. (2004) conducted shipboard sighting surveys in the area to evaluate distribution and density in 1999 and 2000. Humpback whale sightings (n = 81, 153 individuals) were recorded using line transect methodology. They estimated abundance over the continental shelf from 5 to 12°S (20,040 km^2) with a total of 872.1km surveyed on effort. Humpback whales were distributed from nearshore to the 800 m isobath, but 93.5% of sightings were recorded shoreward of the 300-m isobath. They suggest that the relatively high density off northeastern Brazil suggests that the species is reoccupying historical areas of distribution and the presence of newborn individuals indicates that calving and nursing occur in the area.
- Freitas et al. (2004) also report that the Abrolhos Bank in Brazil (16°40′S to 19°30′S; 37°25′W to 39°45′W) as the main mating and calving ground of the IWC breeding stock ‘A’ in the Southwestern Atlantic Ocean based on photo-identification data collected between 1996 and 2000.

Patagonian Austral Inter-jurisdictional Marine Coastal Park and Brazilian Whale and Dolphin Sanctuary

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Breeding / Calving	
Species:	Southern right whale (*Eubalaena australis*)	
Classification Rank:	High Density	0
	Breeding/Calving	1
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Areas noted for breeding are within 22 km of the coastline.	

2B – Breeding / Calving

- Groch et al. (2005) and other studies report that groups of right whales use the shallow, protected waters of southern Brazil as a wintering ground from May to December. Their main aggregation area occurs off Santa Catarina state, particularly the central-southern coast from Ilha de Santa Catarina (27º25'S, 48º30'W) to Cabo de Santa Marta, Laguna (28º36'S, 48º48'W) (Groch et al., 2005).
- Groch et al. (2005) also report that as of 2003, the Brazilian Right Whale Catalogue contained 315 different individual whales of which 31 were resighted in other years (23 females, 3 yearlings and 5 whales of unknown age/sex). They report that the modal observed interval between calving events is 3 years, consistent with successful reproduction.
- Groch et al. (2005) note that from 1997 to 2003 the number of reproductive females in the Central Survey Area off Brazil increased at a rate of 29.8% per year (95% CL 15.7, 44.0), and at 14% per year (95% CL 7.1, 20.9) from 1987 to 2003. These rates are significantly different from zero ($t=4.133$, $p<0.009$ and $t=4.06$, $p<0.004$, respectively). The increase from 1997 to 2003 is higher than the rates observed for right whales in other wintering grounds in the South Atlantic.

IUCN Marine Region 12: East Africa

Saya de Malha Banks MPA

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Breeding	
Species:	Humpback whale (*Megaptera novaeangliae*) Blue whale (*Balaenoptera musculus*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

This is the world's least-explored shallow marine ecosystem. Encompassing more than 40,000 square kilometers, the northern and southern portions of the Saya de Malha Banks support a diversity of marine mammals, such as spotted dolphins and sperm, blue, and pilot whales (GOB, 2010).

2A – High Density

- We did not find supporting information for this criterion at this time.

2B – Breeding / Calving / Foraging / Migration Corridor

- There are statements that this area is a major breeding ground for blue whales. The Saya de Malha Expedition 2002 which commenced on March 11 and ended March 28, 2002 did not sight any large whale species. They hypothesized that the lack of sighting occurred due timing (not breeding season) or bathymetry (large whales prefer the bank edges rather than shallow water) (LF, 2002).
- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

IUCN Marine Region 13: East Asian Seas

Bontang-East Kutai MPA

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Breeding	
Species:	Humpback whale (*Megaptera novaeangliae*) Sperm whale (Physeter macrocepbalus) Fin whale (Balaenoptera physalus)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough supporting information to support designation at this time.	

2A – High Density

- We did not find supporting information for this criterion at this time.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

IUCN Marine Region 14: North and South Pacific

Pacific Remote Islands Marine National Monument

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	All	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation outside of the 12 nmi buffer around of any of the islands at this time.	

2A – High Density

- We did not find supporting information for this criterion at this time.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Northwestern Hawaiian Islands (NWHI)

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Breeding / Calving	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding / Calving	3
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Areas noted for breeding are within 22 km of the coastline. Not enough information to support designation outside of the 12 nmi buffer around of any of the islands at this time.	

2B – Breeding / Calving

- Johnston et al. (2007) modeled the extent and spatial location of humpback whale wintering habitat across the Hawaiian Archipelago, using bathymetry data and synoptic and January–March averaged sea surface temperature. Using the data, they produced polygons identifying areas shallower than 200 m and warmer than 21.1°C as potential wintering habitat.

  They conducted a March 2007 pilot survey across the NWHI and reported nine sightings of humpback whales (n = 19) during the 15 d cruise, including 3 groups with small calves or exhibiting breeding behaviors. All sightings occurred in warm, shallow water at or within our predicted habitat regions . They detected humpback whales on the shallow banks surrounding Nihoa Island, Necker Island, Gardner Pinnacles, Maro Reef , and Lisianski Island (Johnston et al., 2007).

- Lammers et al. (2011) deployed 9 ecological acoustic recorders (EARs) throughout 9 sites in the archipelago to record the occurrence of humpback whale song (an indicator of winter breeding activity). They reported that songs were prevalent at Maro Reef, Lisianski Island, and French Frigate Shoals but was also recorded at Kure Atoll, Midway Atoll, and Pearl and Hermes Atoll. The earliest occurrence in the NWHI was at French Frigate Shoals in December 2008 and the latest was at Maro Reef in May 2009 (Lammers et al., 2011).

  Of the 9 sites monitored, Maro Reef had the highest incidence of song between the first and last detections, with 95% of the intervening days marked by the presence of song. The 3 northwestern most atolls (Kure, Midway, and Pearl and Hermes) showed the lowest abundance of song. The northernmost atolls of Kure, Midway, and Pearl and Hermes exhibited notably less humpback whale song presence. Although small peaks in activity occurred in February and March, both song persistence and abundance were comparatively much lower than at other locations (Lammers et al., 2011).

