FINAL
SUPPLEMENTAL
ENVIRONMENTAL IMPACT STATEMENT
FOR
SURVEILLANCE TOWED ARRAY SENSOR SYSTEM
LOW FREQUENCY ACTIVE
(SURTASS LFA) SONAR
Volume 1 of 2

Department of the Navy
Chief of Naval Operations
April 2007

Prepared for
Department of the Navy

in accordance with
Chief of Naval Operations Instruction 5090.1B

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

Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

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Abstract

This Supplemental Environmental Impact Statement (SEIS) 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 Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions) and the National Environmental Policy Act of 1969 (NEPA). The Navy currently plans to operate up to four SURTASS LFA sonar systems. At present the Research Vessel (R/V) *Cory Chouest* and the USNS IMPECCABLE (T-AGOS 23) are the only vessels equipped with SURTASS LFA sonar. The additional SURTASS LFA sonar systems would be installed on the USNS VICTORIOUS (T-AGOS 19) Class ocean surveillance vessels. In addition to the No Action Alternative, the SEIS analyzed four additional alternatives. The analysis of these five alternatives is intended to address NEPA deficiencies identified in the Ninth District Court's 26 August 2003 opinion, as well as to fulfill the Navy's responsibilities under NEPA with regard to providing additional information related to the proposed action. The SEIS considers mitigation measures, including coastal standoff restrictions of 22 and 46 km (12 and 25 nm) and the designation of additional offshore biologically important areas.

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PREFACE

This Supplemental Environmental Impact Statement (SEIS) evaluates the potential environmental effects of employment of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems. The proposed action herein is the U.S. Navy employment of up to four SURTASS LFA sonar systems in the oceanic areas as presented in Figure 1-1 (SURTASS LFA Sonar Systems Potential Areas of Operations) of the Final Overseas Environmental Impact Statement/Environmental Impact Statement (FOEIS/EIS) for SURTASS LFA Sonar (DON, 2001). 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 during biologically important seasons, and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites.

The purpose of the SURTASS LFA Sonar SEIS is 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 National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and Marine Mammal Protection Act (MMPA)[1];
- Provide information necessary to apply for a new five-year Rule that would provide for incidental takes under the MMPA when the current rule expires 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.

References to Underwater Sound Levels

1. 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.
2. References to underwater Sound Exposure Level (SEL) in this SEIS refer to the squared pressure over a duration of the sound referenced to the standard underwater sound reference level (1 µPa) expressed in dB, and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise stated.

Sources: Urick (1983); ANSI S1.8-1989

[1] 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.

In response to U.S. District Court ruling on the motion for preliminary injunction, the Deputy Assistant Secretary of the Navy for Environment (DASN(E)) decided that the purposes of NEPA would be served by supplemental analysis of employing SURTASS LFA sonar systems. On 11 April 2003, the DASN(E) directed the Navy to prepare a supplemental environmental impact statement (EIS) to address concerns identified by the Court, to provide additional information regarding the environment that could potentially be affected by the SURTASS LFA sonar systems, and to provide additional information related to mitigation (See APPENDIX A).

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[2] and Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions)[3]. The DASN(E) signed the Record of Decision (ROD) on 16 July 2002 (*Federal Register* (FR) (67 FR 48145)), authorizing the operational employment of SURTASS LFA sonar systems contingent upon issuance by NMFS of letters of authorization (LOAs) under the MMPA and incidental take statements (ITSs) under ESA for each vessel.

In order 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 and training operations that are the subject of NMFS’s July 16, 2002, Final Rule constitute a military readiness activity 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 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.
- Amended definition of “harassment” as it applies to military readiness activities and scientific activities conducted on behalf of the Federal government.

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

- 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[4].
- NMFS's 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 SEIS focuses on:

- DASN(E) direction to:
    - Provide additional information regarding the environment that could potentially be affected by employment of SURTASS LFA;
    - Provide additional information related to mitigation of the potential impacts of the system;
- Addressing pertinent deficiencies raised by the Court including:
    - Additional mitigation and monitoring;
    - Additional area alternatives analysis;
    - Analysis of the potential impacts of LF sound on fish;
- Providing the information necessary to apply for a new five-year rule that would provide for incidental takes under the MMPA, taking into account the NDAA FY04 amendments to the MMPA for military readiness.

Additional SEIS analyses include:

- Updating literature reviews and determination of data gaps, especially for fish, sea turtles, and marine mammals;
- Marine animal LF sound thresholds/impacts based on Fish Controlled Exposure Experiments (CEE) and updated literature reviews;
- LF sound impact analysis to include:
    - Geographic areas;
    - Marine mammal impacts under NDAA FY04 definition of "harassment;"
    - Fish impacts;
    - Other listed species' impacts, as required;
- Mitigation (need for mitigation determined by impact analysis based on new legislation).

[4] On 31 June 2006 and 23 June 2007, the Deputy Secretary of Defense invoked the national defense exemption under the MMPA for certain mid-frequency sonar activities. Neither of these national defense exemptions apply to SURTASS LFA sonar employment as detailed in this SEIS.

The information in the SURTASS LFA sonar FOEIS/EIS remains valid, except as noted or modified in the SEIS. The contents of the FOEIS/EIS are incorporated into the SEIS by reference, except as noted or modified.

Table P-1 provides a comparison of the FOEIS/EIS with the SEIS.

Table P-1. SURTASS LFA Sonar FOEIS/OEIS and SEIS comparison.

FOEIS/EIS		**SEIS**		**Comparison**
Chapter	**Section**	**Chapter**	**Section**	
1		1		▪ Updated Purpose and Need statement. ▪ Updated background and chronology of key events. ▪ Updated environmental impact analysis process description. ▪ Updated analytical context.
2		2		▪ Updated general SURTASS LFA 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 greater coastal standoff distance, additional offshore biologically important areas, and potential shutdown for fish.
3	3.1	3	3.1	▪ Generally, no changes—FOEIS/EIS incorporated by reference.
	3.2.1		3.2.1	▪ Species Screening—No substantial changes except for fishes.
	3.2.2		3.2.2	▪ Fish—Updated literature review.
	3.2.3		3.2.3	▪ Sea Turtles—Updated literature review.
	3.2.4		3.2.4.1	▪ Mysticete Species—Updated literature review.
	3.2.5		3.2.4.2	▪ Odontocete Species—Updated literature review.
	3.2.6		3.2.5	▪ Pinnipeds—Updated literature review.
	3.3.1		3.3.1	▪ Commercial and Recreational Fisheries—Updated literature review.
	3.3.1.4		3.3.1.3	▪ Marine Mammals—Expanded section to include subsistence whaling, scientific research, IWC whale sanctuaries, and marine mammal bycatch.
	3.3.2		3.3.2	▪ Other Recreational Activities—Updated literature review.
	3.3.3		3.3.3	▪ Research and Exploration Activities—Updated literature review.
	3.3.4		3.3.4	▪ Coastal Zone Management—No changes— FOEIS/EIS incorporated by reference.
4	4.1		4.1	▪ Potential Impacts on Fish and Shark Stocks—Analysis updated. ▪ Presented results of Fish Controlled Exposure Experiment.
	4.1.2		4.2	▪ Potential Impacts on Sea Turtles—Analysis updated.

FOEIS/EIS		SEIS		Comparison
Chapter	**Section**	**Chapter**	**Section**	
	4.2		4.3	▪ Potential Impacts to Marine Mammals—Changes including non-auditory injury, hearing threshold, and biologically significant behavior. ▪ Analysis of SURTASS LFA Operations under Current MMPA Rule—Risk assessment approach and case study. ▪ Evaluation of the Use of Small Boats and Aircraft for Pre-operational Surveys—New. ▪ Marine Mammal Strandings—New. ▪ Multiple System Analysis—No substantial change, FOEIS/EIS Subchapter 4.2.7.4 incorporated by reference.
	4.3		4.5	▪Socioeconomic—Analysis updated.
	4.4		4.6	▪ Cumulative Effects—Analysis updated.
	4.4.1 4.4.2		4.6.1	▪ Cumulative Impacts from Anthropogenic 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	▪ Comparison of SURTASS LFA with Other Human-Generated Sources of Oceanic Noise—Analysis updated.
			4.6.2	▪ Cumulative Impacts due to Injury and Lethal Takes—New.
	4.4.4		4.6.3	▪ Summary of Cumulative Impacts—Conclusion updated.
			4.7	▪ Evaluation of Alternatives—New.
5		5		▪ Mitigation Measures—Changes include possible increased number of offshore biologically import areas, and possible increase in coastal standoff.
6		6		▪ Federal, State, Local Plans, Policies, and Controls—Updated.
7		7		▪ No change/Incorporated by reference.
8		8		▪ No change/Incorporated by reference.
9		9		▪ No change/Incorporated by reference.
10		10		▪ Public Review Process—No process change from FOEIS/EIS, DSEIS Public Hearing information provided.
11		11		▪ Distribution—Updated.
12				▪ Glossary—No changes/Incorporated by reference.
13		12		▪ Literature Cited—Updated.
14		13		▪ List of Preparers and Reviewers—Updated.

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Executive Summary
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This Supplemental Environmental Impact Statement (SEIS) 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 Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions) and the National Environmental Policy Act of 1969 (NEPA). The Navy currently plans to operate up to four SURTASS LFA sonar systems. At present the Research Vessel (R/V) *Cory Chouest* and the USNS IMPECCABLE (T-AGOS 23) are the only vessels equipped with SURTASS LFA sonar. The additional SURTASS LFA sonar systems would be installed on the USNS VICTORIOUS (T-AGOS 19) Class ocean surveillance vessels. In addition to the No Action Alternative, the SEIS analyzed four additional alternatives. The analysis of these five alternatives is intended to address NEPA deficiencies identified in the Ninth District Court's 26 August 2003 opinion, as well as to fulfill the Navy's responsibilities under NEPA with regard to providing additional information related to the proposed action. The SEIS considers mitigation measures, including coastal standoff restrictions of 22 and 46 km (12 and 25 nm) and the designation of additional offshore biologically important areas.

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EXECUTIVE SUMMARY

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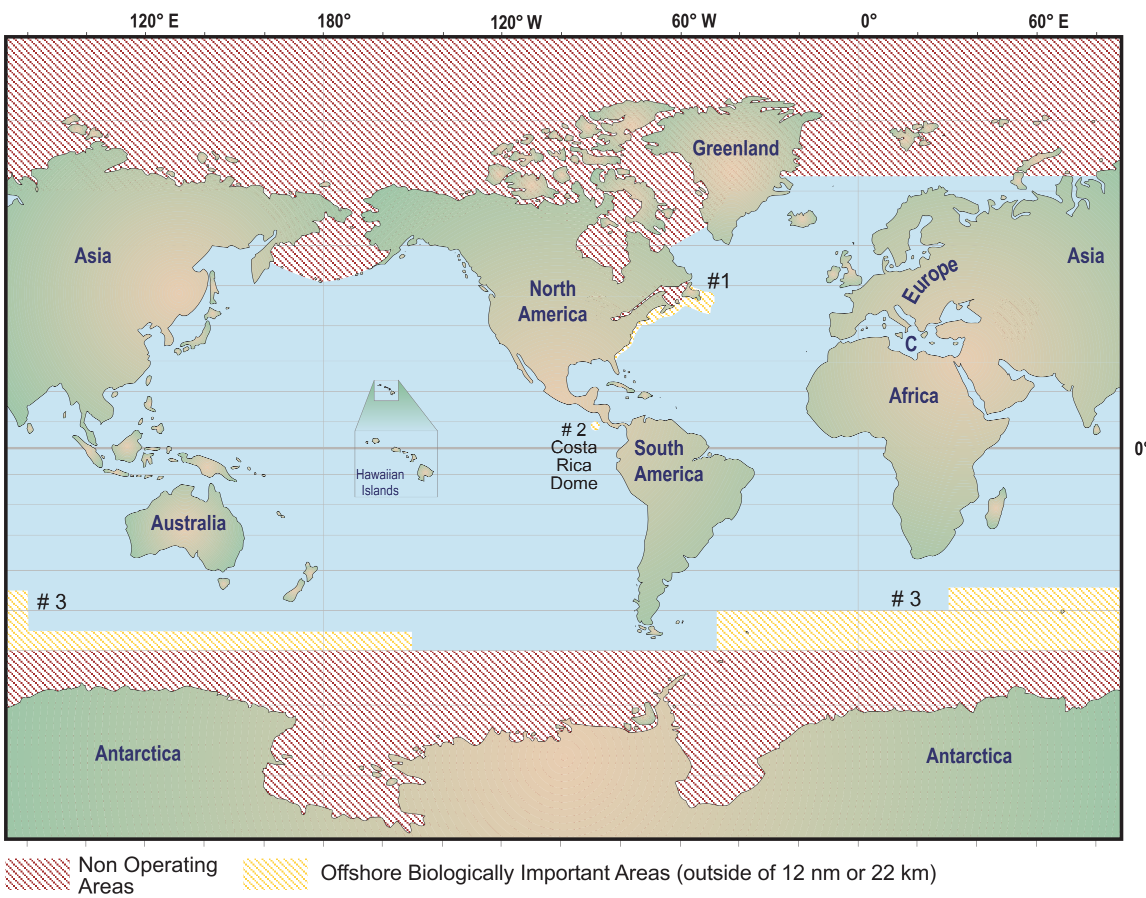

Figure ES-1. SURTASS LFA Sonar Potential Areas of Operations

The purpose of the SURTASS LFA Sonar SEIS is 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 National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and Marine Mammal Protection Act (MMPA)[1];
- Provide information necessary to apply for a new five-year Rule that would provide for incidental takes under the MMPA when the current rule expires 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.

References to Underwater Sound Levels

1. 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.
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[1] 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.
[2] The provisions of NEPA apply to major federal actions that occur or have effects in the United States, its territories, and possessions.
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The provisions of this act that specifically relate to SURTASS LFA 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.
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- Eliminated the "small numbers" and "specified geographic region" requirements from the incidental take permitting process for military readiness activities.

[4] On 31 June 2006 and 23 June 2007, the Deputy Secretary of Defense invoked the national defense exemption under the MMPA for certain mid-frequency sonar activities. Neither of these national defense exemptions apply to SURTASS LFA sonar employment as detailed in this SEIS.

The SEIS focuses on:

- DASN(E) direction to:
    - Provide additional information regarding the environment that could potentially be affected by employment of SURTASS LFA;
    - Provide additional information related to mitigation of the potential impacts of the system;
- Addressing pertinent deficiencies raised by the Court including:
    - Additional mitigation and monitoring;
    - Additional area alternatives analysis;
    - Analysis of the potential impacts of LF sound on fish;
- Providing the information necessary to apply for a new five-year rule that would provide for incidental takes under the MMPA, taking into account the NDAA FY04 amendments to the MMPA for military readiness.

Additional SEIS analyses include:

- Updating literature reviews and determination of data gaps, especially for fish, sea turtles, and marine mammals;
- Marine animal LF sound thresholds/impacts based on Fish Controlled Exposure Experiments (CEE) and updated literature reviews;
- LF sound impact analysis to include:
    - Geographic areas;
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    - Other listed species' impacts, as required;
- Mitigation (need for mitigation will be determined by impact analysis based on new legislation).

The information in the SURTASS LFA sonar FOEIS/EIS remains valid, except as noted or modified in the SEIS. The contents of the FOEIS/EIS are incorporated into the SEIS by reference, except as noted or modified.

ES.1 Purpose and Need

The original stated purpose for SURTASS LFA sonar systems from the FOEIS/EIS was:

> "The purpose of the proposed action is to meet U.S. need for improved capability to detect quieter and harder-to-find foreign submarines at long range. This capability would provide U.S. forces with adequate time to react to, and defend against, potential submarine threats while remaining a safe distance beyond a submarine's effective weapons range."

This statement remains valid, and may be more compelling now than when it was presented in the FOEIS/EIS in January 2001. With the Cold War ending more than a decade ago, the Navy is now faced with a large number of diesel-electric submarines with operations confined to a smaller littoral area rather than the open ocean nuclear submarine fleet[5]. Maritime strategies rely heavily on quiet submarines to patrol the littorals, blockade strategic choke points, and stalk aircraft carrier battle groups[6].

To meet its long-range detection need, the Navy investigated the use of a broad spectrum of acoustic and non-acoustic technologies to enhance antisubmarine warfare (ASW) capabilities. Of those technologies evaluated, low frequency active sonar remains the only system capable of providing long-range detection during most weather conditions, day or night. Low frequency active sonar is, therefore, the only available technology capable of meeting the U.S. need to improve detection of quieter and harder-to-find foreign submarines at long range. SURTASS LFA sonar is providing a quantifiable improvement in the Navy's capabilities against this threat and markedly improves the survivability of U.S Naval forces in a hostile ASW scenario.