IUCN Marine Region 16: Northwest Pacific

Kuroshio Current and Oyashio Current Large Marine Ecosystems

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	Breeding / Calving	
Species:	North Pacific right whales (*Eubalaena japonica*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

2B – Breeding / Calving

- Rosenbaum et al., (2000) study on North Pacific right whales provides evidence for the existence of a distinct genetic lineage of right whales in the North Pacific, but it did not provide evidence for the location of feeding or breeding grounds in the LME.
- Based upon our search, minke, Bryde's, sei, blue, and fin whales do not have known concentrated feeding or breeding grounds within either of the LMEs. We did not find supporting information for these criteria at this time.

Ogasawara (Bonin) and Mariana Archipelagos

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	Breeding / Calving	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding / Calving	1
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation outside of the 12 nmi buffer around of any of the islands at this time.	

2B – Breeding / Calving

- The humpback whale known to winter near the Philippines, Okinawa, and Ogasawara Islands is found in nearshore waters. Evidence suggests that less than 1,000 animals— of the 20,000 humpback whales estimated to exist in the North Pacific—winter off these islands (Calambokidis et al., 2008).

Shatsky Rise

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	All	
Species:	Cetaceans – Low frequency hearing specialists.	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

2A – High Density

- We did not find supporting information for this criterion at this time.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

The Emperor Seamount Chain

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	All	
Species:	Fin whale (*Balaenoptera physalus*) Blue whale (*Balaenoptera musculus*) Minke whale (*Balaenoptera acutorostrata*) Bryde's whale (*Balaenoptera edeni*) Sei whale (*Balaenoptera borealis*)	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	1
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

2A – High Density

- Moore et al. (2002) monitored blue whale calls from SOSUS and other offshore hydrophones using the U.S. Navy Ocean Processing Facility (NOPF) on Whidbey Island WA. They noted that overall, blue whale calls were two to three times more numerous in the NW region (40°N to 55°N latitude, between 150°E and 180°W longitude) than in other regions of the North Pacific, with consistently high calling rates from August through November. However, the authors state that the actual number of individuals producing the calls was not known.

2B – Breeding / Calving / Foraging / Migration Corridor

- Regarding foraging areas, Moore et al. (2002) suggest that cold sea surface temperature fronts seemed a consistent feature of blue whale habitat in the northwest Pacific from spring through fall, while noting that chlorophyll-a (primary productivity) may not be an ideal indicator of good blue whale habitat.
- Konishi et al. (2009) developed density prediction models for common minke, sei and Bryde's whales in the Western North Pacific during their feeding season. Regarding foraging sites, they reported that SST was most sensitive predictors followed by latitude and longitude. Similar to Moore et al.'s (2002) results, they found the sensitivity of Chlorophyll a was small.
- However, an Independent Expert Panel (IEP) from the International Whaling Committee expressed major concerns with the Konishi et al. (2009) study related to the lack of full treatment of uncertainty. As part of the treatment of uncertainty the IEP recommended that the analyses of data should: (a) incorporate the use of several reasonable models and include the range of possible results in reporting the work; (b) use that range in subsequent analyses (including any ecosystem modelling) that employ these daily/annual consumption estimates and (c) undertake sensitivity analyses for the range of parameter values used in the consumption equations (Tamura et al., 2009).

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Transition Domain (40-44° N;155-180° E)

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	All	
Species:	Cetaceans – Low frequency hearing specialists.	
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

2A – High Density

- Several studies have documented bycatch of Northern fur seals, Dall's porpoises, northern right whale dolphins, and Pacific white-sided dolphins in squid driftnets in the region (Baba, Kiyota, Hatanaka, & Nitta, 1993; Buckland, Cattanach, & Hobbs, 1993; Yatsu, Shimada, & Murata, 1993).
- We have found no other reports of large whale bycatch in this fishery and did not find supporting information for this criterion at this time.

2B – Breeding / Calving / Foraging / Migration Corridor

- We did not find supporting information for these criteria at this time.

2C – Small Distinct Population

- We did not find supporting information for this criterion at this time.

Babuyan Islands and northern Luzon, Philippines

Basis:	NRDC Comments on DSEIS/SOEIS	
Criteria Reviewed:	Breeding / Calving	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding / Calving	3
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Areas noted for breeding are within 22 km of the coastline. Not enough information to support designation of a known, defined calving areas outside of the 22 km coastal restriction at this time.	

2B – Breeding / Calving

- The waters of the Babuyan Islands, Northern Luzon, are the only known breeding ground of humpback whales in the Philippines (Acebes, Darling, & Yamaguchi, 2007) and represent the southernmost known breeding and calving area for humpback whales in the western North Pacific (Yamaguchi, Acebes, & Miyamura, 2005).
- Sighting effort for this area was conducted primarily from shore-based small boats (Calambokidis et al., 2008).

IUCN Marine Region 17: Southeast Pacific

Costa Rican Whale and Dolphin Sanctuary

Basis:	(Hoyt, 2011)	
Criteria Reviewed:	Breeding / Calving	
Species:	Humpback whale (*Megaptera novaeangliae*)	
Classification Rank:	High Density	0
	Breeding / Calving	1
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Areas noted for breeding are within 22 km of the coastline. Not enough information to support designation of a known, defined calving areas outside of the 22 km coastal restriction at this time.	

2B – Breeding / Calving

- Acevedo-Gutiérrez and Smultea (1995) documented the first records of humpback whales, including mothers with calves, in Golfo Dulce and at Isla del Coco, Costa Rica.
- Golfo Dulce is an estuarine embayment on the south Pacific coast of Costa Rica. The Gulf is about 50-km long and 15-km wide; characterized by a steeply sloped, deep inner basin with a mean depth of 140 m (maximum depth 215 m) and a shallow outer basin with a sill depth of 70 m (mean depth 30 m) (Acevedo-Gutiérrez & Smultea, 1995).
- Isla del Coco is a small (23-km circumference), isolated volcanic island located approximately 500 km southwest of Costa Rica (Acevedo-Gutiérrez & Smultea, 1995).

IUCN Marine Region 18: Australia-New Zealand

Southeast Commonwealth Marine Reserve Networks

Basis:	(Hoyt, 2011)	
Criteria Reviewed:		
Species:		
Classification Rank:	High Density	0
	Breeding / Calving	0
	Foraging	0
	Migration Corridor	0
	Small Distinct Population	0
Analysis Result:	Not enough information to support designation at this time.	

Australia's South-east Commonwealth Marine Reserve Network is the first temperate deep sea network of marine reserves in the world. At this time, no cetaceans are listed within the interim management plans for any of the marine reserves (Hoyt, 2011).

Apollo Commonwealth Marine Reserve
Beagle Commonwealth Marine Reserve
Boags Commonwealth Marine Reserve
East Gippsland Commonwealth Marine Reserve
Flinders Commonwealth Marine Reserve
Franklin Commonwealth Marine Reserve
Freycinet Commonwealth Marine Reserve
Huon Commonwealth Marine Reserve
Macquarie Island Commonwealth Marine Reserve
Murray Commonwealth Marine Reserve
Nelson Commonwealth Marine Reserve
South Tasman Rise Commonwealth Marine Reserve
Tasman Fracture Commonwealth Marine Reserve
Zeehan Commonwealth Marine Reserve

Areas Within 22 Kilometers of Any Coastline

Areas in bold analyzed for biological criteria for OBIAs for SURTASS LFA sonar.

IUCN Marine Region 3: Mediterranean Sea
Vjose-Narte Protected Landscape – Albania
Sazani Island-Karaburuni Peninsula MPA – Albania
Cap de Garde Marine Reserve – Algeria
Îles Habibas Marine Nature Reserve – Algeria
Kaliakra Nature Reserve SAC – Bulgaria
Gulf of el-Salloum MPA – Egypt
Scandola/Revellata/Calvi SAC – France (Corsica)
Plateau du Cap Corse SAC – France (Corsica)
Golfe d'Ajaccio SAC – France (Corsica)
Capu Rossu, Scandola, Reveletta, Calvi SPA – France (Corsica)
Côte Languedocienne SPA – France
Calanques et Iles Marseillaises, Cap Canaille et Massif du Grand Caunet SAC – France
Rade d'Hyères SAC – France
Kolkheti National Park – Republic of Georgia
Cape Anaklia to Sarp MPA – Republic of Georgia
Supsa MPA – Republic of Georgia
Chorokhi MPA – Republic of Georgia
Southern Waters of Gibraltar SAC – UK
Gulf of Saronikos MPA – Greece
Northern Sporades MPA – Greece
Northern Aegean Sea MPA – Greece
Dodekanese MPA – Greece
Amvrakikos Gulf MPA – Greece
Amvrakikos Kolpos, Delta Lourou Kai Arachthou (Petra, Mytikas, Evryteri Periochi) SAC- Greece
Gulf of Trieste Miramare MPA – Italy
Isole di Ventotene e Santo Stefano MPA – Italy
Capo Carbonara MPA – Italy
Egadi Islands MPA – Italy
Tavolara and Punta Coda Cavallo MPA – Italy
Capo Rizzuto Island MPA – Italy
Cinque Terre National Park – Italy
Gulf of Portofino MPA – Italy
Tuscan Archipelago National Park – Italy
Capo Testa-Punta Falcone MPA – Italy
Pelagie Islands MPA – Italy
Asinara Island National Park – Italy
Maddalena Archipelago National Park – Italy
Regno di Nettuno MPA – Italy
Capo Caccia – Isola Piana Natural MPA – Italy
Porto Cesareo MPA – Italy
Natural Marine Reserve of the Sinis Penisola – Italy
Al Hocemia National Park – Morocco
Marine Reserve 2 Mai – Romania
Vama Veche and SAC – Romania
Danube Delta Biosphere Reserve – Romania
Cape Tuzla MPA – Romania
Sochinskiy National Nature Park – Russian Federation
Kerch Strait MPA – Russian Federation
Bol'shoi Utrish Nature Sanctuary – Russian Federation
Taman Bay MPA – Russian Federation
Cabo de Gata-Nijar Natural Park - Spain
Costes del Garraf SAC – Spain
Islas Columbretes SAC – Spain
Isla de Tabarca SAC – Spain
Medio Marino de Murcia SAC - Spain
Cabrera y Mignorn SAC – Spain
Arxipelag de Cabrera SAC – Spain
Bahía de Alcudia SAC – Spain
Isla de Alborán SAC – Spain
Estrecho Oriental SAC – Spain
Seco de los Olivos SAC - Spain
Cañón de Creus SAC - Spain
Delta del Ebro-Columbretes SAC
La Galite MPA and SPAMI – Tunisia
Zembra and Zembretta MPA and SPAMI – Tunisia
Kneiss MPA and SPAMI – Tunisia
Gökova SEP Area – Turkey
Fethiye-Göcek SEP Area – Turkey
Datça-Bozburun SEP Area – Turkey
Saros Bay MPA – Turkey
Kemer–Antalya Coast MPA – Turkey
Igneada Protected Area – Turkey (Black Sea)
Kizilirmak Delta Ramsar Site – Turkey (Black Sea)
Yeşilırmak Delta MPA – Turkey (Black Sea)
Sarikum Nature Reserve – Turkey (Black Sea)
Cide MPA – Turkey
Prebosphoric MPA – Turkey
Turkish Straits System MPA – Turkey
Cape Sarych to Cape Khersones MPA – Ukraine
Black Sea Biosphere Reserve – Ukraine
Cape Martyan Nature Reserve – Ukraine
Karadag Nature Reserve – Ukraine
Opuk Nature Reserve – Ukraine
Kazantip Nature Reserve – Ukraine
Azov and Sivash National Nature Park – Ukraine
Swan Islands Crimean Nature Reserve – Ukraine
Meotida Landscape Park – Ukraine (Sea of Azov)
Danube Biosphere Reserve – Ukraine
Tarkhankut National Nature Park MPA – Ukraine
Zernov's Phyllophora Field – Ukraine

Note: SACs are of relevance to common bottlenose dolphins, *Tursiops truncatus*, and harbour porpoises, *Phocoena phocoena*, whereas a SPAMI is applicable for many species and characteristics (SPA Protocol, 1995) (Cañadas, Sagarminaga, De Stephanis, Urquiola, & Hammond, 2005).