ES.2 Description of Proposed Action and Alternatives

SURTASS LFA sonar systems are long-range systems operating in the LF band (below 1,000 Hertz [Hz]) within the frequency range of 100 to 500 Hz. These systems are composed of both active and passive components as shown in 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 "fish finders" to military ASW systems for detection and classification of submarines. There are two broad 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 basically 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.

[5] Friedman, N. 2004. The New Challenge—and a New Solution. Sea Technology, 45:11 p. 7.
[6] Goldstein, L., and B. Murray. 2003. China's Subs Lead the Way. Proceedings, U.S.Nav.Inst., Vol 129/3/1,202 pp.58-61.

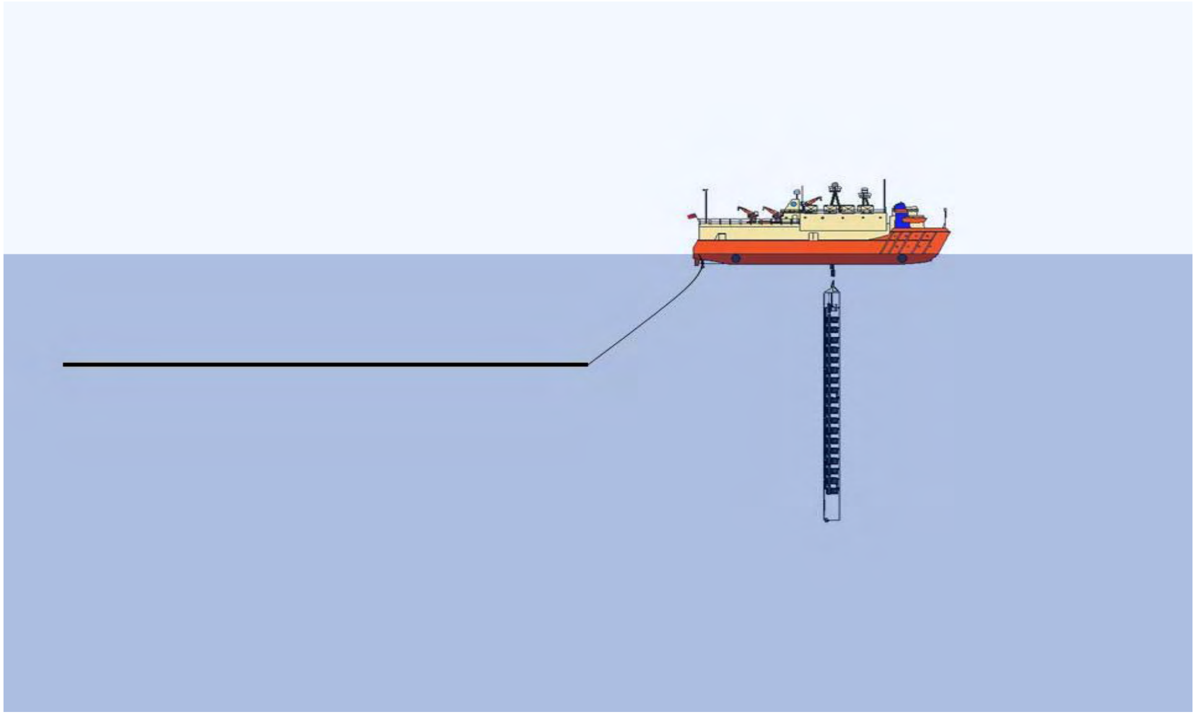

Figure ES-2. SURTASS LFA sonar systems.

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 as presented in the FOEIS/EIS for SURTASS LFA Sonar and Figure ES-1. Based on current operational requirements, exercises using these sonar systems would occur in the Pacific, Atlantic, and Indian oceans, and the Mediterranean Sea.

As future undersea warfare requirements continue to transition to littoral ocean regions, the development and introduction of a compact active system deployable from existing, smaller SURTASS SWATH-P ships is paramount. This system upgrade is known as Compact LFA, or CLFA. CLFA consists of smaller, lighter-weight source elements than the current LFA system, and will be compact enough to be installed on the existing SURTASS platforms, VICTORIOUS (T-AGOS 19) Class. The operational characteristics of the compact system are comparable to the existing LFA systems as presented in Subchapter 2.1 of the FOEIS/EIS and the SEIS. Therefore, the potential impacts from CLFA are expected to be similar to, and no greater than, the effects from the existing SURTASS LFA sonar 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.

At present, there are two existing SURTASS LFA sonar systems—one each onboard the Research Vessel (R/V) *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23). Three additional CLFA systems are planned for the T-AGOS 19 Class. With the R/V *Cory Chouest* retiring in Fiscal Year (FY) 2008, only two or three systems will be operational through FY 2010. Early in

FY 2011 the potential exists for four vessels to be operational. At no point are there expected to be more than four systems in use.

The active component of the system, LFA, is a set of LF acoustic transmitting source elements (called projectors) suspended by cable from underneath a ship. These projectors produce the active sonar signal or “ping.” A "ping" or transmission can last between 6 and 100 seconds. The time between transmissions is typically from 6 to 15 minutes. The average duty cycle (ratio of sound “on” time to total time) is between 10 and 20 percent. The typical duty cycle based on historical LFA operations from 2003 to 2006 is nominally 7.5 to 10 percent (DON, 2007)[7]. The SURTASS LFA sonar signal is not a continuous tone, but rather a transmission of various waveforms that vary in frequency and duration. The duration of each continuous frequency sound transmission is never longer than 10 seconds. The signals are loud at the source, but levels diminish rapidly over the first kilometer.

The passive, or listening, component of the system is SURTASS, which detects returning echoes from submerged objects, such as threat submarines, through the use of hydrophones on a receiving array that is towed behind the ship. The SURTASS LFA ship maintains a speed of 5.6 kilometers (km) per hour (kph) (3 knots [kt]) through the water to tow the horizontal line hydrophone array.

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). The FOEIS/EIS initially analyzed all potential technologies, both acoustic and non-acoustic, and determined that only active sonar (specifically LFA) would meet the purpose and need. The FOEIS/EIS then analyzed the No Action Alternative and two additional alternatives. The District Court’s 26 August 2003 opinion found that the Navy did not fulfill its responsibilities under NEPA with regard to the alternatives analyses. To address the Court’s findings, the SEIS analyzed the No Action Alternative and four additional alternatives. The analyses of these five alternatives are intended to address, among other things, mitigation measures including coastal standoff restrictions of 22 and 46 km (12 and 25 nautical miles [nm]), seasonal restrictions, the designation of additional offshore biologically important areas (OBIAs), and shutdown procedures for schools of fish. The five alternatives considered in the SEIS are as follows:

- No Action Alternative;
- Alternative 1—Same as the FOEIS/EIS Preferred Alternative;
- Alternative 2 (Preferred Alternative)—Alternative 1 with additional OBIAs;
- Alternative 3—Alternative 1 with extended coastal standoff distance to 46 km (25 nm); and
- Alternative 4—Alternative 1 with additional OBIAs, extended coastal standoff distance to 46 km (25 nm), and shutdown procedures for schools of fish.

[7] Department of the Navy (DON). 2007. 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 216 Subpart Q. January 2007

ES.3 Affected Environment

The areas of the marine environment that have the potential to either affect, or be affected by, SURTASS LFA sonar employment are:

- Marine Environment, including ambient noise in the oceans, physical environmental factors affecting acoustic propagation, ocean acoustic regimes, and oceanographic features affecting marine mammal distribution;
- Marine Organisms, including fish, sea turtles, and marine mammals; and
- Socioeconomic Conditions, including commercial and recreational fishing, other recreational activities, and research and exploration activities.

ES.3.1 Marine Environment

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

In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the U.S. Marine Mammal Commission (MMC) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. The actual percentage of the total anthropogenic acoustic energy budget added by each LFA source is estimated to be 0.5 percent per system (or less), when compared to other man-made sources (Hildebrand, 2004)[8]. When combined with the naturally occurring and other man-made sources of noise in the oceans, LFA barely contributes a measurable portion of the total acoustic energy. This and LFA's low duty cycle (nominally 7.5 to 10 percent during the projected 432 hours of operations per vessel per year) support the conclusion that the operation of up to four SURTASS LFA systems will not be expected to significantly add to oceanic ambient noise.

ES.3.2 Scientific Screening of Marine Animal Species for Potential Sensitivity to LF Sound

In order for marine species to be affected by the operation of the SURTASS LFA sonar, they 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.

[8] Hildebrand, John. 2004. Sources of Anthropogenic Sound in the Marine Environment. Report to the Policy on Sound and Marine Mammals: An International Workshop. U.S. Marine Mammal Commission and Joint Nature Conservation Committee, UK. London, England.

This selection rationale was presented in the FOEIS/EIS and is updated in the SEIS. The selection started with virtually all marine animal species, including both invertebrates and vertebrates. Based on the above criteria, this list was distilled down to five groups of vertebrates, including sharks and rays, bony fish, sea turtles, whales and dolphins, and seals and sea lions. Virtually all invertebrates were eliminated from further consideration because: 1) they do not have delicate organs or tissues whose acoustic impedance is significantly different from water, and 2) there is no evidence of auditory capability in the frequency range used by SURTASS LFA sonar.

ES.3.3 Marine Organisms

A thorough review of available literature of fish, sea turtles, and marine mammals was conducted with emphasis on data developed after the completion of the FOEIS/EIS in 2001. These data are detailed in the SEIS, Subchapter 3.2.

ES.3.4 Socioeconomic

A thorough review of available literature of commercial and recreational fisheries, recreational activities, and research and exploration activities was conducted with emphasis on data developed after the completion of the FOEIS/EIS in 2001. These data are detailed in the SEIS, Subchapter 3.3.

ES.4 SEIS Analytical Process

The SEIS analyses and results of the potential impacts or effects upon various components of the environment that could result from the implementation of the proposed action and of alternatives to the proposed action are consistent with the SURTASS LFA sonar FOEIS/EIS. They have been updated based on the best available literature, the Long Term Monitoring Program of current SURTASS LFA sonar operations, and continuing research. Further, there are no new data that contradict any of the assumptions or conclusions regarding Chapter 4 in the FOEIS/EIS; hence its contents are incorporated by reference herein to the SEIS.

This section 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 (maximum of four);
- Geographic restrictions imposed on system employment;
- Narrow bandwidth of SURTASS LFA sonar active signal (approximately 30 Hz);
- Slowly moving ship (5.6 kph [3 knots]), coupled with low system duty cycle means marine animals spend less time in the LFA mitigation zone (180-dB sound field); further, with both the vessel and the animal moving, the potential for animals being in the sonar transmit beam during the nominal 7.5 to 10 percent of the time (projected 432 hours per vessel per year) the sonar is actually transmitting is very low; and
- Small size of the LFA mitigation zone (180-dB sound field) relative to open ocean areas.

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, all marine animals exposed to $\geq$ 180 dB Received Level (RL) are evaluated as if they are injured.
- **Permanent threshold shift (PTS)**: A severe situation occurs when sound intensity is very high or of such long duration that the result is PTS or permanent hearing loss on the part of the listener.
- **Temporary threshold shift (TTS)**: Sounds of sufficient loudness can cause a temporary condition in which an animal's hearing is impaired for a period of time (TTS). 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 intense sound.
- **Behavioral change**: Various vertebrate species are affected by the presence of intense sounds in their environment. For military readiness activities, like 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 or marine mammal stock 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. While sea turtles and fish do not fall under harassment definitions, like marine mammals, it is possible that loud sounds could disturb the behavior of fish and sea turtles in the same way, resulting in the same kinds of consequences as for marine mammals.
- **Masking**: The presence of intense sounds in the environment can potentially interfere with an animal’s ability to hear sounds of relevance to it. 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.

ES.4.1 Potential Impacts on Fish

The Court found the FOEIS/EIS lacking because the Navy failed to adequately consider potential impacts to fish. In order to determine the effects of SURTASS LFA sonar on fish, the Navy sponsored independent research with the University of Maryland to examine whether exposure to high-intensity, low frequency sonar, such as the Navy’s SURTASS LFA sonar, would affect fish. This study 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*) and included observations of fish behavior before, during, and after sound exposure.

Since the SURTASS LFA sonar FOEIS/EIS was completed in 2001, there have been a small number of useful studies on the potential effects of underwater sound on fish, including sharks. However, the University of Maryland study (funded by the Navy to provide data for this SEIS) is directly relevant to potential effects of SURTASS LFA sonar on fish. Thus, while earlier studies examined the effects of sounds using pure tones for much longer duration than the SURTASS

LFA sonar signals, this study provides insight into the impact of LF sounds on fish. With the caveat that so far only two species have been examined in this study, the investigations found little or no effect of high intensity sounds, and there was no mortality as a result of sound exposure, even when fish were maintained for days post-exposure.

The Fish CEE concentrated on the fish species with the potential to be most effected by LFA—listed salmonid from the order *Salmoniformes*. Because the rainbow trout (a hearing generalist) is of the same toxemic genus, they have similar, if not identical, ears and hearing sensitivity, they can be used as “reference species” to determine the potential effects on other salmonid and, more generally, on other hearing generalist. Channel catfish were selected for the CEE to be reference species for hearing specialist. Thus, one must examine select species and use them as “reference species.” From the perspective of the University of Maryland studies, the rainbow trout and the channel catfish are excellent reference species for fish that do not hear well (trout) and those that do hear well (Catfish).

Results of SURTASS LFA sonar study

As of 30 June 2005, there have been four sets of studies (each lasting one week) on rainbow trout and two on channel catfish (Popper et al., 2005[9]; Halvorsen et al., 2006[10]). There are several significant findings.

- No fish died as a result of exposure to the experimental source signals.
- Despite the high level of sound exposure (193 dB RL at the fish), there were no gross pathological effects on fish. Histopathology was done on all major body tissues (brain, swim bladder, heart, liver, gonads, blood, etc.) and no differences were found among sound-exposed fish, controls, or baseline animals.
- There were no short- or long-term effects on ear tissue. The sensory cells of the ears of both species were healthy and intact both immediately post-exposure and then 96 hours after the end of exposure.
- Fish behavior after sound exposure was no different than behavior prior to the tests.
- Catfish and some specimens of rainbow trout showed 10-20 dB of hearing loss immediately after exposure to the LFA sound when compared to baseline and control animals, but hearing appeared to return to, or close to, normal within about 24 hours for catfish. Other rainbow trout showed minimal or no hearing loss.

Conclusions from SURTASS LFA sonar study

The critical question addressed in the SURTASS LFA sonar study was whether this type of sound source would impair the survival of fish and, more importantly, whether survival would be impaired in a typical environment when a ship using SURTASS LFA sonar was in the vicinity of a fish. Several factors were taken into consideration.

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[9] 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. J. Acoust. Soc. Am. 117, 2440 (2005).

[10] Halvorsen, M. B., Wysocki, L. E., and Popper, A. N. 2006. Effects of high-intensity sonar on fish. J. Acoust. Soc. Am. 119:3283.

First, the sound level to which fish were exposed in these experiments was 193 dB RL, a level that is only found within about 200 m (656 ft) of the SURTASS LFA source array. Thus, the likelihood of exposure to this or a higher sound level is extremely small. The volume of the ocean ensonified by a single SURTASS LFA sonar source at 193 dB RL or higher is very small compared to fish or fish school ocean habitats.

Second, the LFA sound used in the study can be considered to represent a "worst-case" exposure. In effect, the exposures during the experiments were most likely substantially greater than any exposure a fish might encounter in the wild. In the study described here, each fish received three 108-second exposures to high-level LFA sound. However, under normal circumstances the SURTASS LFA sonar source is on a moving ship. A fish in one location can only receive maximum ensonification for a very few seconds (depending on ship speed and whether the fish is moving or not, and its direction of motion and speed). Before the SURTASS LFA vessel gets close to the fish, or after the ship has moved on, the sound level at the fish would be much lower. Since exposure at maximum levels 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. 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 108 seconds to an even higher sound level may not have adversely affected the fish.

To quantify the possible effect of SURTASS LFA sonar on fisheries catches, an analysis of nominal SURTASS LFA sonar operations in a region off the Pacific Coast of the U.S. was presented in the FOEIS/EIS Subchapter 4.3.1 for the NMFS Fisheries Resource Region—Pacific Coast, defined here to encompass the area from the Canadian to Mexican border, from the shoreline out to 926 km (500 nm). The results of this analysis–that the percent of fisheries catch potentially affected would be negligible compared to fish harvested commercially and recreationally in the region–remain valid. In fact, because this analysis was based on 180-dB injury level (1000 vice 200 m) and a 20 percent (20 vice 7.5 percent) duty cycle, the results are *highly conservative.*

ES.4.2 Potential Impacts on Sea Turtle 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 than the SURTASS LFA sonar signals. The SEIS provides summaries of recent research and updates to the analysis of the potential effects of the alternatives based on the SURTASS LFA sonar operational parameters.

Sea turtles could be affected if they are inside the LFA mitigation zone (180-dB sound field) during a SURTASS LFA sonar transmission. The SEIS updates the FOEIS/EIS analysis, focusing on the potential impacts to individual sea turtles and the issue of potential impact to sea turtle stocks. To quantify the potential impact on sea turtle stocks, the analysis provided in the FOEIS/EIS was updated based on more current information for leatherback sea turtles in the Pacific Ocean. Leatherbacks were chosen for this analysis because they are the largest, most pelagic, and most widely distributed of any sea turtle found between 71 degrees N and 47 degrees S latitude, inhabit the oceanic zone, and are capable of transoceanic migrations. They are rarely found in coastal waters and are deep, nearly continuous divers with usual dive depths around 250 m (820 ft). Based on a conservative estimate of 20,000 leatherback sea turtles for the Pacific basin, the possible number of times a leatherback could be within the 180-dB sound field of a SURTASS LFA sonar vessel during transmissions was estimated to be less than 0.2 animals per year per vessel. Therefore, the potential for SURTASS LFA sonar operations to impact leatherback sea turtle stocks is negligible, even when up to four systems are considered.

In the unlikely event that SURTASS LFA sonar operations coincide with a sea turtle "hot spot," the following factors mitigate any potential impact on the animals to a negligible level: 1) the narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz bandwidth); 2) the ship is always moving (coupled with low system duty cycle [nominal 7.5 to 10 percent], which means sea turtles would have less opportunity to be located in the LFA mitigation zone during a transmission); 3) the sea turtle is often moving; and 4) the monitoring mitigation incorporated into the alternatives (visual and active acoustic [HF] monitoring).

ES.4.3 Potential Impacts on Marine Mammal Stocks

The types of potential effects on marine mammals from SURTASS LFA sonar operations can be broken down into non-auditory injury (such as tissue damage and acoustically mediated bubble growth), permanent loss of hearing, temporary loss of hearing, behavioral change, and masking. The analyses of these potential impacts were presented in the SURTASS LFA sonar FOEIS/EIS. Updated literature reviews and research results indicate that there are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS; thus, its findings regarding potential impacts on marine mammals remain valid and are incorporated by reference to the SEIS.

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.

ES.4.4 Risk Assessment Approach for SURTASS LFA Sonar Operations

The FOEIS/EIS provided detailed risk assessments of potential impacts to marine mammals covering the major ocean regions of the world: North and South Pacific Oceans, Indian Ocean, North and South Atlantic Oceans, and the Mediterranean Sea. The 31 acoustic modeling sites in the FOEIS/EIS represented the upper bound of impacts (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. The conservative assumptions of the FOEIS/EIS are still valid. Moreover, there are no new data that contradict any of the assumptions or conclusions made in the FOEIS/EIS. Thus, it is not necessary to reanalyze the potential acoustic impacts in the SEIS.

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 areas of operation. The LOA application analytical process utilizes 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 incorporation 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 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 applications for LOAs.

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

ES.4.4.1 Interim Operational Restrictions and Proposed Modifications to Mitigation

The SEIS evaluates the interim operational restrictions imposed by NMFS during the regulatory process under the initial MMPA Rule and LOAs, as issued, and questions raised by the Court concerning mitigation.

NMFS interim operational restrictions

In the SURTASS LFA Sonar Final Rule under the MMPA (67 FR 46785), NMFS added interim operational restrictions, including the establishment of a 1-km (0.54-nm) buffer shutdown zone outside of the 180-dB LFA mitigation zone and limiting the operational frequency of SURTASS LFA sonar to 330 Hz and below.

1-km buffer zone

The 1-km (0.54 nm) buffer zone interim operational restriction has proven to be practical under the current operations, but the analysis in the SEIS demonstrates that it did not perceptibly minimize adverse impacts below 180-dB RL. The differences in the number of animals affected were insignificant. Thus, the removal of this interim operational restriction would not appreciably change the percentage of animals potentially affected.

330-Hz restriction

The LFA rule-making process under the MMPA commenced in 1999 and ended when the LFA Rule was promulgated in July 2002. During this period, the potential for LFA, and sonar in general, to cause resonance-related injury in marine mammals above 330 Hz was an open issue.

NMFS, therefore, added an interim operational restriction to the LFA Rule and associated LOAs limiting LFA operations to 100 to 330 Hz vice 100 to 500 Hz as originally stated in the FOEIS/EIS. For the SURTASS LFA sonar systems installed onboard the R/V *Cory Chouest* and USNS IMPECCABLE, this interim restriction was feasible. However, the frequency requirements for the Compact LFA (CLFA) to be installed onboard the smaller VICTORIOUS Class (T-AGOS 19 Class) vessels are somewhat higher, but still within the original 100 to 500 Hz range.

In November 2002, NMFS provided its "Report of the Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans" (DOC, 2002)[11]. The report concluded that the tissue-lined air spaces most susceptible to resonance are too large in marine mammals to have resonance frequencies in the range used by either mid or low frequency sonar. In 2004 the Marine Mammal Commission sponsored a workshop on understanding the impacts of anthropogenic sound on beaked whales (Cox et al., 2006)[12].The MMC workshop results stated that acoustic resonance is highly unlikely in the lungs of beaked whales, but did recommend further studies to fully eliminate this hypothesized mechanism (Cox et al., 2006). Cudahy and Ellison (2002)[13] stated that each of their *in vivo* and theoretical studies relating to tissue damage from underwater sound support a damage threshold on the order of 180 to 190 dB.

Since the FOEIS/EIS was published in early 2001, research has been published in a peer-reviewed journal that supports the 180-dB criterion for injury. Laurer et al. (2002)[14] from the Department of Neurosurgery, University of Pennsylvania School of Medicine, exposed Sprague-Dawley rats to 5 minutes of continuous high intensity, low frequency (underwater) sound (HI-LFS) either at 180 dB SPL re 1 µPa at 150 Hz or 194 dB SPL re 1 µPa at 250 Hz, and found no overt histological damage in brains of any group. Also blood gases, heart rate, and main arterial blood pressure were not significantly influenced by HI-LFS, suggesting that there was no pulmonary dysfunction due to prolonged exposures at 180 dB and 194 dB. This published paper was based on work performed in support of Technical Report #3 of the SURTASS LFA Sonar FOEIS/EIS.

[11]Department of Commerce (DOC). 2002. Report on the workshop on acoustic resonance as a source of tissue trauma in cetaceans. April 24 and 25, 2002. Silver Spring, Maryland. National Marine Fisheries Service, Silver Spring, Maryland.

[12] 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. Understanding the impacts of anthropogenic sound on beaked whales. J. Cetacean Res. Manage. 7(3):177-187.

[13] Cudahy, E. and W.T. Ellison. 2002. A review of the potential for *in vivo* tissue damage by exposure to underwater sound, report for the Department of the Navy. Department of the Navy, Washington, D.C

[14] Laurer, H.L., A.N. Ritting, A.B. Russ, F.M. Bareyre, R. Raghupathi, and K.E. Saatman. 2002. Effects of underwater sound exposure on neurological function and brain histology. Ultrasound in Med. &. Biol., Vol. 28, No. 7, pp. 965-973.

Finally, the Ocean Studies Board of the National Research Council (NRC) in its report on Marine Mammal Populations and Ocean Noise stated that resonance from air spaces is not likely to lead to detrimental physiological effects on marine mammals (NRC, 2005)[15].

Analyses sponsored by the Navy (Cudahy and Ellison, 2002; Laurer et al., 2002), reports on two workshops on acoustic impacts (DOC, 2002; Cox, et al., 2006), and the NRC Ocean Studies Board (NRC, 2005) support the conclusion that resonance from LFA operations is not a reasonably foreseeable impact, providing the empirical and documentary evidence that resonance and/or tissue damage from LFA transmissions are unlikely to occur in marine mammals in the frequency range 330 to 500 Hz within or outside the LFA mitigation zone. As a result, the Navy has requested NMFS to rescind this interim operational restriction in the new rule making.

Court's issues

The Court found the FOEIS/EIS lacking because the Navy: 1) should have considered training in areas that present a reduced risk of harm to marine life and the marine environment when practicable; 2) should have further considered extending the shutdown procedures beyond marine mammals and sea turtles to schools of fish; 3) failed to adequately consider potential impacts to fish; and 4) raised the question concerning the inclusion of requirements for additional monitoring and mitigation through the use of aircraft or small observational craft prior to operating close to shore.

Training in areas of reduced risk

The identification of a SURTASS LFA sonar operating area that is particularly devoid of marine life is not straightforward. The reason that certain areas are believed to have minimal marine mammal activity could very well be because of gaps in animal distribution, abundance and density data there. It usually is more feasible to identify areas of high marine life concentrations and avoid them when practicable. This sensitivity/risk process is the methodology applied to SURTASS LFA sonar operations.

The process starts with the Navy's antisubmarine warfare (ASW) requirements to be met by SURTASS LFA sonar based on mission areas proposed by the Chief of Naval Operations (CNO) and fleet commands. Thereupon, available published data are collected, collated, reduced and analyzed with respect to marine mammal populations and 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. If marine mammal densities prove to be high and/or sensitive animal activities are expected, the mission areas are changed and/or refined and the process is re-initiated for the modified area. Next, standard acoustic modeling and risk analysis are performed, taking into account spatial, temporal or operational restrictions. Then, standard mitigation is applied and risk estimates for marine mammal stocks in the proposed mission area are calculated. Based on these estimates, a decision

[15] National Research Council (NRC). 2005. Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects. National Academy Press. Washington, D.C.

is made as to whether the proposed mission area meets the conditions on MMPA regulations and LO)As, 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, it is considered that 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.

Potential injury to fish

The Court found the FOEIS/EIS lacking because the Navy failed to adequately consider potential impacts to fish. Independent research was sponsored by the Navy to address this issue (as discussed above). 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 (193 dB RL) on a number of taxonomically[16] and morphologically[17] diverse species of fish, and there was no mortality as a result of sound exposure, even when fish were maintained for days post-exposure.

Modification of shutdown procedures for schools of fish

Modifying the current SURTASS LFA sonar shutdown protocols to include schools of fish must be weighed against the feasibility and practicality of such a mitigation procedure in the context of military readiness and training. First, based on recent field experimentation, for a fish to suffer injury, it must be extremely close (within 200 m [656 ft]) to the source array during transmission (nominally transmitting 7.5 to 10 percent of the time). The SURTASS LFA vessel travels at an average speed of 5.6 kph (3 knots) and fish travel at nominal speeds of 5.6 kph (3 knots) (e.g., herring, pike, carp) up to maximum speeds of 74 to 93 kph (40 to 50 knots) (e.g., tuna, swordfish). Thus, the opportunity for a fish or a school of fish to be exposed to sound pressure levels from SURTASS LFA transmissions that could cause harm must be considered to be negligible. Moreover, the implementation of fish mitigation procedures is impractical. Visual monitoring (daylight only) cannot be relied upon to detect fish schools, passive acoustic detection is infeasible, and active acoustics would give so many false alarms that the impact on the effectiveness of the military readiness activity (and, hence impact on National Security) would be high. Therefore, mitigation protocols for fish are first and foremost not required because the potential for effects is negligible based on scientific research. Furthermore, these protocols are infeasible and impractical when applied to military readiness and training activities.

Pre-operational surveys

In order to determine if pre-operational aerial or small boat surveys are feasible and necessary mitigation measures according to the MMPA's treatment of such considerations in a military readiness context, the SEIS evaluated the feasibility of these surveys based on the following factors: 1) weather conditions, 2) time of day, 3) availability of small boats or small aircraft, 4) proximity to hostile territory, 5) sea state, 6) logistics, 7) overall safety considerations, and 8)

[16] Taxonomically means to be based on formal classification of organisms into phylum, order, family, genus, or species.

[17] Morphologically means to be based on the structure and form of living organisms.

National Security. The findings were that small boat and pre-operational aerial surveys for SURTASS LFA operations are not feasible because they are not practicable, not effective, may increase the harassment of marine mammals, and are not safe to the human performers.

In its comments on the Draft SEIS, the Marine Mammal Commission concurred that carrying out small boat or aerial surveys immediately before and during SURTASS LFA sonar operations in the various offshore training areas would not be a practical mitigation option.

ES.4.4.2 Marine Mammal Strandings

Marine mammal strandings are not a rare occurrence. The Cetacean Stranding Database (www.strandings.net) registers that over a hundred strandings occurred worldwide in the year 2004. However, mass strandings, particularly multi-species mass strandings, are relatively rare. Many theories exist as to why noise may be a factor in marine mammal strandings. Several recent stranding events that have been publicly reported and which may, or may not, have been attributed to anthropogenic sound, are discussed in the SEIS.

There are different types of anthropogenic sounds potentially associated with possible impacts to and strandings of marine mammals. Accounts of many of these stranding events are associated with military sonars. A wide range of military sonars are used to detect, localize and classify underwater targets. For the purposes of the SURTASS LFA SEIS analysis, these systems are categorized as low frequency active (LFA) (< 1000 Hz) and mid frequency active (MFA) (1 to 10 kHz). Differences in operational parameters dictate that the potential for LFA and MFA to affect marine mammals is not the same.

Cox et al. (2006) provided a summary of common features shared by the strandings events in Greece (1996), Bahamas (2000), and Canary Islands (2002). These included deep water close to land (such as offshore canyons), presence of an acoustic waveguide (surface duct conditions), and periodic sequences of transient pulses (i.e., rapid onset and decay times) generated at depths less than 10 m (32.8 ft) by sound sources moving at speeds of 2.6 m/s (5.1 knots) or more during sonar operations (D'Spain et al., 2006)[18]. Several of these features do not relate to LFA operations. First, the SURTASS LFA vessel operates with a horizontal line array (SURTASS: a passive listening system) of 1,500 m (4,921 ft) length at depths below 150 m (492 ft) and a vertical line array (LFA sonar source) at depths greater than 100 m. Second, operations are limited by mitigation protocols to at least 22 km (12 nm) offshore. For these reasons SURTASS LFA sonar cannot be operated in deep water that is close to land. Also the LFA signal is transmitted at depths well below 10 m (32.8 ft), and the vessel has a slow speed of advance of 1.5 m/s (3 knots).

While it is true that there was a LF component of the sonar in use at the time of the Greek stranding in 1996, only mid-frequency components were present in the strandings in the Bahamas in 2000, Madeira 2000, and Canaries in 2002. This supports the logical conclusion that

[18] 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. J. Cetacean Res. Manage. 7:223-23.

the LF component in the Greek stranding was not causative (ICES, 2005[19]; Cox et al., 2006). In its discussion of the Bahamas stranding, Cox et al. (2006) stated, “The event raised the question of whether the mid-frequency component of the sonar in Greece in 1996 was implicated in the stranding, rather than the low-frequency component proposed by Frantzis (1998)[20].” The International Council for the Exploration of the Sea (ICES) in its “Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish” raised the same issue as Cox et al., stating that the consistent association of MF sonar in the Bahamas, Madeira, and Canary Islands strandings suggest that it was the MF component, not the LF component, in the NATO sonar that triggered the Greek stranding of 1996 (ICES, 2005).

Most odontocetes have relatively sharply deceasing hearing sensitivity below 2 kHz. If a cetacean cannot hear a sound of a particular frequency or hears it poorly, then it is unlikely to have a significant behavioral impact (Ketten, 2001)[21]. Therefore, it is unlikely that LF transmissions from LFA would induce behavioral reactions from animals that have poor LF hearing; e.g., beaked whales, bottlenose dolphins, striped dolphins, harbor porpoise, belugas, and orcas (summarized in: Nedwell et al., 2004).[22]

The ICES (2005) report concluded that no strandings, injury, or major behavioral change has yet to be associated with the exclusive use of LF sonar.

The important point here is that there is no record of SURTASS LFA sonar ever being implicated in any stranding event since LFA prototype systems were first operated in the late 1980s. The logical conclusion that LFA sonar is not related to marine mammal strandings is supported by the 2004 Workshop on Understanding the Impacts of Anthropogenic Sound on Beaked Whales convened by the Marine Mammal Commission (Cox et al., 2006) and the ICES Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish (AGISC) (ICES, 2005).