IUCN Marine Region 4: Northwest Atlantic
The St. Lawrence Estuary Marine Protected Area - Canada

IUCN Marine Region 5: Northeast Atlantic
Faial-Pico Channel Marine Park – Portugal
Vadehavet med Ribe Å, - Denmark
Tved Å og Varde Å vest for Varde SAC - Denmark
Wadden Sea Nature Reserve – Denmark
Ouessant-Molène SAC – France
Chaussée de Sein SAC – France
Baie du Mont Saint-Michel SAC – France
Pertuis Charentais SAC – France
Chausey SAC – France
Recifs Gris-Nez, Blanc-Nez SAC – France
Bancs des Flandres SAC – France
Plateau rocheux de l'île d'Yeu SAC – France
Cap d'Erquy–Cap Fréhel SAC – France
Schleswig-Holsteinisches Wattenmeer – International
Niedersächsisches Wattenmeer SAC – Germany
Chimeneas de Cádiz SAC - Spain
North East Scotland Marine Reserve – Scotland
Coastal Wales Marine Reserve and Cetacean Critical Habitat Network - UK
South West England Marine Reserve and Cetacean Critical Habitat Network - UK

IUCN Marine Region 6: Baltic
Skagens Gren og Skagerrak SAC - Denmark
Flensborg Fjord - Denmark
Bredgrund og farvandet omkring Als SAC - Denmark
Ingermanlandsky Reserve – Russian Federation
Vrångöskärgården SAC and SPA – Sweden

IUCN Marine Region 7: Wider Caribbean
Netherlands Antilles Caribbean Marine Mammal Sanctuary – Extent not determined
Walker's Cay Marine Park - Bahamas
Confluence River Meta and Orinoco – Columbia
El Tuparro National Park – Columbia
Tayrona National Natural Park – Columbia
Corales del Rosario – Columbia
San Bernardo National Natural Park – Columbia
Rosario and San Bernardo Archipelago MPA – Columbia
Via Salamanca Island Park – Columbia
Los Flamencos Fauna and Flora Sanctuary – Columbia
Santa Marta's Large Marsh Fauna and Flora Sanctuary – Columbia
El Corchal 'Mono Hernandez' Fauna and Flora Sanctuary – Columbia
Old Providence McBean Lagoon National Natural Park – Columbia
Cispata Bay Integrated Management District – Columbia
Costa Rican Whale and Dolphin Sanctuary – Costa Rica
Cahuita National Park – Costa Rica
Amana National Nature Reserve – French Guiana
Île du Grand-Connétable National Nature Reserve – French Guiana
Cayos Cochinos Marine Natural Monument – Honduras
Portland Bight Protected Area - Jamaica
Panamá Marine Corridor – Panama
Isla Bastimentos Marine National Park – Panama
Four multiple use management areas – Suriname
Arrau Turtle Wildlife Refuge – Venezuela
Parima Tapirapecó National Park – Venezuela
Yapacana National Park – Venezuela
Santos Luzardo National Park – Venezuela
Aguaro-Guariquito National Park – Venezuela
Orinoco Delta Biosphere Reserve, including Orinoco Delta National Park – Venezuela
Perijá National Park – Venezuela
Turuépano National Park – Venezuela
Peninsula de Paria National Park – Venezuela
Ciénagas de Juan Manuel National Park - – Venezuela
Ciudad Bolívar in the narrowness of the Orinoco River – Venezuela
Mochima National Park – Venezuela
National Monument Cerro Autana – Venezuela
Jeanette Kawas National Park – Honduras
Fort Clinch State Park Aquatic Reserve – US

IUCN Marine Region 8: West Africa
Iona National Park – Angola
Kissama National Park – Angola
Sebadales de Güi-Güí SAC – Canary Islands
Baía da Murdeira Marine Reserve – Cape Verde
Desert Nature Reserve – Cape Verde
Akanda National Park – Gabon
Loango National Park – Gabon
Mayumba National Park – Gabon
Pongara National Park – Gabon
Namibian Islands Marine Protected Area – Namibia
Conkouati-Douli National Park – Congo
Bird Island MPA – South Africa
Aliwal Shoal MPA – South Africa

IUCN Marine Region 9: South Atlantic

Punta Bermeja Natural Protected Area – Argentina
Puerto Lobos Natural Protected Area – Argentina
Caleta de los Loros-Punta Mejillón – Argentina
El Doradillo Municipal Protected Area – Argentina
Punta León Natural Protected Area – Argentina
Isla de los Estados Provincial Reserve – Argentina
Patagonian Austral Inter-jurisdictional Marine Coastal Park - Argentina
Isiboro Sécure National Park – Bolivia
Noel Kempff Mercado National Park – Bolivia
Iténez Departmental Park – Bolivia
Bruno Racua Departmental Wildlife Reserve – Bolivia
Muncipal PA Ibare-Mamore – Bolivia
Beni Biosphere Reserve Biological Station – Bolivia
Brazilian Whale and Dolphin Sanctuary – Brazil
Piagaçu-Purus Sustainable Dev. Reserve – Brazil
Jaú National Park – Brazil
Amazônia National Park – Brazil
Tapajós National Forest – Brazil
Juami-Japurá Ecological Station – Brazil
Anavilhanas National Park – Brazil
São Paulo State Env. Protection – Brazil
Cahuinarí National Natural Park – Columbia
Lake Complex of Tarapoto – Columbia
El Correo PA – Columbia
Puré River National Park – Columbia
Amacayacu National Natural Park – Columbia
National Natural Park La Paya – Columbia
Cuyabeno Faunistic Reserve – Ecuador
Yasuní Biosphere Reserve and National Park – Ecuador
Pacaya-Samiria National Reserve – Peru
Caballo Cocha Lake PA – Peru
Güeppí Reserved Zone – Peru
Pucacuro Reserved Zone – Peru
Santiago-Comaina Reserved Zone – Peru
Allpahuayo Mishana National Reserve – Peru
Tristan da Cunha Cetacean Sanctuary - UK
Gough Island Nature Reserve – UK
Inaccessible Island Nature Reserve – UK
Laguna de Rocha MPA – Uraguay
La Coronilla-Cerro Verde MPA – Uraguay

IUCN Marine Region 10: Central Indian Ocean

Protected Area Network for Cetacean Diversity – India
Royal Manas National Park – Bhutan
Chagos Islands Marine Protected Area – UK
Upper Ganga River – India
Kaziranga National Park – India
Kulsi Conservation Reserve – India
Subansiri Conservation Reserve – India
Bhitarkanika Mangroves Wildlife Sanctuary – India
Gulf of Kachchh Marine National Park – India
Satapada/Chilika Dolphin Sanctuary – India
Sahebganj Dolphin Sanctuary – India
Dibru-Saikhowa National Park – India
Khabalu-Ghagarmukh Dolphin Sanctuary – India
Katerniya Ghat Gharial Sanctuary – India
Hastinapur Wildlife Sanctuary – India
Mahatma Gandhi Marine National Park – India
North, Middle and South Button Island National Parks – India
Maldives Whale and Dolphin Sanctuary – Maldives
Ayeyarwady River Dolphin Protected Area – Myanmar
Ayeyarwady River Protected Area – Myanmar
Meinmahla Kyun Wildlife Sanctuary – Myanmar
Koshi Tappu Wildlife Reserve – Nepal
Bar Reef Marine Sanctuary – Sri Lanka

IUCN Marine Region 11: Arabian Seas

Hawar Islands Protected Area – Bahrain
Samadai Reef Dolphin House – Egypt
Ras Mohammed National Park – Egypt
Great Red Sea Reef Protected Area – Egypt
Wadi El Gemal – Hamata National Park and Natural Monument – Egypt
Dahlak Marine National Park – Eritrea
Indus Dolphin Reserve – Pakistan
Chashma Barrage Dolphin Sanctuary – Pakistan
Taunsa Barrage Wildlife Sanctuary – Pakistan
Indus Delta Ramsar Wetland – Pakistan
Hingol National Park – Pakistan
Keti Bunder Wildlife Sanctuaries – Pakistan
Jiwani Coastal Ramsar Wetland – Pakistan
Ormara Turtle Beaches Ramsar Wetland – Pakistan
Astola Island Ramsar Wetland – Pakistan
Farasan Islands Marine Reserve – Saudi Arabia
Sanganeb Atoll Marine National Park – Sudan
Dungonab Bay-Mukkawar Island Marine Protected Area – Sudan
Marawah Marine Protected Area – United Arab Emirates
Socotra Islands Protected Area – Yemen

IUCN Marine Region 12: East Africa

Amsterdam and St Paul Marine Reserve – France
Velondriake MPA – Madagascar
Mayotte Marine Natural Park – France
Primeiras and Segundas Reserve/National Park – Mozambique
Quirimbas National Park – Mozambique
Anse aux Anglais, Grand Bassin, Passe Demie, Rivière Banane Marine Reserves – Rodrigues
Aldabra Atoll Special Reserve – Seychelles
Pemba Channel Conservation Area – Tanzania
Tanga Coelacanth Marine Park – Tanzania

IUCN Marine Region 13: East Asian Seas

Kaimana MPA – Indonesia
Dampier Strait MPA – Indonesia
Kofiau and Boo Islands MPA – Indonesia
Berau MPA – Indonesia
Bontang-East Kutai MPA – Indonesia
Natural Reserve Habitat Pesut Mahakam – Indonesia
Mahakam River – Indonesia
Pahang Marine Park – Malaysia
Semporna Islands Park – Malaysia
Pulau Tiga Marine Park – Malaysia
Songkhla Lake Dolphin PA - Thailand

IUCN Marine Region 14: North and South Pacific

Coral Sea NNR – Australia
War in the Pacific National Historical Park – Guam
Phoenix Islands Protected Area – Kiribati
Lagoons of New Caledonia – New Caledonia
Palau Marine Mammal Sanctuary – Palau
Kimbe Bay Marine Conservation Area – Palau
Tokelau Whale Sanctuary – Tokelau

IUCN Marine Region 15: Northeast Pacific

San Pedro Martir Island Biosphere Reserve – Mexico
Gulf of California Islands – Mexico
Marieta Islands National Park – Mexico
Cabo Pulmo National Marine Park – Mexico
Espirítu Santo Insular Complex – Mexico
Bahía de los Angeles, Canales de Ballenas y Salsipuedes Biosphere Reserve – Mexico
San Lorenzo Archipelago National Park – Mexico
Cabo San Lucas Underwater Refuge Zone – Mexico

IUCN Marine Region 16: Northwest Pacific

Southwest Lantau Marine Park – China
Soko Islands Marine Park – China
Brothers Islands Marine Park – China
Taishan Daijin Island Chinese White Dolphin Provincial Nature Reserve – China
Hepu Dugong (State) National Nature Reserve – China
Shishou Tian-e-Zhou Baiji National Natural Reserve – China
Tongling Yangtze Freshwater Cetacean National Natural Reserve – China
Zhenjiang Yangtze Cetacean Provincial Natural Reserve – China
Poyang Lake Yangtze Finless Porpoise Provincial Natural Reserve – China
Yueyang East Dongting Lake Yangtze Cetacean Natural Reserve – China
Anqing Yangtze Cetacean Natural Reserve – China
Shiretoko National Park – Japan
Batanes Islands Protected Land and Seascape – Philippines

IUCN Marine Region 17: Southeast Pacific

Isla Chañaral Marine Reserve – Chile
Cape Horn Biosphere Reserve – Chile
San Ignacio de Huinay – Chile
Isla Grande de Atacama – Chile
Tictoc Melimoyu MPA – Chile
Tortel Multiple Use Marine and Coastal Area – Chile
Malpelo Island Flora and Fauna Sanctuary – Columbia
Costa Rican Whale and Dolphin Sanctuary – Costa Rica
Manuel Antonio National Park – Costa Rica
Santa Rosa National Park – Costa Rica
Guanacaste Conservation Area – Costa Rica
Las Baulas National Marine Park – Costa Rica
Santa Elena Fauna Reserve – Ecuador
El Morro Reserve – Ecuador
Coastal Marine Zones of Guatemala – Guatemala
San Juan del Sur Humpback Whale MPA – Nicaragua
Panamá Marine Corridor – Panama
Punta Patiño Wetland – Panama
Las Perlas Archipelago – Panama
Guano Islands and Capes National Reserve – Peru