ES.4.5 Socioeconomics

This SEIS 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.

Commercial and recreational fisheries

SURTASS LFA sonar operations are geographically restricted such that LFA received levels are less than 180 dB RL at least 22 km (12 nm) from coastlines and at the boundaries of offshore biologically important areas during biologically important seasons, where fisheries productivity is generally high. In addition, the results from the LFA controlled exposure studies by the

[19] International Council for the Exploration of the Sea (ICES). 2005. Ad-Hoc Group on the Impact of Sonar on Cetaceans. ICES AGISC 2005. Copenhagen, Denmark.

[20] Frantzis, A. 1998. Does acoustic testing strand whales? Nature 392:29.

[21] Ketten, D. 2001. Congressional Testimony House Resources Committee, Subcommittee on Fisheries Conservation, Wildlife and Oceans Hearing: Marine Mammal Protection Act/Low Frequency Sonar. October 11, 2001.

[22] Nedwell, J.R., B. Edwards, A.W.H. Turnpenny, and J. Gordon. 2004. Fish and Marine Mammal Audiograms: A Summery of Available Information. September 3, 2004.

University of Maryland provide evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB RL) have minimal impact on the reference species of fish studied (rainbow trout and channel catfish). Therefore, the University of Maryland data support the conclusion that SURTASS LFA will have no or minimal effects on commercial or recreational fishing (Popper et al., 2005; Halvorsen et al., 2006).

Other recreational activities

There are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS regarding swimming, snorkeling, diving, and whale watching.

Research and exploration activities

It is not believed that SURTASS LFA sonar operations will affect research submersibles, nor seafloor cable-laying. Oceanographic research activities and oil and gas exploration could potentially be affected, as they use equipment such as air guns, hydrophones, and ocean-bottom seismometers. If in the vicinity of a research or exploration activity, SURTASS LFA sonar could possibly interfere with or saturate the hydrophones of these other operations. Research activities and oil and gas exploration, though, could also potentially interfere with SURTASS LFA sonar operations. For these reasons, SURTASS LFA sonar operations are not expected to be close enough to these activities to significantly affect them to any measurable degree.

ES.4.6 Potential Cumulative Impacts

Three areas are evaluated to compare the incremental impacts of SURTASS LFA sonar operations with past, present, and reasonably foreseeable future actions. These include:

- Comparison to anthropogenic oceanic noise levels;
- Comparison of injury and lethal takes from anthropogenic causes; and
- Synergistic effects.

The potential cumulative impact issue associated with SURTASS LFA sonar operations is the addition of underwater sound to oceanic ambient noise levels, which in turn could have impacts on marine animals through the potential to cause masking and stress. Masking has the potential to increase marine animals' susceptibility to other impacts, such as bycatch and ship strikes. 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).

In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (U.S.) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. The actual percentage of the total anthropogenic acoustic energy budget added by each LFA source is estimated to be 0.5 percent per system (or less), when other man-made sources are considered (Hildebrand, 2004). When combined with the naturally occurring and other man-made sources of noise in the oceans, LFA barely contributes a measurable portion of the total acoustic energy. This and the LFA low duty cycle (nominally 7.5 to 10 percent) support the conclusion that the operation of up to four SURTASS LFA systems will not be expected to significantly add to oceanic ambient noise.

Because LFA transmissions are intermittent and will not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from the proposed four SURTASS LFA sonar systems for masking and stress are not a reasonable foreseeable significant adverse impact on marine animals. Therefore, cumulative impacts and synergistic effects that would lead to injury or lethal takes of marine animals from masking including bycatch and ship strikes are not a reasonable foreseeable significant adverse impact on marine animals from exposure to LFA.

In view of the fact that there are major differences in signal characteristics between LFA, MFA, and seismic air guns, there is negligible chance of producing a "synergistic" sound field. It is also unlikely that LFA sources, if operated in proximity to each other would produce a sound field so complex that marine animals would not be able to escape.

In the analysis of the potential for socioeconomic impacts to commercial and recreational fisheries, other recreational activities, and research and exploration activities, it was that there would be no substantial effects from implementation of the alternatives under consideration. Therefore, socioeconomic cumulative impacts and synergistic effects are not reasonably foreseeable.

Given the information provided in this subchapter, the potential for cumulative impacts and synergistic effects from the operations of up to four SURTASS LFA sonars is considered to be small and 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, and naturally-occurring sounds (e.g., storms, lightning strikes, subsea earthquakes, underwater volcanoes, whale vocalizations, etc.), the SURTASS LFA sonar systems do not add appreciably to the underwater sounds to which fish, sea turtle and marine mammal stocks are exposed. Moreover, SURTASS LFA sonar will cause no lethal takes of marine mammals.

Therefore, cumulative impacts and synergistic effects of the operation of up to four SURTASS LFA sonar systems are not reasonably foreseeable.

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 those that are practical and feasible from a technical and economic standpoint.

The SEIS provides 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 satisfy the Court's findings and to determine the potential effects of changes to the proposed action. These alternatives include:

- No Action Alternative
- Alternative 1—Same as the FOEIS/EIS Alternative 1 with 22 km (12 nm) coastal standoff distance and the original four OBIAs as presented in the FOEIS/EIS and the LOAs, as issued.;
- Alternative 2—Alternative 1 with additional OBIAs;
- Alternative 3—Alternative 1 with extended coastal standoff distance to 46 km (25 nm); and
- Alternative 4—Alternative 1 with additional OBIAs, extended coastal standoff distance to 46 km (25 nm), and shutdown procedures for fish schools.

ES.4.7.1 Analysis of Alternatives

The SEIS analyses these alternatives, including additional OBIAs (Table ES-1), shutdown procedures for fish schools, and increasing the coastal standoff from 22 to 46 km (12 to 25 nm).

Table ES-1. Offshore Biologically Important Areas

Area Number	Name of Area	Location of Area	Months of Importance
1	200 m isobath of North American East Coast[1]	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[2]	Centered at 21°N and 157° 30″W	November 1 through May 1
5	Cordell Bank NMS[2]	Boundaries IAW 15 CFR 922.110	Year Round
6	Gulf of the Farallones NMS[2]	Boundaries IAW 15 CFR 922.80	Year Round
7	Monterey Bay NMS[2]	Boundaries IAW 15 CFR 922.130	Year Round
8	Olympic Coast NMS[2]	Within 23 nm of coast from 47°07'N to 48°30'N latitude	December, January, March and May
9	Flower Garden Banks (NMS)[2]	Boundaries IAW 15 CFR 922.120	Year Round

Note: 1. OBIA boundaries encompass Northern Right Whale Critical Habitat, Stellwagen Bank NMS, Monitor NMS, and Gray's Reef NMS.
2. Office of National Marine Sanctuaries, National Ocean Service, NOAA, letter dated 15 May 2001.

Offshore biologically important areas (OBIAs)

The Navy has addressed the Court-defined deficiency regarding additional OBIAs in its preferred alternative, Alternative 2. The additional OBIAs are shown in Table ES-1 (Area numbers 4 through 9), and 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.

Shutdown procedures for schools of fish

Recent scientific results from fish controlled exposure experiments (CEEs) 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 harm is negligible. Therefore, mitigation protocols for fish are not required because the potential for effects is negligible based on scientific research. Furthermore, these protocols are infeasible and impractical when applied to military readiness and training activities.

Generic analytical methodology for coastal standoff range comparison

Analyses in the FOEIS/EIS and this SEIS support the argument that the highest potential for impact from SURTASS LFA sonar operations would be to marine mammals. Hence, a generic analytical methodology was applied to determine the difference in potential impact to marine animals (including fish, sharks, and sea turtles, but particularly for marine mammals) between a 22 km (12 nm) and a 46 km (25 nm) coastal standoff for SURTASS LFA sonar operations. A six-step process was followed for this analysis. Based on the analysis of the risk areas and potential impacts to marine mammals, increasing the coastal standoff range does decrease exposure to higher received levels for 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.

It is important to note that the results of this analysis—that overall there is a greater risk of potential impacts to marine animals with the increase of the coastal standoff distance from 22 km (12 nm) to 46 km (25 nm)—may at first appear counter-intuitive. This greater risk is due to an increase in affected area, with less of the ensonified zone of influence overlapping land for the 46 km (25 nm) standoff distance than for the 22 km (12 nm) standoff distance. . Essentially, by locating the array in waters further from land, nominally the same animal density regions are typically ensonified, but more water area is affected.

ES.5 Mitigation and Monitoring

Alternative 2 (the Navy's preferred alternative) incorporates mitigation measures into operation of the SURTASS LFA sonar. The objective of these mitigation measures is to avoid injury to marine mammals and sea turtles near the SURTASS LFA sonar source and to recreational and commercial divers in the coastal environment.

This objective would be met by Navy adherence to the following restrictions on SURTASS LFA sonar operations:

- SURTASS LFA sonar-generated sound field would be below 180 dB (RL) within 22 km (12 nm) of any coastlines and in offshore areas outside this zone that have been determined by NMFS and the Navy to be biologically important (see Table ES-1 for the inclusion of additional Offshore Biologically Important Areas);
- When in the vicinity of known recreational or commercial dive sites, SURTASS LFA sonar would be operated such that the sound fields at those sites would not exceed 145 dB (RL); and
- SURTASS LFA sonar operators would estimate SPLs 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 the 180-dB and 145-dB sound field criteria.

In addition, the following monitoring to prevent injury to marine animals would be required when employing SURTASS LFA sonar:

- Visual monitoring for marine mammals and sea turtles from the vessel during daylight hours by personnel trained to detect and identify marine mammals and sea turtles;
- Passive acoustic monitoring using the low frequency SURTASS 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 the Navy developed, enhanced high frequency (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 180-dB sound field (LFA mitigation zone). The HF/M3 sonar will provide for detection of marine animals 24 hours a day and during periods of reduced visibility.

ES.7 Conclusion

The following conclusions are supported by the analyses addressing the operations of up to four SURTASS LFA sonar systems in the FOEIS/EIS, which are incorporated by reference herein; and the supplementary analyses undertaken in this SEIS, which also encompass the at-sea operations of up to four systems.

No Action Alternative

In summary, the No Action Alternative would avoid all environmental effects of employment of SURTASS LFA sonar. It does not, however, support the Navy's stated priority ASW need for long-range underwater threat detection. The implementation of this alternative would allow potentially hostile submarines to clandestinely threaten U.S. Fleet units and land-based targets. Without this 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.

Alternative 1

Under Alternative 1, as was concluded in the FOEIS/EIS, the potential impact 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 and possible indirect impacts to marine mammals due to potential impacts on prey species 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 impact on any stock of fish, sharks or sea turtles from injury is also considered to be negligible, and the effect on the stock of any fish, sharks or sea turtles from significant change in a biologically important behavior is considered to be negligible to minimal. Any auditory masking in fish, sharks or sea turtles is expected to be of minimal significance and, if occurring, would be temporary.

Alternative 2 (the preferred alternative)

Under Alternative 2, additional geographical restrictions would be levied on SURTASS LFA sonar operations through the inclusion of more offshore biologically important areas (OBIAs). The general summary provided in the above paragraph for Alternative 1 would also apply to this alternative.

Alternative 3

Under Alternative 3, additional geographical restrictions would be levied on SURTASS LFA sonar operations through the increase in the coastal standoff range from 22 km (12 nm) to 46 km (25 nm). The general summary provided in the above paragraph for Alternative 1 would also apply to this alternative. Based on the analysis of the risk areas and the potential impacts to marine animals, increasing the coastal standoff range does decrease exposure to higher received levels for the concentrations of marine animals closest to shore; but does so at the expense of increasing exposure levels for shelf break species and pelagic species.

Alternative 4

Under Alternative 4, the additional geographical restrictions of both Alternative 2 (additional OBIAs) and Alternative 3 (increase in coastal standoff range from 22 km [12 nm] to 46 km [25 nm]), plus shutdown procedures for schools of fish would be combined. The general summary provided for Alternative 1 above also applies here, as do the results from Alternative 2 regarding additional OBIAs and Alternative 3 regarding the increased standoff range.

Recent scientific results from fish controlled exposure experiments (CEEs) 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 harm is negligible. Therefore, mitigation protocols for fish are not necessary because the potential for effects is negligible based on scientific research. Furthermore, these protocols are infeasible and impractical when applied to military readiness and training activities.

Results Summary

Table ES-2 provides a qualitative estimate of the ability of each alternative to meet the Navy's purpose and need. Alternative 2 (additional OBIAs) would be expected to decrease to some extent the littoral areas where SURTASS LFA sonar could operate outside of 22 km (12 nm); thus the detection of threats in the littorals and training in the littorals would remain high but may be slightly degraded compared to Alternative 1. Alternatives 3 and 4, the expansion of the coastal standoff range from 22 km (12 nm) to 46 km (25 nm), and the expansion of the coastal standoff range plus the additional OBIAs would be expected to impose the greatest impact on meeting the Navy's purpose and need, and military readiness, as a much larger portion of the littorals would be restricted from the conduct of SURTASS LFA sonar operations.

Given the results from the alternatives analysis presented above and Table ES-2, the Navy's preferred alternative is Alternative 2.

Table ES-2. Estimate of ability to meet the Navy's Purpose and Need/Military Readiness/Training for Alternatives 1 through 4.

	Detection of threats in open ocean	Detection of threats in littorals	Training in open ocean	Training in littorals
No Action Alternative	N/A	N/A	N/A	N/A
Alternative 1	H	H	H	H
Alternative 2	H	H	H	H
Alternative 3	H	M/H	H	M/H
Alternative 4	H	M/H	H	M/H

N/A = Does not meet/not applicable
M = Medium level
L = Low level
H = High level

ES.8 Public Participation

The public participation program for the SURTASS LFA Sonar SEIS began with publication of a Notice of Intent (NOI) to prepare a supplemental analysis in the *Federal Register* on July 28, 2003 (68 FR 44311).

Commencing in early November 2005, copies of the Draft SEIS were distributed to agencies and officials of federal and state governments, citizen groups and associations, and other interested parties. A Notice of Availability (NOA) was published in the *Federal Register* (70 FR 68443). The Draft SEIS was made available for review at 17 public libraries located in many coastal states including Hawaii. A copy of the Draft SEIS was also available on the SURTASS LFA Sonar OEIS/EIS Internet website (http://www.surtass-lfa-eis.com).

During the 90-day public comment period on the Draft SEIS, public hearings were conducted in Washington, DC; San Diego, California; and Honolulu, Hawaii. Notifications for the public hearings were published in the *Federal Register* and in local newspapers. The hearings were conducted in accordance with NEPA requirements and comments became part of the record.

During the comment period, which ended on February 10, 2006, the Navy received comments from 97 government agencies, organizations, and individuals. No petitions were submitted. In addition, no statements were presented at the December 1, 2005, public hearing in Washington, DC; 3 statements were presented at the December 3, 2005, public hearing in San Diego, CA; and 11 statements were presented at the December 5, 2005, public hearing in Honolulu, HI.

All comments received were categorized into broad issues based on the organization of the SEIS. These issues were further subdivided into more specific comments/questions. Responses to these comments/questions were then drafted and reviewed for scientific and technical accuracy and completeness. The Navy's responses also identify cases in which a specific comment generated a revision to the Draft SEIS (denoted by underlined text), or when the existing text of the Final SEIS is deemed an adequate response to a comment, the appropriate chapter, subchapter, and/or appendix is identified.

Comment submissions, written hearing transcripts and statements have been included in Volume 2 to the SEIS.