IUCN Marine Region 18: Australia-New Zealand

Batemans Marine Park – Australia
Nuyts Archipelago Marine Park – Australia
West Coast Bays Marine Park – Australia
Investigator Marine Park – Australia
Thorny Passage Marine Park – Australia
Sir Joseph Banks Group Marine Park – Australia
Neptune Islands Group Marine Park – Australia
Gambier Islands Group Marine Park – Australia
Franklin Harbor Marine Park – Australia
Upper Spencer Gulf Marine Park – Australia
Eastern Spencer Gulf Marine Park – Australia
Southern Spencer Gulf Marine Park – Australia
Lower Yorke Peninsula Marine Park – Australia
Upper Gulf St Vincent Marine Park – Australia
Western Kangaroo Island Marine Park – Australia
Southern Kangaroo Island Marine Park – Australia
Upper South East Marine Park – Australia
Lower South East Marine Park – Australia
Ngari Capes Marine Park – Australia
Regnard Marine Management Area – Australia
Kent Group Marine Reserve – Australia
Port Davey Marine Reserve – Australia
Clifford and Cloudy Bay Marine Mammal Sanctuary – New Zealand
Catlins Coast Marine Mammal Sanctuary – New Zealand
Te Waewae Bay Marine Mammal Sanctuary – New Zealand
Hauraki Gulf Marine Park – New Zealand
Parininihi Marine Reserve – New Zealand
Nga Motu/Sugar Loaf Islands Marine Protected Area – New Zealand
Campbell Island Marine Reserve – New Zealand
Kermadec Marine Park – New Zealand

References

Acebes, J. M. V., Darling, J., & Yamaguchi, M. (2007). Status and distribution of humpback whales (Megaptera novaeangliae) in northern Luzon, Philippines. *Journal of Cetacean Research and Management, 9*(1), 37.

Acevedo-Gutiérrez, A., & Smultea, M. A. (1995). First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of Northern and Southern hemisphere populations. *Marine Mammal Science., 11*(4), 554-560.

Baba, N., Kiyota, M., Hatanaka, H., & Nitta, A. (1993). Biological information and mortality of northern fur seals (Callorhinus ursinus) by the high seas Japanese squid driftnet fishery. *International North Pacific Fisheries Commission Bulletin, 53*, 461-472.

Best, P. B., Payne, R., Rowntree, V., Palazzo, J. T., & Both, M. D. C. (1993). Long-range movements of south Atlantic right whales Eubalaena australis. *Marine Mammal Science, 9*(3), 227-234.

Biggs, D. C., Jochens, A. E., Howard, M. K., DiMarco, S. F., Mullin, K. D., Leben, R. R., . . . Hu, C. (2005). Eddy forced variations in on-and off-margin summertime circulation along the 1000-m isobath of the northern Gulf of Mexico, 2000-2003, and links with sperm whale distributions along the middle slope. *Geophysical Monograph-American Geophysical Union, 161*, 71.

Buckland, S., Cattanach, K., & Hobbs, R. (1993). Abundance estimates of Pacific white-sided dolphin, northern right whale dolphin, Dall's porpoise and northern fur seal in the North Pacific, 1987-1990. *International North Pacific Fisheries Commission Bulletin, 53*(3), 387-407.

Calambokidis, J., Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, P., Ford, J., . . . Rojas-Bracho, L. (2008). SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific. *Unpublished report submitted by Cascadia Research Collective to USDOC, Seattle, WA under contract AB133F-03-RP-0078 [available from the author]*.

Canese, S., Cardinali, A., Fortuna, C. M., Giusti, M., Lauriano, G., Salvati, E., & Greco, S. (2006). The first identified winter feeding ground of fin whales (Balaenoptera physalus) in the Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom, 86*, 903-907.

Castellote, M., Clark, C. W., & Lammers, M. O. (2010). Population identity and migration movements of fin whales (Balanoptera physalus) in the Mediterranean Sea and Strait of Gibraltar. *Journal of Cetacean Research and Management, SC/62/SD2*, 5 pp.

Cañadas, A., Sagarminaga, R., De Stephanis, R., Urquiola, E., & Hammond, P. S. (2005). Habitat preference modelling as a conservation tool: proposals for marine protected areas for cetaceans in southern Spanish waters. *Aquatic Conservation: Marine and Freshwater Ecosystems, 15*(5), 495-521.

Certain, G., Ridoux, V., Van Canneyt, O., & Bretagnolle, V. (2008). Delphinid spatial distribution and abundance estimates over the shelf of the Bay of Biscay. *ICES Journal of Marine Science: Journal du Conseil, 65*(4), 656-666.

Clark, J., Dolman, S. J., & Hoyt, E. (2010). Towards Marine Protected Areas for Cetaceans in Scotland, England and Wales: A scientific review identifying critical habitat with key recommendations. (pp. 178 pp.). Chippenham, UK: Whale and Dolphin Conservation Society.

Davis, R. W., Evans, W. E., & Wursig, B., eds. (2000). Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations. Volume I: Executive Summary: Prepared by Texas A&M University at Galveston and the National Marine Fisheries Service. US Department of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-002 27. 27 pp.

Davis, R. W., Ortega-Ortiz, J. G., Ribic, C. A., Evans, W. E., Biggs, D. C., Ressler, P. H., . . . Würsig, B. (2002). Cetacean habitat in the northern oceanic Gulf of Mexico. *Deep Sea Research Part I: Oceanographic Research Papers, 49*(1), 121-142.

de Boer, M. N. (2010). Spring distribution and density of minke whale Balaenoptera acutorostrata along an offshore bank in the central North Sea. *Marine Ecology Progress Series, 408*, 265-274.

De Stephanis, R., Cañadas, A., Villalba, N., Perez-Gimeno, N., Sagarminaga, R., Segura, A., . . . Guinet, C. (2001). Fin whale (balaenoptera physalus) migration through the Strait of Gibraltar? *European Research on Cetaceans, 15*, 382-384.

Debrot, A. O., Witte, R. H., & Scheidat, M. (2011). The marine mammals of the Dutch Caribbean: a comparison between EEZ sectors, contrasts and concerns. In SC/63/E9 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). (pp. 8 pp.).

DON. (2010). *Final Environmental Impact Statement/Overseas Environmental Impact Statement for Gulf of Mexico Range Complex*.

d'Andrade, M. I. L. B. (2008). *Spatial distribution of cetaceans in the Bay of Biscay and implications of the Marine Strategy Directive for their conservation.* (M.Sc.), University of Lisbon.

Engel, M. H., Fagundes, N. J. R., Rosenbaum, H. C., Leslie, M. S., Ott, P. H., Schmitt, R., . . . Bonatto, S. L. (2008). Mitochondrial DNA diversity of the Southwestern Atlantic humpback whale (Megaptera novaeangliae) breeding area off Brazil, and the potential connections to Antarctic feeding areas. *Conservation Genetics, 9*(5), 1253-1262.

Freitas, A., Kinas, P. G., Martins, C. C. A., & Coitinho, M. H. E. (2004). Abundance of humpback whales on the Abrolhos Bank wintering ground, Brazil. *Journal of Cetacean and Research Management, 6*(3), 225-230.

Fuller, S. D., & Myers, R. A. (2004). The Southern Grand Bank : a marine protected area for the world, World Wildlife Fund-Canada (pp. 99 pp.). Halifax, Canada.

GOB. (2010). Global Ocean Biodiversity Initiative: Working towards high seas conservation (pp. 24): IUCN.

Groch, K. R., Palazzo Jr., J. T., Flores, P. A. C., Adler, F. R., & Fabian, M. E. (2005). Recent rapid increases in the right whale (Eubalaena australis) population off southern Brazil. *Latin American Journal of Aquatic Mammals, 4*(1), 41-47.

Hoyt, E. (2005). *Marine protected areas for whales, dolphins, and porpoises: a world handbook for cetacean habitat conservation* (1st ed.): Earthscan/James & James.

Hoyt, E. (2011). *Marine Protected Areas for Whales, Dolphins, and Porpoises: A World Handbook for Cetacean Habitat Conservation and Planning* (2nd ed.): Earthscan.

INDEMARES. (2010a). Banco de Galicia Retrieved May 2012, from http://www.indemares.es/index.php?option=com_content&view=article&id=21&Itemid=50&lang=en

INDEMARES. (2010b). Cañón de Avilés – May and June Campaign - CEMMA Retrieved May 2010, from http://www.indemares.es/index.php?option=com_content&view=article&id=20&Itemid=49&lang=en

IWC. (2001). Report of the Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison. *Journal of Cetacean Research and Management, 2*(Special Issue), 1-35.

Jefferson, T. A., & Schiro, A. J. (1997). Distribution of cetaceans in the offshore Gulf of Mexico. *Mammal Review, 27*(1), 27-50.

JNCC. (2010). Offshore Special Area of Conservation: Dogger Bank, SAC Selection Assessment. Version 9.0 (26th August 2011). (pp. 32). Peterborough, Cambridgeshire, UK: Marine Protected Sites, Joint Nature Conservation Committee.

Jochens, A., Biggs, D., Benoit-Bird, K., Engelhaupt, D., Gordon, J., Hu, C., . . . Wursig, B. (2008). Sperm whale seismic study in the Gulf of Mexico: Synthesis report: US Dept. of Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-006. 341 pp.

Johnston, D. W., Chapla, M. E., Williams, L. E., & Mattila, D. K. (2007). Identification of humpback whale Megaptera novaeangliae wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. *Endangered Species Research, 3*(3), 249-257.

Kerem, D., Hadar, N., Goffman, O., Scheinin, A., Kent, R., Boisseau, O., & Schattner, U. (2012). Update on the Cetacean Fauna of the Mediterranean Levantine Basin. *Open Marine Biology Journal, 6*, 6-27.

Konishi, K., Kiwada, H., Matsuoka, K., Hakamada, T., & Tamura, T. (2009). Density prediction modeling and mapping of common minke, sei and Bryde's whales distribution in the western North Pacific using JARPN II (2000-2007) data set: SC/J09/JR19.

Lammers, M. O., Fisher-Pool, P. I., Au, W. W. L., Meyer, C. G., Wong, K. B., & Brainard, R. E. (2011). Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. *Marine Ecology Progress Series, 423*(Dawbin 1966), 261-268.

LF. (2002). Saya de Malha Expedition 2002 (pp. 107). Hamburg, Germany: Lighthouse Foundation.

Marini, L., Consiglio, C., Sanna, A., Angradi, A., & Symoens, J. (1992). *Some notes on the fin whale (Balaenoptera physalus) in the Western Mediterranean Sea.* Paper presented at the Proceedings of the Symposium "Whales: Biology – Threats – Conservation", Brussels, Belgium.

Marini, L., Villetti, G., & Consiglio, C. (1996). Wintering areas of fin whales (Balaenoptera physalus) in the Mediterranean Sea: a preliminary survey. *European Research on Cetaceans, 9*, 126-128.

Martins, C. C. A., Morete, M. E., Coitinho, M. H. E., Freitas, A., Secchi, E. R., & Kinas, P. G. (2001). Aspects of habitat use patterns of humpback whales in the Abrolhos Bank, Brazil, breeding ground. *Memoirs of the Queensland Museum, Brisbane, 47*(2), 563-570.

Moore, S. E., Watkins, W. A., Daher, M. A., Davies, J. R., & Dahlheim, M. E. (2002). Blue whale habitat associations in the Northwest Pacific: Analysis of remotely-sensed data using a Geographic Information System. *Oceanography, 15*(3), 20-25.