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APPENDICES

ACRONYMS AND ABBREVIATIONS

ABR	Auditory Brainstem Response
ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and contiguous Atlantic area
AGISC	Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish
AIP	Air Independent Propulsion
ANPR	Advance Notice of Proposed Rulemaking
ARLO	Acoustic Research Letters Online
ASA	Acoustical Society of America
ASW	Antisubmarine Warfare
ATOC	Acoustic Thermometry of Ocean Climate
AUSI	Autonomous Undersea Systems Institute
AUV	Autonomous Underwater Vehicle
BiOp	Biological Opinion
BRS	Behavioral Response Study
C	Centigrade
CAPTAS	Combined Active Passive Towed Array
CBRC	Cetacean Bycatch Resource Center
CEE	Controlled Exposure Experiment
CEL	Commission on Environmental Law
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CIE	Center for Independent Experts
CITES	Convention on International Trade in Endangered Species
CLFA	Compact Low Frequency Active
cm	Centimeter(s)
cm/s	Centimeters per second
CNO	Chief of Naval Operations
COSEWI	Committee on the Status of Endangered Wildlife in Canada
CR	Critical Ratios
CREM	Council on Regulatory Environmental Modeling
CSG	Carrier Strike Group
CSI	Cetacean Society International
CV	Critical Variance
CW	Continuous Wave
CZ	Convergence Zone
CZCS	Coastal Zone Color Scanner
CZMA	Costal Zone Management Act
DAN	Divers Alert Network
DASN(E)	Deputy Assistant Secretary of the Navy for Environment
dB	Decibel(s)
DFO	Canadian Department of Fisheries and Oceans
DoC	Department of Commerce
DoD	Department of Defense
DON	Department of the Navy
DPS	Distinct Population Segment
DRDC	Defense Research and Development Canada
DSEIS	Draft Supplemental Environmental Impact Statement
E	Endangered
ECBC	European Cetacean Bycatch Campaign
EDM	EMCON Emission Control

EEZ EFH EIS EMCON EO ESA ETP EU EWS	Exclusive Economic Zone Essential Fish Habitat(s) Environmental Impact Statement Emission Control (Presidential) Executive Order Endangered Species Act Eastern Tropical Pacific European Union Early Warning System
F FAO FOEIS/EIS FM FR ft ft/s FY	Fahrenheit Food and Agriculture Organization of the United Nations Final Overseas Environmental Impact Statement/Final Environmental Impact Statement Frequency Modulated Federal Register Feet Feet per second Fiscal Year
GAO GIS GNP	General Accounting Office Geographic Information System Gross National Product
HESS HF HFM HF/M3 HIFT HI-LFS HLA HR hr Hz	High Energy Seismic Survey High Frequency Hyperbolic Frequency Modulated High Frequency Marine Mammal Monitoring Heard Island Feasability Test High Intensity, Low Frequency (Underwater) Sound Horizontal Line Array House of Representative Bill Hour Hertz
ICES ICW IFAW IFR IHA in in prep. ITS IUCN IUSS IWC IWC-SC	International Council for the Exploration of the Sea Intra-Coastal Waterway International Fund for Animal Welfare Instrument Flight Rules Incidental Harassment Authorization Inch In preparation Incidental Take Statement International Union for Conservation of Nature and Natural Resources Integrated Undersea Surveillance System International Whaling Commission IWC Scientific Committee
JASA JCS	Journal of the Acoustical Society of America Joint Chiefs of Staff
kg kg/m^3 kJ/m kHz km km/h kt	Kilogram Kilogram per cubic meter (density) Kilojoule per meter Kilohertz Kilometer(s) Kilometer(s) per hour Knot(s)
L lb lb/yd^3	Liter Pound(s) Pound per cubic yard (density)

LDEO LF LFA LFS SRP LINTS LOA LTM	Lamont-Doherty Earth Observatory Low Frequency Low Frequency Active Low Frequency Sound Scientific Research Program Linear Threshold Shift Letter of Authorization Long Term Monitoring
m m/s MAI MBNMS MF MFA M/H mi min MIT MMC MMPA MMRP MMS MoD MPA ms mt mtDNA	Meter(s) Meters per second (sound speed) Marine Acoustics, Inc. Monterey Bay National Marine Sanctuary Mid Frequency Mid Frequency Active Medium/High Mile(s) (statute) Minute(s) Massachusetts Institute of Technology Marine Mammal Commission Marine Mammal Protection Act Marine Mammal Research Program (ATOC) Minerals Management Service Ministry of Defence (UK) Marine Protected Areas Millisecond Metric ton(s) Mitochondrial DNA
N NATO NAUI NDAA NE NEPA NGDC NGO nm or nmi NMFS NMS NOAA NODC NOI NPAL NRC NRDC NSMRL NW	North North Atlantic Treaty Organization National Association of Underwater Instructors National Defense Authorization Act Northeast National Environmental Policy Act of 1969 (NOAA) National Geophysical Center Non-Governmental Organization Nautical mile(s) National Marine Fisheries Service National Marine Sanctuary National Oceanic and Atmospheric Administration National Oceanographic Data Center Notice of Intent North Pacific Acoustic Laboratory National Research Council National Resources Defense Council Naval Submarine Medical Research Laboratory Northwest
OAML OAT OBIA OIC OPAREA ONR	Oceanographic and Atmospheric Master Library Ocean Acoustic Tomography Offshore Biologically Important Area(s) Officer in Charge Operations Area Office of Naval Research
Pa PADI PBR PE pers. comm.	Pascal Professional Association of Diving Instructors Potential Biological Removal level Parabolic Equation Personal Communication

PTS	Permanent Threshold Shift
RL rms ROD ROPOS ROV RPM RTCs R/V	Received Level Root Mean Squared Record of Decision Remotely Operated Platform for Ocean Science Remotely Operated Vehicle Revolutions Per Minute Response to Comments Research Vessel
S SACLANT SACLANTCEN SAG SARA sec SEIS SEL SEM SERDP SL SLASM SMRU SONAR SOR SPD SPE SPL SPP SRP SS SSC SSP SURTASS SWATH	South Supreme Allied Commander, Atlantic SACLANT Antisubmarine Warfare Center Surface Active Group (Canadian) Species at Risk Act Second(s) Supplemental Environmental Impact Statement Sound Exposure Level Scanning Electron Microscopy Strategic Environmental Research and Development Program Source Level System de Lutte Anti Sous-marine Sea Mammal Research Unit SOund Navigation And Ranging Stand-off ranges Sound Pressure Difference Single Ping Equivalent Sound Pressure Level Species Scientific Research Program Sea State Species Survival Commission Sound Speed Profile Surveillance Towed Array Sensor System Small Waterplane Area Twin Hull
T T-AGOS TIAPS TL TRPs TTS	Threatened Ocean Surveillance Ship Towed Integrated Active-Passive Sonar Transmission Loss Take Reduction Plans Temporary Threshold Shift
UK UNOLS UN U.S. or US U.S.C. or USC USD USFWS U.S.H.S. USNS USW	United Kingdom University - National Oceanographic Laboratory System United Nations United States United States Code United States Dollar U.S. Fish and Wildlife Service United States Humane Society United States Naval Ship Undersea Warfare
VFR VLA	Visual Flight Rules Vertical Line Array
W WCPA WDCS	West World Commission on Protected Areas Whale and Dolphin Conservation Society

WHOI	Woods Hole Oceanographic Institution
XBT	Expendable Bathythermograph
ZMRG	Zero Mortality Rate Goal
ZOI	Zone of Influence
Symbols	
=	Equal to
/	Divided by
+	Plus
≥	Greater than or equal to
>	Greater than
<	Less than
~	Approximately
±	Plus or minus
μ	Micro (10^{-6})
Log	Logarithm

1 PURPOSE AND NEED

This Supplemental Environmental Impact Statement (SEIS) evaluates the potential environmental effects of employment of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems. The proposed action herein is the U.S. Navy employment of up to four SURTASS LFA sonar systems in the oceanic areas as presented in Figure 1-1 (SURTASS LFA Sonar Systems Potential Areas of Operations) of the Final Overseas Environmental Impact Statement/Environmental Impact Statement (FOEIS/EIS) for SURTASS LFA Sonar (DON, 2001). 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 during biologically important seasons, and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites.

SURTASS LFA sonar systems are long-range sonar systems that operate day or night in most weather conditions in the low frequency (LF) band (below 1,000 Hertz [Hz]) within the frequency range of 100 to 500 Hz. These systems have both active and passive components. The active component, LFA, is an augmentation to the passive towed array detection system (SURTASS), and is planned for use when passive system performance is inadequate. LFA is a set of acoustic transmitting source elements suspended by cable from underneath ocean surveillance ships, such as the Research Vessel (R/V) *Cory Chouest*, USNS IMPECCABLE (T-AGOS 23), and the VICTORIOUS Class (T-AGOS 19 Class). The active array transmits LF sound pulses that reflect off an object in the water, and the reflected pulses return in the form of echoes. The passive towed array receives the return echoes through listening devices (hydrophones).

The word "employment" as used in this document means the use of SURTASS LFA sonar systems during routine training and testing as well as the use of the system during military operations. This analysis does not apply to the use of the system in armed conflict or direct combat support operations, nor during periods of heightened threat conditions, as determined by the President and Secretary of Defense or their duly designated alternates or successors, as assisted by the Chairman of the Joint Chiefs of Staff (JCS).

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 the National Environmental Policy Act of 1969 (NEPA)[1] and Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal

[1] The provisions of NEPA apply to major federal actions that occur or have effects in the United States, its territories, and possessions.

Actions)[2] (DON, 2001). The Deputy Assistant Secretary of the Navy for Environment (DASN(E)) signed the Record of Decision (ROD) on 16 July 2002 *Federal Register* (FR) (67 FR 48145), authorizing the operational employment of SURTASS LFA sonar systems contingent upon issuance by NMFS of letters of authorization (LOAs) under the Marine Mammal Protection Act (MMPA) and incidental take statements (ITSs) under the Endangered Species Act (ESA) for each vessel.

The FOEIS/EIS augmented other environmental reviews associated with using SURTASS LFA sonar systems, including:

- Formal consultation under Section 7 of the Endangered Species Act;
- Issuance of authorizations to incidentally take marine mammals pursuant to regulations for implementing the Marine Mammal Protection Act; and
- Consistency determinations under provisions of the Coastal Zone Management Act.

In response to U.S. District Court ruling on the motion for preliminary injunction, the DASN(E) decided that the purposes of NEPA would be served by supplemental analysis of employing SURTASS LFA sonar systems. On 11 April 2003, the DASN(E) directed the Navy to prepare a supplemental EIS to address concerns identified by the Court, to provide additional information regarding the environment that could potentially be affected by the SURTASS LFA sonar systems, and to provide additional information related to mitigation (See APPENDIX A).

1.1 Purpose and Need for Proposed Action

The original stated purpose for the SURTASS LFA sonar system from the FOEIS/EIS was:

> "The purpose of the proposed action is to meet U.S. need for improved capability to detect quieter and harder-to-find foreign submarines at long range. This capability would provide U.S. forces with adequate time to react to, and defend against, potential submarine threats while remaining a safe distance beyond a submarine's effective weapons range." (DON, 2001)

This statement remains valid, and may be more compelling now than when it was presented in the FOEIS/EIS in January 2001. With the Cold War ending more than a decade ago, the Navy is faced with a smaller number of diesel-electric submarines, and although their operations are confined to smaller areas (Friedman, 2004), their operational and weapons capabilities have increased measurably. Moreover, today's maritime strategies rely heavily on quiet submarines to patrol the littorals, blockade strategic choke points, and stalk aircraft carrier battle groups (Goldstein and Murray, 2003).

To meet its long-range detection need, the Navy investigated the use of a broad spectrum of acoustic and non-acoustic technologies to enhance antisubmarine warfare (ASW) capabilities. Of

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

those technologies evaluated, low frequency active sonar remains the only system capable of providing long-range, detection during most weather conditions, day or night. (See SURTASS LFA Sonar FOEIS/EIS pages 1-8 to 1-12.) Low frequency active sonar is, therefore, the only available technology capable of meeting the U.S. need to improve detection of quieter and harder-to-find foreign submarines at long range. SURTASS LFA is providing a quantifiable improvement in the Navy's capabilities against this threat and markedly improves the survivability of U.S Naval forces in a hostile ASW scenario.

Excerpts from Statement of Admiral William J. Fallon, U.S. Navy
Vice Chief of Naval Operations
before the
Subcommittee on Readiness and Management Support
United States Senate Armed Services Committee
on Environmental Sustainment
March 13, 2003

"………New ultra-quiet diesel-electric submarines armed with deadly torpedoes and cruise missiles are proliferating widely. New technologies such as these could significantly threaten our fleet as we deploy around the world to assure access for joint forces, project power from the sea, and maintain open sea-lanes for trade. To successfully defend against such threats, our Sailors must train realistically with the latest technology, including next-generation passive and active sonars."

"The Navy has immediate need for SURTASS LFA. The Chief of Naval Operations has stated that Anti-Submarine Warfare (ASW) is essential to sea control and maritime dominance. Many nations are capable of employing submarines to deny access or significantly delay execution of joint and coalition operations in support of our vital interests. The submarine threat today is real and in some ways has become more challenging than during the Cold War. Of the approximately 500 non-U.S. submarines in the world, almost half that number are operated by non-allied nations. Of greatest concern are the new ultra-quiet diesel-electric submarines armed with deadly torpedoes and cruise missiles being produced by the People's Republic of China, Iran, and North Korea."

"These diesel submarines are very difficult to detect outside the range at which they can launch attacks against U.S. and allied ships using passive sonar systems. Active systems like SURTASS LFA, when used in conjunction with other anti-submarine sensor and weapons systems, are necessary to detect, locate and destroy or avoid hostile submarines before they close within range of our forces. To ensure our Sailors are properly prepared to counter this growing submarine threat, we must make certain they train with the best systems available."

The Navy's primary mission is to maintain, train, equip, and operate combat-ready naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas. The Secretary of the Navy and Chief of Naval Operations (CNO) have continually validated that ASW is a critical part of that mission—a mission that requires unfettered access to both the high seas and the littorals. In order to be prepared for all potential threats, the Navy must not only continue to test and train in the open ocean, but also in littoral environments.

Excerpts from Declaration of Vice Admiral John B. Nathman, U.S. Navy
Vice Chief of Naval Operations
To the United States District Court Northern District of California
September 25, 2002

“ I am aware of the threat to naval forces posed by increasingly quiet submarines. SURTASS Low Frequency Active (LFA) is needed – and needed now – to counter this threat.”

“The threat from modern, quiet diesel-electric submarines to the U.S. Navy is acute and that threat will only increase in the future. I would rank the diesel submarine threat at the very top of those facing the U.S. Navy due to the difficulty in countering it, the potential that threat will proliferate, and its ability to affect naval operations in a number of our most crucial areas of operations.”

“This threat already presents a clear and present danger in crucial parts of the world including the Persian Gulf, along the Korean Peninsula, and in the Taiwan Strait, reflecting the known capabilities of Iran, North Korea and China. This threat increases daily. The U.S. Navy is conducting operations in areas that can be reached by diesel-electric submarines and our Navy’s operations in those areas must continue. Our national interests demand that the U.S. Navy operate naval forces safely and effectively in these areas. The costs of not being able to do so are incalculable.”

“Technologies currently in use, whether traditional mid-frequency active sonar or passive sonar, with recent enhancements, do not provide the capability to detect and engage the diesel-electric submarine threat at a sufficient stand-off distance. Without a low frequency, long-range, active sonar like SURTASS LFA, the diesel submarine threat poses an unacceptable risk to the Navy’s carrier battle groups and amphibious task forces and the men and women who are embarked with these forces. Our ability to conduct the full spectrum of operations from combat, to support for peacekeeping, to non-combat evacuation, to peacetime presence is jeopardized by our vulnerability to this threat.”

“No operational commander can employ a system, of any type, with confidence that it is effective in combat unless the personnel using the system have trained to use it and have used it, in a variety of realistic situations. Tactics must also be developed and honed. …………SURTASS LFA cannot simply be kept ‘on the shelf’ for use in time of armed conflict. The process of preparing to use it takes time. It is therefore critical that preparing to use this system not be delayed any further.”

“The Navy takes its responsibility to the marine environment seriously, and has committed a great deal of time and money to ensure that the proposed use of SURTASS is consistent with those responsibilities.”

1.1.1 The Immediate Submarine Threat

For a host of reasons, submarine forces are attractive to many nations. Because diesel submarines are relatively inexpensive, they are the most cost-effective platform for the delivery of several types of weapons, including torpedoes, long-range anti-ship cruise missiles, and a variety of anti-ship mines—as well as strategic nuclear weapons. With their stealth and ability to operate independent of escort vessels, submarines are very effective in attacking surface ships with torpedoes and missiles. Because submarines are inherently covert, they can conduct intrusive operations in sensitive areas, and can be inserted early with a minimal likelihood of being detected. The inability to detect a hostile submarine at long range before it can get close enough to launch a missile is a critical shortfall in the Navy's ASW capability that is harmful to U.S. national security and puts naval vessels and U.S. sailors and marines at risk.