Mullin, K. D., & Fulling, G. L. (2004). Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996–2001. *Marine Mammal Science, 20*(4), 787-807.

Mullin, K. D., Hoggard, W., Roden, C., Lohoefener, R., & Rogers, C. (1991). Cetaceans on the upper continental slope in the north-central Gulf of Mexico (pp. 108 pp.): OCS Study/MMS 91-0027. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Regional Office, New Orleans, LA.

NF. (2011). Results of Nature Foundation Marine Mammal Monitoring Project Jan-May 2011 (pp. 10). St. Maarten, Netherlands Antilles: Nature Foundation St. Maartens.

NMFS. (2010). Recovery plan for the sperm whale (Physeter macrocephalus) (pp. 165). Silver Spring, MD: National Marine Fisheries Service.

NOAA. (2011). NOAA, France partner in historic effort to protect North Atlantic humpback whales Retrieved May, 2012, from http://www.noaanews.noaa.gov/stories2011/20110830_stellwagen.html

Notarbartolo di Sciara, G., Zanardelli, M., Jahoda, M., Panigada, S., & Airoldi. (2003). The fin whale Balaenoptera physalus (L. 1758) in the Mediterranean Sea. *Mammal Review, 33*(2), 105-150.

Piatt, J. F., Methven, D. A., Burger, A. E., McLagan, R. L., Mercer, V. C. K., & Creelman, E. (1989). Baleen whales and their prey in a coastal environment. *Canadian Journal of Zoology, 67*(6), 1523-1530.

Rebull, O. G., Cusí, J. D., Fernández, M. R., & Muset, J. G. (2006). Tracking fin whale calls offshore the Galicia Margin, north east Atlantic Ocean. *The Journal of the Acoustical Society of America, 120*, 2077.

Robinson, K. P., & Tetley, M. J. (2007). Behavioural observations of foraging minke whales (Balaenoptera acutorostrata) in the outer Moray Firth, north-east Scotland. *Journal of the Marine Biological Association of the United Kingdom, 87*(1), 85-86.

Rosenbaum, H. C., Brownell Jr., R. L., Brown, M. W., Schaeff, C., Portway, V., White, B. N., . . . Baker, C. S. (2000). World-wide genetic differentiation of Eubalaena: questioning the number of right whale species. *Molecular Ecology, 9*(11), 1793-1802.

Santos, M. B., Pierce, G. J., Lopez, A., Reid, R. J., Ridoux, V., & Mente, E. (2006). Pygmy sperm whales Kogia breviceps in the northeast Atlantic: new information on stomach contents and strandings. *Marine Mammal Science, 22*(3), 600-616.

Skov, H., Gunnlaugsson, T., Budgell, W., Horne, J., Nřttestad, L., Olsen, E., . . . Waring, G. (2008). Small-scale spatial variability of sperm and sei whales in relation to oceanographic and topographic features along the Mid-Atlantic Ridge. *Deep Sea Research Part II: Topical Studies in Oceanography, 55*(1-2), 254-268.

Tamura, T., Konishi, K., Isoda, T., Okamoto, R., Bando, T., & Hakamada, T. (2009). Some examinations of uncertainties in the prey consumption estimates of common minke, sei and Bryde's whales in the western North Pacific. *Unpublished paper to the IWC Scientific Committee, Madeira, Portugal, 24*.

Tetley, M. J. (2004). *Thesis: The distribution and habitat preference of the North Atlantic minke whale (Balaenoptera acutorostrata acutorostrata) in the southern outer Moray Firth, NE Scotland.* (Master of Science), University of Wales Bangor, Bangor, Wales.

Thomsen, F., McCully, S. R., Weiss, L. R., Wood, D. T., Warr, K. J., Barry, J., & Law, R. J. (2011). Cetacean Stock Assessments in Relation to Exploration and Production Industry Activity and Other Human Pressures: Review and Data Needs. *Aquatic Mammals, 37*(1).

Ward, E., Zerbini, A. N., Kinas, P. G., Engel, M. H., & Andriolo, A. (2006). Estimates of population growth rates of humpback whales (Megaptera novaeangliae) in the wintering grounds off the coast of Brazil (Breeding Stock A). *Journal of Cetacean Research and Management, 47*(2), 1-10.

Waring, G., Josephson, E., Fairfield-Walsh, C., & Maze-Foley, K. (2009). US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments--2008. *NOAA Tech Memo NMFS NE 210, 210*(440), 02543-01026.

Whitehead, H., & Glass, C. (1985). The significance of the Southeast Shoal of the Grand Bank to humpback whales and other cetacean species. *Canadian Journal of Zoology/Revue Canadienne de Zoologie, 63*(11), 2617-2625.

Wursig, B. (2001). Human activities and natural events: impacts on Gulf of Mexico marine mammals, part 1. In Gulf of Mexico Marine Protected Species Workshop, June 1999. In M. McKay, J. Nides, W. Lang & D. Vigil (Eds.), (pp. 171): U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La. OCS Study MMS 2001-039.

Yamaguchi, M., Acebes, J. M., & Miyamura, Y. (2005). The breeding ground distribution of the humpback whales (Megaptera novaeangliae) in the western North Pacific and their trans-movements among the Ogasawara Islands, the Ryukyu Islands and the Babuyan Islands, Philippines. Second Workshop on the Biology and Conservation of Small Cetaceans and Dugongs of SE Asia. CMS Technical Series Publication No. 9 (pp. 159).

Yatsu, A., Shimada, H., & Murata, M. (1993). Distributions of epipelagic fishes, squids, marine mammals, seabirds and sea turtles in the central North Pacific. *International North Pacific Fisheries Commission Bulletin, 53*, 111-146.

Zerbini, A. N., Andriolo, A., Da Rocha, J. M., Simões-Lopes, P., Siciliano, S., Pizzorno, J. O. S. L. U. I., . . . Vanblaricom, G. R. (2004). Winter distribution and abundance of humpback whales (Megaptera novaeangliae) off Northeastern Brazil. *Journal of Cetacean Research and Management, 6*(1), 101-107.

THIS PAGE IS INTENTIONALLY LEFT BLANK