New-generation, ultra-quiet diesel and hybrid-powered submarines pose a major threat to U. S. Naval and allied forces and their coasts. World War II-designed diesel submarines were required to snorkel in order to recharge their batteries and could not move at speeds in excess of 20 knots without depleting their batteries within an hour or less. However, advanced, or hybrid, diesel propulsion systems that allow for long-term submergence with high-speed underwater maneuvering are a reality today. The Russian submarine builder, Rubin, now offers for sale a liquid oxygen and hydrogen fuel cell air-independent propulsion (AIP) option that permits diesel submarines to remain submerged for weeks without snorkeling (Goldstein and Murray, 2003). Submarines equipped with this type of propulsion will not be restricted to operations in shallow water nor to slow speeds.

As we enter the 21st century, the global submarine threat is becoming increasingly more challenging. The Russian Federation and the People's Republic of China have publicly declared that the submarine is the single most potent ship in their fleets and the centerpiece of their respective navies. As China's economy grows, they are able to purchase the best available Russian submarines and weapons systems to support their political goal of controlling the approaches and seas around Taiwan, the Spratly Islands, and the South China Sea (Farrell, 2003). Published naval strategies of potential adversaries, including Iran and North Korea, have expressed similar strategic doctrine. As regional Asian economies recover from the 1997-98 financial crisis, established powers and smaller nations are planning to build or buy highly capable new submarines. The competition threatens to shift the power balance among some of the region's long-standing military rivals and poses a potential threat to key trade routes. China, Taiwan, India, Pakistan, Singapore, Malaysia, South Korea, Japan and Australia are taking delivery or have ordered advanced, stealthy submarines armed with state-of-the-art missiles and torpedoes capable of striking targets at sea or on land far from their home ports. China will take delivery by 2007 of up to eight more advanced Russian-built KILO-class diesel submarines which, combined with the four KILO-class units they already have, make up a formidable force that could allow China to blockade Taiwan's ports (Baker, 2003). From China's point of view, a top-class submarine fleet might make the United States think twice about sending major warships to the Taiwan Strait. Competition between China and India for maritime influence has keyed India's plan to boost its submarine force with 17 new acquisitions over the next decade. Singapore's inventory has recently reached four Swedish-built diesel submarines. Malaysia has ordered two French-built conventional submarines expected to be operational in 2007 and 2008. With Singapore and Malaysia in the submarine market, Thailand is now considering its underwater options. When all these submarines come into service, Asia's key waterways could again become as crowded—and as dangerous—below the surface as they were at the height of the Cold War when U.S. and Soviet submarines hunted each other on a regular basis.

Potential adversary nations are investing heavily in submarine technology, including designs for nuclear attack submarines, strategic ballistic missile submarines, and advanced diesel submarines. Over 40 countries have operational modern submarines, or are planning to add them to their naval forces. Table 1-1 provides a 2003 inventory of worldwide submarines. There are a total of 470 submarines owned by 40 countries—operational or being built. Of these, 257 are diesel submarines—their combination of quiet operation and effective weapons gives them a substantial and multifaceted combat capability. World navy inventories of active combatant submarines fell to below 400 in 2003—less than half the total in the early 1990s—but important technological developments will result in more effective future submarines (Baker, 2004).

Submarine quieting technology is making submarines ever more difficult—in some cases, nearly impossible—to detect, even with the most capable passive sonar systems. A recent U.S.-Australian ASW exercise with the new Australian COLLINS-Class diesel submarine demonstrated that passive sonar had difficulty detecting this modern diesel submarine before ships were in range of its weapons.[3] A single diesel submarine that is able to penetrate U.S. or multinational task force defenses could cause catastrophic damage to those forces, and weaken domestic or coalition political will for peacekeeping or counter-terrorism contingency operations. No navy seems to have viable countermeasures against a wake-homing torpedo, which can be bought to arm the KILO-submarine (Friedman, 2004). Even the threat of a quiet diesel submarine, in certain circumstances, would deny access to vital operational areas to U.S. or coalition naval forces.

1.1.2 SURTASS LFA Is Critical to Meet the Submarine Threat

Because of these threats, the Navy identified a need for long-range detection of hostile submarines before they could get close enough to use their weapons. The most effective and best available technology to reliably meet this long-range detection need is the SURTASS LFA sonar system. This capability is particularly significant in a concentration of friendly forces, such as the case occurring in the Arabian and Mediterranean Seas in support of operations in Afghanistan and Iraq, or during Operations Desert Shield and Desert Storm in 1990-1991. Aircraft carrier and amphibious task forces, their supporting ships and crews must operate in littoral zones and constricted waters. Choke points offer the perfect opportunity for quiet diesel submarines to stalk and ambush U.S. and allied ships. A pre-positioned diesel submarine, conducting a quiet patrol on battery power, is almost impossible to detect with passive sonar. The SURTASS LFA system, through long-range detection, can effectively counter this threat to the Navy and national security. Without this active augmentation (LFA) to passive and tactical systems, diesel submarines pose unacceptable risks to the U.S. Navy's carrier strike groups (CSGs) and expeditionary strike groups, and the sailors and marines that man them.

[3] Statement of Vice Admiral Dennis V. McGinn, Deputy Chief of Naval Operations for Warfare Requirements and Programs before the Subcommittee on Fisheries Conservation, Wildlife, and Oceans of the House Committee on Resources on the Marine Mammal Protection Act and Surveillance Towed Array Sensor System Low Frequency Active Sonar, 11 October 2001.

Table 1-1. World Submarine Inventory

Country	Total Nuclear Powered	Total Nuclear Building	Total Conventional & Non-Nuc AIP	Total Conventional Building
Atlantic/Baltic/Mediterranean/Black				
Algeria			2	
Canada			3	1
Denmark			2	
Egypt			4	
Germany			12	4
Greece			8	4
Israel			3	
Italy			6	2
Netherlands			4	
Norway			6	
Poland			4	1
Portugal			2	2
Spain			6	
Sweden			5	2
Turkey			12	4
Ukraine			1	
South America				
Argentina			3	
Brazil			4	1
Chile			2	2
Columbia			2	
Ecuador			1	
Peru			6	
Venezuela			2	
Western Pacific/Indian Ocean				
Australia			6	
Peoples Republic of China	4	2	58	12
India		3	16	2
Indonesia				2
Iran			3	
Japan			16	5
Malaysia				2
North Korea			26	
Pakistan			9	1
Singapore			4	
South Africa				3
South Korea			9	3
Taiwan			2	
US/UK/France/Russia				
US	69	7		1
UK	14	3		
France	10	4		
Russia	38	3	8	2
Total Nuclear Powered	**135**			
Total Nuclear Building		**22**		
Total Conventional/Non-Nuclear AIP			**257**	
Total Conventional/Non-Nuclear AIP Building/Conversions				**56**
World Submarine Population (40 countries)				**470**

Note: World Submarine Population does not include mini-subs (midget and swimmer delivery vehicles)
Reference: Saunders (2003); Scherr (2003)

1.1.3 Littorals

The U.S. military anticipates that future naval conflicts are most likely to occur within littoral or coastal areas. This is a distinct change from the Cold War, where such conflicts were most likely to occur in mid-ocean areas. These littoral areas have highly variable and frequently high underwater background noise, largely as a result of commercial shipping, and difficult underwater acoustic propagation conditions, such as multi-path propagation, that make for shorter detection ranges. Passive sonar is significantly degraded in such complex littoral environments. SURTASS LFA provides the U.S. Navy with the most effective and best available means to monitor submarines in the littoral areas at distances sufficient to allow them to be detected, tracked and, if necessary, attacked, before they pose threats to U.S. or allied naval/land forces, or civilian coastal targets.

Littoral Environment
The term "littoral" is one of the most misunderstood terms used in naval warfare. Based on the dictionary, the adjective "littoral" pertains to, or existing on a shore. In the noun form, the word means a shore or coastal region. The Navy's meaning differs because it is based on a tactical, not geographic, perspective relating to overall coastal operations including all assets supporting a particular operation regardless of how close, or far, from the shore it may be operating. The Navy defines littoral as the region that horizontally encompasses the land/watermass interface from fifty (50) statute miles (80 kilometers [km]) ashore to two hundred (200) nautical miles (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 shift from open ocean areas to shallow, acoustically complex near-shore areas forces drastic changes in the ways in which anti-submarine warfare (ASW) operations can be conducted. The United States and numerous other nations have looked at 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. Many of the world's busiest sea-lanes pass through these waters, an area the Chinese want very much to control and where billions of dollars in American investments will almost guarantee U.S. involvement (Farrell, 2003).

In June 2002, the United States General Accounting Office (GAO) provided a report to the U.S. House of Representatives concerning questions raised as to whether SURTASS LFA will increase the Navy's undersea detection capabilities and whether the Navy has an alternative for the system (GAO, 2002). In response to the Congressional request, the GAO examined the extent that SURTASS LFA sonar will enhance the Navy's ASW capabilities to detect submarines and whether there are other existing or planned systems that can provide the same long-range detection capabilities as those of SURTASS LFA. The GAO report concluded that SURTASS LFA will increase the Navy's capability to detect submarines in the open ocean, but there has been limited demonstration of the system's capabilities in littoral waters where the threat is increasing.

Excerpts from GAO report (GAO-02-692)—Defense Acquisitions: Testing Needed to Prove SURTASS/LFA Effectiveness in Littoral Waters
The single recommendation from the GAO report related to the lack of testing in littoral areas. The report stated: "Without testing in littoral areas, the Navy will not know whether the system is suitable and effective where the enemy threat is of increasing concern and detection is more challenging."

1.2 Background

Consistent with responsible stewardship of the environment, the United States is firmly committed to the protection of marine mammals and is mindful of the potential effects that man-made sound may have upon marine life. The Navy has conducted extensive research on this issue, including testing the effects of certain active sonar systems on some marine species. Research concerning active sonar's potential effects has demonstrated that, under certain circumstances and conditions, use of active sonar has an effect upon particular marine species. The U.S. recognizes that active sonar testing and training to defend against this threat (i.e., the global proliferation of extremely quiet submarines posing a critical threat to the maritime interests of the U.S. and its allies) must be accomplished in an environmentally sound manner that is science-based and protective of marine life.

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. For the acquisition of any emergent system (regardless of classification) to be successful, environmental compliance must be taken into account early in the planning process (Johnson et al., 2002). Recent strandings of beaked whales, coincident with naval maneuvers in which active tactical sonars were in use, have put naval sonars in the spotlight. None of these strandings involved SURTASS LFA sonar.

LFA Operations Without Incidents
Many citizens, scientists and environmental groups opposed the Navy's development and use of LFA technology. Based on the evidence available at the time, these concerns that LFA posed potential threats to marine life over large distances were considered by the Navy. Operational testing of LFA was halted in 1997 until the completion of an extensive environmental analysis under the National Environmental Policy Act and compliance to numerous other environmental regulations to include the Marine Mammal Protection Act and the Endangered Species Act. Except for the Low Frequency Sound Scientific Research Project in 1997-98, LFA operations did not commence again until January 2003 when the R/V *Cory Chouest* began reintroduction into the Pacific Fleet. Over a year later, the USNS IMPECCABLE commenced operations in April of 2004. No evidence has come forth of any injury or stranding of marine mammals either during the brief periods of the SURTASS LFA research projects in the late 1990s (which were conducted close to land, with extensive monitoring, and during periods of high marine mammal densities—areas where LFA will not operate) or since LFA operations were resumed in 2003 (DON, 2007).

SURTASS LFA sonar was the first Navy program for an operational system to have completed the NEPA process, a process that began on 18 July 1996, when the Navy published its Notice of Intent (NOI) in the *Federal Register* (67 FR 37452) to prepare an environmental impact statement (EIS) for SURTASS LFA Sonar under NEPA and Presidential EO 12114. It culminated with the signing of the ROD on 16 July 2002 (67 FR 48145). The Navy's ESA Section 7 consultation with the NMFS and permitting requirements under the MMPA concluded with NMFS's issuance of the Biological Opinion and Incidental Take Statement (NMFS, 2002a; 2002b) and the issuance of a LOA (67 FR 55818) under the MMPA Final Rule (50 CFR Part 216 Subpart Q) (67 FR 46785) for the operation of SURTASS LFA Sonar on R/V *Cory Chouest*.

A chronology of key regulatory events is provided in Table 1-2.

1.2.1 Court Opinion and Order

On 7 August 2002, the National Resources Defense Council, the U.S. Humane Society and four other plaintiffs filed suit against the Navy and NMFS over SURTASS LFA sonar use and permitting. Key litigation events included:

- 7 August 02—Plaintiffs filed suit in United States District Court for the District of Northern California to halt deployment of SURTASS LFA.
- 31 October 02—Court issued Opinion and Order Granting Plaintiffs' Motion for a Preliminary Injunction.
- 14 November 02— Mediation with Court-appointed mediator regarding scope of preliminary injunction.
- 15 November 02—Court issued Stipulation and Order re: Tailored Preliminary Injunction for operations of LFA in a stipulated area in northwest Pacific/Philippine Sea, south and east of Japan.

- September 02 to June 03—The parties filed cross motions for summary judgment.
- 30 June 03—Oral arguments on cross-motions for summary judgment.
- 26 August 03—Court issued Opinion and Order on Cross-Motions for Summary Judgment.
- 25 September 03—Mediation with Court-appointed mediator regarding scope of permanent injunction.
- 14 October 03—Court issued Stipulation Regarding Permanent Injunction for operations of LFA in stipulated areas in northwest Pacific/Philippine Sea, Sea of Japan, East China Sea, and South China Sea.
- 2 December 04—Court vacated and dismissed the MMPA small numbers and specific geographic regions claims.
- 7 July 05—Court issued amendment to the Stipulation Regarding Permanent Injunction for expansion of operating areas in northwestern Pacific Ocean.

On 25 January 2003, the R/V *Cory Chouest*, having met all environmental compliance requirements, commenced testing and training in the northwestern Pacific Ocean under the tailored Preliminary Injunction issued by the Court on 15 November 2002. Since then the R/V *Cory Chouest* has successfully completed numerous training operations. These operations were conducted within the stipulated areas and under the mitigation requirements of the Final Rule and LOA issued by NMFS. The culmination of this complex process took six years of dedicated effort by both Navy and NMFS personnel.

The Court issued its Opinion and Order on the parties' motions for summary judgment in the SURTASS LFA litigation on 26 August 2003. The Court found that deficiencies in the Navy and NMFS compliance with the MMPA, ESA, and NEPA warranted issuing a tailored permanent injunction; however, a complete ban on the use of SURTASS LFA was not warranted. Specifically, the Court found that a total ban on the employment of SURTASS LFA would interfere with the Navy's ability to ensure military readiness and to protect those serving in the military against the threat posed by hostile submarines. The Court directed the parties to meet and confer on the scope of a tailored permanent injunction, which would allow for continued operation of the system with additional mitigation measures. This mediation session occurred on 25 September 2003 in San Francisco. On 14 October 2003, the Court issued a Stipulation Regarding Permanent Injunction for the operations of SURTASS LFA from both R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23) in stipulated portions of the Northwest Pacific/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, as shown in Figure 1-1.

Table 1-2. Chronology of Key SURTASS LFA Regulatory Events

Year	Key SURTASS LFA Regulatory Events
1996	• Notice of Intent (NOI) to prepare an EIS published in the *Federal Register*. • Public scoping meetings held in Norfolk, San Diego and Honolulu. • Written comments received on scoping for the Draft EIS.
1997	• Public outreach meetings held (4). • Scientific Working Group meetings held (2). • LF Sound Scientific Research Program (LFS SRP) Phase I: So. California Bight. • Naval Submarine Medical Research Lab (NSMRL) study on bioeffects of LF sound on divers.
1998	• Public outreach meeting held (1). • Scientific Working Group meeting held (1). • LFS SRP Phase II: central California coast; and Phase III: Big Island, Hawaii. • NSMRL study on bioeffects of LF sound on divers (cont'd.). • NMFS agreed to be a cooperating agency in the preparation of the EIS.
1999	• NSMRL issued interim guidance for LF sound in presence of divers. • Draft EIS published with 90-day public comment period. • Public hearings held on Draft EIS in Norfolk, San Diego and Honolulu. • Navy submitted application to NMFS for authorization to incidentally take marine mammals under the MMPA. • Navy initiated formal Section 7 consultation with NMFS under the ESA with submittal of the Biological Assessment. • NMFS published Advance Notice of Proposed Rulemaking (ANPR) on Navy's application for incidental taking of marine mammals in *Federal Register*. • SURTASS LFA Open Houses held for public info dissemination: Seattle, Boston, Miami, Los Angeles and Honolulu.
2000	• Completed successful testing of high frequency (HF) marine mammal monitoring (HF/M3) sonar. • Navy drafted responses to 1,070 comments and 11 petitions received during the Draft EIS 90-day comment period.
2001	• Final EIS published and availability announced in the *Federal Register*. • NMFS published Proposed Rule in the *Federal Register*. • Public hearings held on NMFS's Proposed Rule: Los Angeles, Honolulu, and Silver Spring.
2002	• DASN (E) signed the Record of Decision (ROD), published in *Federal Register*. • NMFS published Final Rule in the *Federal Register*. • NMFS issued Letter of Authorization (LOA) under MMPA for SURTASS LFA employment on R/V *Cory Chouest*; published notice of issuance in the *Federal Register*. • NMFS issued Biological Opinion under ESA. • NMFS issued Incidental Take Statement (ITS) under ESA.
2003	• 25 January 2003 R/V *Cory Chouest*, having met all environmental compliance requirements, commenced testing and training in the Western Pacific Ocean. • Navy submitted application to NMFS for authorization to incidentally take marine mammals for second year operations under MMPA for SURTASS LFA employment on R/V *Cory Chouest* and USNS IMPECCABLE. • NMFS issued LOAs for second year operations; published notice of issuance in the *Federal Register*. • NMFS issued Biological Opinion and ITS under ESA.
2004	• Navy submitted application to NMFS for authorization to incidentally take marine mammals for third year operations. • NMFS issued LOAs and Biological Opinion/ITS for third year operations.
2005	• Navy submitted application to NMFS for authorization to incidentally take marine mammals for fourth year operations. • NMFS issued LOAs and Biological Opinion/ITS for fourth year operations.
2006	• Navy submitted application to NMFS for authorization to incidentally take marine mammals for fifth year operations. • NMFS issued LOAs and Biological Opinion/ITS for fifth year operations.

1.2.2 Military Readiness and Environmental Compliance

As detailed above, the Navy faces an increasing threat from quiet diesel submarines operated by several non-allied nations, including Iran, North Korea, and China. To combat this threat the Navy must continue employment and advanced research and development of ASW weapons systems. The employment of these systems during routine training, testing and military operations inevitably involves interaction with marine mammals and, therefore, application of the MMPA. In meeting its obligation under current environmental laws, the Navy undertook a comprehensive and exhaustive environmental planning and associated research efforts to support the deployment of SURTASS LFA. Working in cooperation with NMFS, the Navy completed an EIS, developed measures to protect marine species, and obtained all required permits pursuant to the MMPA and ESA. The scientific research and EIS involved extensive participation by independent scientists from a large number of laboratories and academic organizations, with wide-ranging public participation in the EIS process. Based on this, NMFS concluded that the planned SURTASS LFA operations would have negligible impacts on marine mammals.

In order 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).

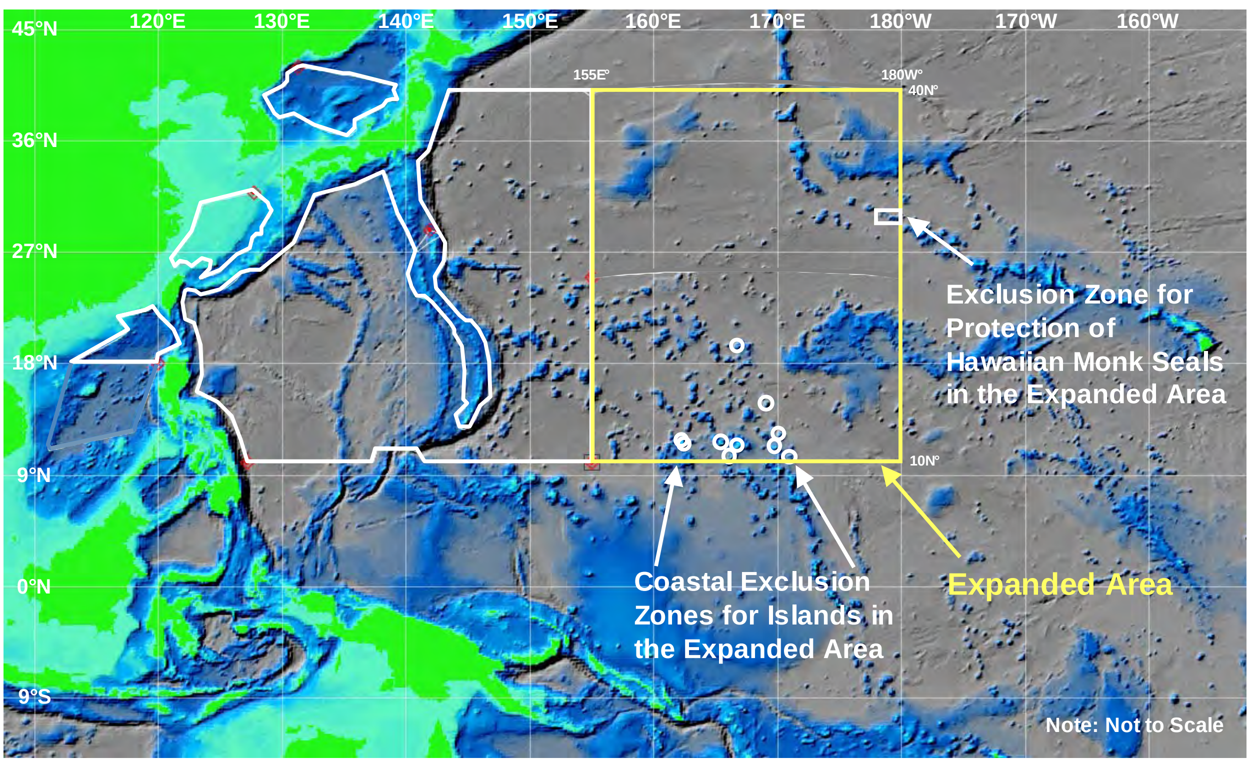

Figure 1-1. SURTASS LFA Sonar Operations Areas Permitted under Stipulation Regarding Permanent Injunction as Amended

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 and training operations that are the subject of NMFS's July 16, 2002, Final Rule constitute a military readiness activity 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 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.
- Amended definition of "harassment" as it applies to military readiness activities and 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[4].
- NMFS's 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 amended definition of "harassment" focuses authorization of military readiness and scientific research activities on biologically significant impacts to marine mammals, a science-based approach.

These revisions to the MMPA do not eliminate the requirement for mitigation and monitoring. The Navy still must operate under the Final Rule and is required to obtain annual LOAs from NMFS for each vessel. Congress also commended DoD and the Navy for their extensive marine mammal research, but directed an annual report be provided to Congress on research conducted and accompanying funding to ensure a continued level of effort of at least $7 million per year.

[4] On 31 June 2006 and 23 June 2007, the Deputy Secretary of Defense invoked the national defense exemption under the MMPA for certain mid-frequency sonar activities. Neither of these national defense exemptions apply to SURTASS LFA sonar employment as detailed in this SEIS.

1.2.3 System Upgrades

SURTASS LFA is part of the Integrated Undersea Surveillance System (IUSS). IUSS is designed to detect, classify and track diesel and nuclear submarines operating in both shallow and deep regions of littoral waters and deep ocean areas. 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. To meet this requirement, IUSS active sensors must be able to be operated in these challenging environments. 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 must be considered: 1) mono-static or independent operations, 2) bi-static operations where one system functions as the active source and other assets function as the active receivers, and 3) multi-static operations where multiple active sources are employed cooperatively with multiple receivers.

To meet these emergent requirements, the Navy has initiated a program to upgrade individual undersea surveillance systems. This will include SURTASS LFA system upgrades and modifications necessary to install and operate LFA from the smaller VICTORIOUS Class (T-AGOS 19 Class) ocean surveillance ships as shown in Figure 1-2.

Figure 1-2. VICTORIOUS Class (T-AGOS 19 Class) Ocean Surveillance Ship.

1.3 Environmental Impact Analysis Process

The purpose of this SEIS is 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 NEPA, ESA, and MMPA[5];
- Provide information necessary to apply for a new five-year Rule that would provide for incidental takes under the MMPA when the current rule expires 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.

This SEIS focuses on:

- DASN(E) direction to:
    - Provide additional information regarding the environment that could potentially be affected by employment of SURTASS LFA;
    - Provide additional information related to mitigation of the potential impacts of the system;
- Addressing pertinent deficiencies raised by the Court including:
    - Additional mitigation and monitoring;
    - Additional area alternatives analysis;
    - Analysis of the potential impacts of LF sound on fish;
- Providing the information necessary to apply for a new five-year rule that would provide for the incidental takes under the MMPA, taking into account the NDAA FY04 amendments to the MMPA for military readiness.

Additional SEIS analyses include:

- Updating literature reviews and determination of data gaps, especially for fish, sea turtles, and marine mammals;
- Marine animal LF sound thresholds/impacts based on Fish Controlled Exposure Experiments (CEE) and updated literature reviews;
- LF sound impact analysis to include:
    - Geographic areas;
    - Marine mammal impacts under NDAA FY04 definition of "harassment;"
    - Fish impacts;
    - Other listed species' impacts, as required (e.g., sea turtles);
- Mitigation (need for mitigation will be determined by impact analysis based on new legislation); and
- Cumulative impact analysis.

[5] 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.

The Navy is the lead agency in the development of the SEIS with NMFS of the Department of Commerce's (DOC) National Oceanic and Atmospheric Administration (NOAA) as a cooperating agency (See APPENDIX A).

1.4 Analytical Context

There have been no substantial changes to the framework for the development of the analytical context since the FOEIS/EIS. This information in the FOEIS/EIS remains valid. Except as noted, the contents of the Subchapter 1.4 of the FOEIS/EIS are incorporated by reference. The specific scientific information for marine animals was updated to ensure that the best available data was utilized in this analysis.

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. The information in Subchapter 1.4.1 of the FOEIS/EIS remains valid, and the contents are incorporated by reference.

1.4.2 Adequacy of Scientific Information on Marine Animals

The information in the FOEIS/EIS remains valid for the analysis of the potential effects of LF sound on marine animals. The contents of Subchapter 1.4.2 of the FOEIS/EIS are incorporated by reference. Additional information on the potential effects on marine mammals and fish are included in this SEIS and are addressed in Subchapters 1.4.2.1, 1.4.2.4, and 1.4.2.5 below.

1.4.2.1 Estimating the Potential for Injury to Marine Mammals

There have been no significant changes to the knowledge or understanding of the potential for LF sound to injure marine mammals. The information in Subchapter 1.4.2.1 of the FOEIS/EIS remains valid, and the contents are incorporated by reference. However, since the FOEIS/EIS, concerns have been raised about direct impacts on tissue, indirect impacts on tissues surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas. These issues are discussed in this SEIS.

1.4.2.2 Estimating the Potential for Behavioral Effects

There have been no significant changes to the knowledge or understanding of the potential for LF sound to modify significant biologically important behavior in marine mammals. The information in Subchapter 1.4.2.2 of the FOEIS/EIS remains valid, and the contents are incorporated by reference.

1.4.2.3 Masking

There have been no significant changes to the knowledge or understanding of the potential for LF sound to mask biologically important sounds. The information in Subchapter 1.4.2.3 of the FOEIS/EIS remains valid, and the contents are incorporated by reference.

1.4.2.4 Estimating the Potential for Injury to Fish Stocks

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) was conducted by the University of Maryland designed to examine the effects of LFA on hearing, the structure of the ear, and selected non-auditory systems in a *salmonid* (rainbow trout) and channel catfish (Popper et al., 2005b; Halvorsen et al., 2006).

1.4.2.5 Marine Mammal Strandings

There have been no significant changes to the data available on beaked whale strandings presented in Subchapter 3.2.5.1 of the FOEIS/EIS and its contents are incorporated by reference. Additional information on marine mammal strandings is presented in Subchapter 4.4.3 of this SEIS. None of these strandings involved SURTASS LFA sonar.

1.4.3 Analytical Approach

There have been no significant changes to the analytical approach and the associated conservative assumptions. The information in Subchapter 1.4.3 of the FOEIS/EIS remains valid, and the contents are incorporated by reference.

1.4.4 NEPA Disclosure

There have been no significant changes to the NEPA disclosure statement. The information in Subchapter 1.4.4 of the FOEIS/EIS remains valid and the contents are incorporated by reference.

Therefore, under 50 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 LFA sonar in relationship to reasonably foreseeable significant impacts. The SEIS updated the information and data provided in the FOEIS/EIS and provided evaluations and summaries of existing credible scientific evidence.

2 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.

Based on the Court's findings and DASN(E) direction to the Chief of Naval Operations (N7) to develop a supplemental EIS (SEIS), this document provides additional information regarding the environment that could potentially be affected by employment of SURTASS LFA, and identifies geographic areas and seasonal periods of high marine mammal abundance to assist the Navy in selecting SURTASS LFA operating areas. Further, the Court's opinion found that the Navy violated NEPA by: 1) failing to consider adequate alternatives in the form of considering training in areas that present a reduced risk of harm; 2) failing to adequately consider acoustic transmission shut downs to protect fish; and 3) failing to adequately consider potential impacts to fish. These issues are addressed in this document.

References to Underwater Sound Levels

1. 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.
2. References to underwater Sound Exposure Level (SEL) in this SEIS refer to the squared pressure over a duration of the sound referenced to the standard underwater sound reference level (1 μPa) expressed in dB, and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise.

Sources: Urick (1983); ANSI S1.8-1989 (R 2006)

2.1 General System Descriptions

SURTASS LFA sonars are long-range systems operating in the LF band (below 1,000 Hz) within the frequency range of 100 to 500 Hz. These systems are composed of both active and passive components as shown in 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 "fish finders" to military ASW systems for detection and classification of submarines. There are two broad 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 basically 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.

Existing operational LFA systems are installed on two SURTASS vessels: R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23). As future undersea warfare requirements continue to transition to littoral ocean regions, the development and introduction of a compact active system deployable from existing, smaller SURTASS Swath-P ships is paramount. This system upgrade is known as Compact LFA, or CLFA. CLFA consists of smaller, lighter-weight source elements than the current LFA system, and will be compact enough to be installed on the existing SURTASS platforms, VICTORIOUS Class (T-AGOS 19). The operational characteristics of the compact system are comparable to the existing LFA systems as presented in the Subchapter 2.1 of the FOEIS/EIS 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.

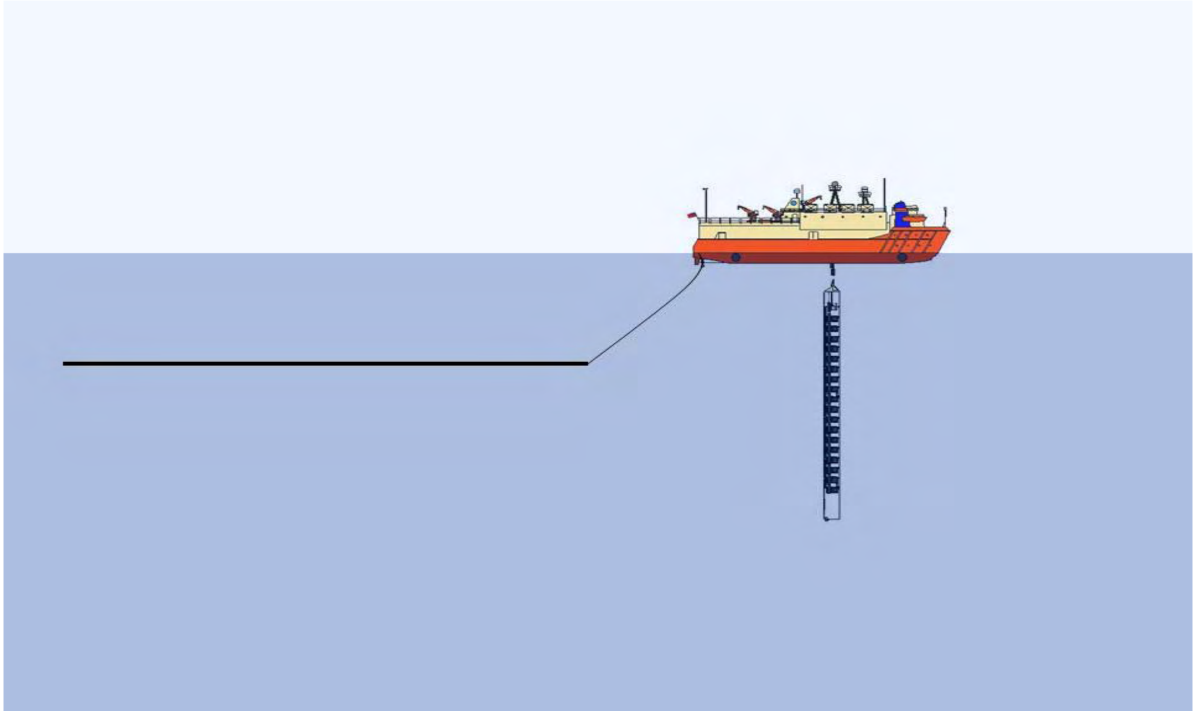

Figure 2-1. SURTASS LFA Sonar Systems

At present, there are two existing SURTASS LFA sonar systems—one each onboard the R/V *Cory Chouest* and USNS IMPECCABLE (T-AGOS 23). Three additional CLFA systems are planned for the T-AGOS Class 19. Figure 2-2 shows the projected availability of these systems. With the R/V *Cory Chouest* retiring in FY 2008, only two or three systems will be operational through FY 2010. Early in FY 2011 the potential exists for four vessels to be operational. At no point are there expected to be more than four systems in use, and thus this SEIS considers the employment of up to four systems.

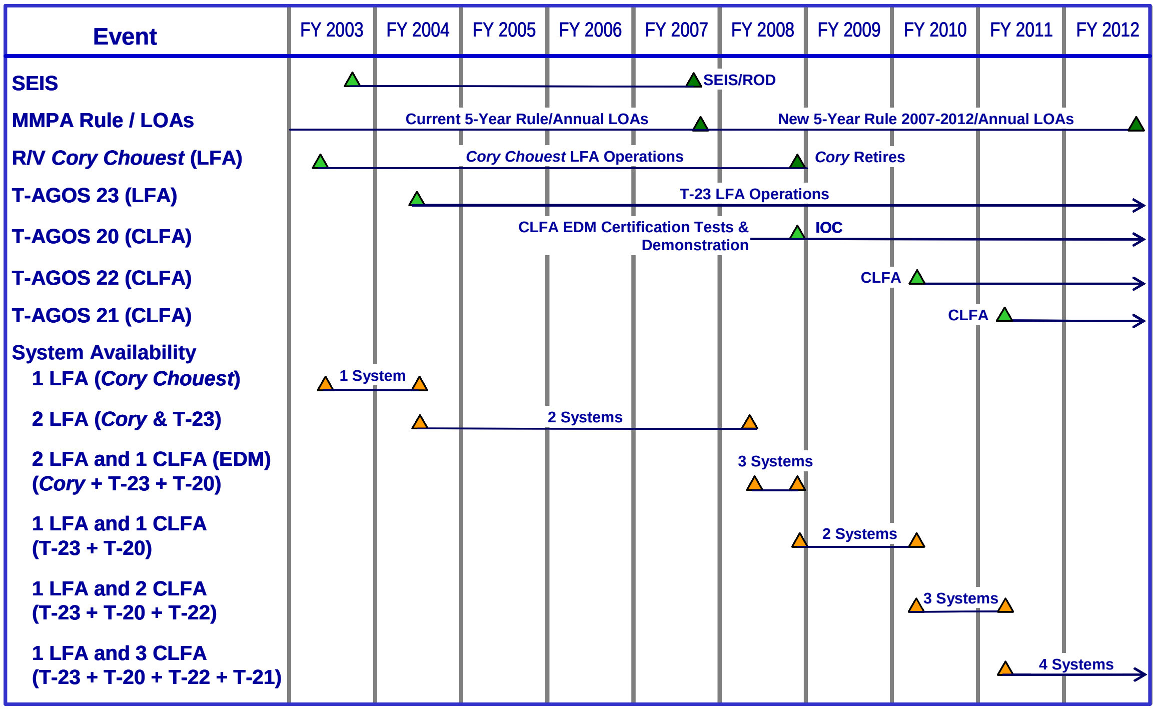

Figure 2-2. Projected LFA and CLFA Sonar Systems Availability

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 R/V *Cory Chouest*, USNS IMPECCABLE (T-AGOS 23), and the VICTORIOUS Class (T-AGOS 19 Class) (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 SL of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB or less. 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 never longer than 10 seconds.
- Average duty cycle (ratio of sound "on" time to total time) is less than 20 percent. The typical duty cycle, based on historical LFA operational parameters (2003 to 2007), is nominally 7.5 to 10 percent.
- 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. The SURTASS hydrophones are mounted on a receive array (horizontal line array [HLA]) that is towed astern of the vessel (Figure 2-1). The SURTASS LFA sonar vessel must maintain a speed of 5.6 kilometers per hour (kph) (3 knots [kt]) through the water in order to tow the hydrophone array. The return signals, which are usually below background or ambient noise level, are then processed and evaluated to identify and classify potential underwater threats.

The general characteristics of the SURTASS passive HLA are:

- Array length: 1,500 m (4,920 ft);
- Operational depth: 152 m (500 ft) to 457 m (1,500 ft);
- Minimum speed for deployment: 5.6 kph (3 kt); and
- Frequency: 0 to 500 Hz.

2.2 Operating Profile

Because of 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 have been developed, based on current LFA operations since January 2003 and projected Fleet requirements. As shown in Table 2-1, a SURTASS LFA sonar deployment schedule for a single vessel could involve up to 294 days per year at sea (underway). A nominal at-sea mission will occur over a 49-day period, with 40 days of operations and 9 days transit. Based on a 7.5 percent duty cycle (based on historical LFA operating parameters), the system will actually be transmitting for a maximum of 72 hours per 49-day mission and 432 hours per year for each SURTASS LFA sonar system in operation. The SURTASS LFA sonar vessel will operate independently of, or in conjunction with, other naval air, surface or submarine assets. The vessel will 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 71 days will be spent in port for upkeep and repair in order to maintain both the material condition of the vessel and its systems, and the morale of the crew.

This operating profile differs somewhat from the one provided in the FOEIS/EIS because that profile was based on estimations of operational requirements, not actual operations and real-time Fleet requirements. Key comparisons are provided in Table 2-2.

2.3 Potential Operational Areas

Because of uncertainties in the world's political climate, a detailed account of future operating locations and conditions cannot be delineated over the next five years. SURTASS LFA sonar operations, including testing of new systems as they come on line, will not be concentrated in specific sites, but will take place within any of the potential operational areas defined in Chapter 1 (Figure 1-1) in the Final OEIS/EIS. 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 kilometers (km) (12 nautical miles [nm]) of land, in offshore biologically important areas during biologically important seasons (see Figure 1-1), and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites.

Potential operations for SURTASS LFA 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.

Table 2-1. Nominal SURTASS LFA Sonar Annual and 49-Day Deployment Schedule—Single Ship

I. Nominal Annual Deployment

6 Days	49 Days			6 Days	49 Days			16 Days	49 Days		
In-Port Upkeep	T	Mission Operations Active	T	In-Port Upkeep	T	Mission Operations Active	T	In-Port Upkeep	T	Mission Operations Active	T

6 Days	49 Days			6 Days	49 Days			31 Days	49 Days		
In-Port Upkeep	T	Mission Operations Active	T	In-Port Upkeep	T	Mission Operations Active	T	Regular Overhaul	T	Mission Operations Active	T
Notes: “T” denotes transit periods when there would be no active transmissions											

II. Nominal 49-Day Mission

Transit	LFA Operations	Transit
4.5 Days	40 Days (72 hours active sonar transmissions @ 7.5% duty cycle*)	4.5 Days

*Note: 7.5% duty cycle is based on historical LFA operating parameters, which include downtime for:
- Corrective maintenance (equipment casualties or system failures)
- Preventive maintenance (database maintenance, daily archive, tow-point changes, etc.)
- Ship re-positioning
- De-confliction of mutual interference with other naval sensor systems
- EMCON (emission control) restrictions during naval operations and exercises

III. Nominal Annual Summary

Underway on Mission	Days	Not Underway	Days
Transit	54	In-Port Upkeep	40
Active Operations (432 hours transmissions based on 7.5% duty cycle*)	240	Regular Overhaul	31
Total Underway	294	Total Not Underway	71
Total Underway & Not Underway			365

Table 2-2. Comparison of Final and Supplemental EIS Annual Operating Profiles

	FOEIS/EIS	**SEIS**
Number of Active Missions	6	6
Number of Days Active per Mission	18	40
Number of Hours Active Ops Per Day	20	24
Duty Cycle	20 percent[1]	7.5 percent[2]
Days Active Ops	108	240
Days Transit/Reposition	108	54
Days In-Port/Regular Overhaul	95	71
Annual Transmission hours per vessel per year	432[3]	432[3]

Notes:
1. 20 percent duty cycle was conservatively based on the maximum LFA duty cycle.
2. 7.5 percent duty cycle is based on historical LFA operational parameters.
3. The FOEIS/EIS analyzed four vessels each with 432 hours of transmission time per year (See FOEIS/EIS Subchapter 2.2). In the ROD, the Navy stated that it would employ only two SURTASS LFA systems because only two systems would be available during the five year period through 2007. In the MMPA Rule, NMFS limited the Navy to two systems, consistent with the ROD, with missions totaling no more than 432 hours of transmissions per vessel per year. Because SURTASS LFA operations were limited to a relatively small area in the northwestern Pacific Ocean by the Court's Permanent Injunction, NMFS restricted the total operating hours to 432 hours for both vessels in the annual LOAs. Because LFA operations are not expected to be geographically restricted (except as noted in the mitigation) in the future, the original planned 432 hours of active transmissions per vessel per year, as analyzed in the FOEIS/EIS, are also proposed in this SEIS.

As an integral part of the SEIS, the Navy must anticipate, or predict, where they have 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 entrances to straits, channels, and canals. It is anticipated that many future naval conflicts are likely to occur within littoral or coastal areas. The Navy must balance National Security needs with environmental requirements and impacts, while protecting both our freedom and the world's natural resources.

It is infeasible to analyze all potential mission areas for all species' stocks for all seasons. The FOEIS/EIS acoustic modeling analysis for 31 worldwide sites remains valid, and deals with potential SURTASS LFA operating areas adequately. In addition, 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 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).

SEIS alternatives analyses are based on balancing National Security requirements for ASW/LFA with environmental compliance considerations. LFA must operate near our potential ASW adversaries, so a process to minimize the potential for environmental effects from these operations must be overlaid with the process for identifying the operations areas themselves. Alternatives development and analyses include operational areas of interest to the Navy for National Security reasons (when and where the Navy desires to operate), acoustic environmental data, animal density and distribution (spatial and temporal), and the best processes to determine areas with the least impact that meet National Security requirements. SEIS alternatives analysis is based on the utilization of the process that has been developed for the annual LOA applications to NMFS to determine desired locations with spatial/temporal analysis (both for biology and LFA operations). The determination of where and when the Navy will operate LFA in the future is a joint, scientifically-based process involving the Navy and NMFS, culminating in NMFS's issuance of annual LOAs. This process is the basis for the analyses of SEIS alternatives and is discussed in Subchapter 4.4

2.4 Mitigation Measures

Based on the results of the FOEIS/EIS and the extensive review process for the SURTASS LFA Final Rule under the MMPA (67 FR 46785), the DASN(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. This decision, known as the ROD, implemented Alternative 1 identified in the FOEIS/EIS for SURTASS LFA Sonar. All practicable means to avoid or minimize environmental harm have been adopted through the incorporation of mitigation measures into operation of the SURTASS LFA sonar and the designation of the LFA Mitigation Zone.

LFA Mitigation Zone

The LFA mitigation zone covers a volume ensonified to a level $\geq$ 180 dB by the SURTASS LFA sonar transmit array. Under normal operating conditions, this zone will vary between the nominal ranges of 0.75 to 1.0 km (0.40 to 0.54 nm) 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 a nominal 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 nm). 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 nm).

The objectives of these current mitigation measures are to avoid injury to marine mammals and sea turtles near the SURTASS LFA sonar source 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 within a specified distance of any coastline and in the offshore biologically important areas that exist outside the 22-km (12-nm) from any coastline during the biologically important season for that particular area; and
    - Does not exceed 145 dB 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 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
- Use of HF active sonar to detect/locate/track potentially affected marine animals near the SURTASS LFA sonar vessel and the sound field which is produced by the SURTASS LFA sonar source array.

These mitigation measures are detailed in Subchapter 2.3.2 and Chapter 5 of the Final OEIS/EIS and form the basis for the alternatives presented in this document. Except as noted below, the contents of Subchapter 2.3.2 and Chapter 5 of the FOEIS/EIS remain valid and are incorporated by reference.

2.5 Interim Operational Restrictions and Proposed Modifications to Mitigation

In the SURTASS LFA Final Rule under the MMPA (67 FR 46785), NMFS added interim operational restrictions in the Final Rule to preclude the potential for injury to marine mammals by resonance effects. These include: 1) establishment of a 1-km (0.54-nm) buffer shutdown zone outside of the 180-dB LFA mitigation zone; and 2) limiting the operational frequency of SURTASS LFA sonar to 330 Hz and below.

In the Court’s Opinion, the question was raised concerning the inclusion of requirements for additional monitoring and mitigation through the use of aircraft or small observational craft prior to operating close to shore; and extending source shutdown procedures beyond marine mammals and sea turtles to schools of fish. The Court also found that the FOEIS/EIS was lacking because the Navy should have considered training in areas that present a reduced risk of harm to marine mammals.

2.5.1 NMFS Interim Operational Restrictions

In response to the possibility of resonance effects on marine mammals, NMFS amended the mitigation measures to incorporate two interim operational restrictions during the first five-year Rule. The first restriction included a SURTASS LFA sonar system shutdown within a buffer zone that extends 1 km (0.54 nm) from the outer limit of the 180-dB safety zone (SURTASS LFA mitigation zone). This may extend up to 2 km (1.1 nm) from the vessel, depending on oceanographic conditions. At this distance, SPLs will be significantly less intense than 180 dB. Second, NMFS imposed an operational restriction on the frequency of the SURTASS LFA sonar sound to 330 Hz and below. These interim operational restrictions would be retained until scientific documentation could be provided which indicated that they could be modified while still providing sufficient protection for marine mammals.

<u>1-km Buffer Zone</u>

The 1-km (0.54 nm) buffer zone interim operational restriction has proven to be practical under the current operations, but the following analysis demonstrates that it did not appreciably minimize adverse impacts below 180-dB RL. The monitoring of the 180-dB mitigation zone is to prevent injury to marine animals. The area between the 180-dB radius and the 1-km (0.54 nm) buffer zone (estimated to extend to about the 174 dB isopleth) is an area where marine mammals will experience Level B incidental takes in accordance with the risk continuum (FOEIS/EIS Subchapter 4.2.3). The determination of the percentage of marine mammal stocks potentially affected by LFA operations in the risk assessment case study (DSEIS Subchapter 4.4.2) was determined based on monitoring mitigation in 180-dB injury zone, without accounting for the 1-km (0.54 nm) buffer zone. The area without the buffer zone is 3.14 km^2 (1.70 nm^2) and the area with the buffer zone is 12.6 km^2 (6.80 nm^2), a difference of 9.5 km^2 (5.1 nm^2). The model analysis was rerun using the total 2-km (1.08 nm) mitigation+buffer zone. The differences in the number of animals affected were insignificant. Thus, the removal of this interim operational restriction would not appreciably change the percentage of animals potentially affected.

<u>330-Hz Restriction</u>

The LFA rule-making process under the MMPA commenced in 1999 and ended when the LFA Rule was promulgated in July 2002. During this period, the potential for LFA, and sonar in general, to cause resonance-related injury in marine mammals above 330 Hz was an open issue. NMFS, therefore, added an interim operational restriction to the LFA Rule and associated LOAs limiting LFA operations to 100 to 330 Hz vice the 100 to 500 Hz analyzed in the FOEIS/EIS. For the SURTASS LFA sonar systems installed onboard the R/V *Cory Chouest* and USNS IMPECCABLE, this interim restriction was feasible. However, the frequency requirements for the Compact LFA (CLFA) to be installed onboard the smaller VICTORIOUS Class (T-AGOS 19 Class) vessels are somewhat higher, but still within the original 100 to 500 Hz range.

The 330-Hz frequency interim operational restriction was based on a statement made by Dr. Darlene Ketten, an expert on the functional morphology of marine mammal hearing, in her testimony before the Subcommittee on Fisheries Conservation, Wildlife and Oceans of the House Committee on Resources on October 11, 2001 (Ketten, 2001). Dr. Ketten's statement was "The consensus of data is that virtually all marine mammal species are potentially impacted by sound sources with a frequency of 300 Hz or higher." The topic of Dr. Ketten's testimony was <u>Marine Mammal Auditory Systems: A Summary of Auditory and Anatomical Data and Its Implementations of Underwater Acoustics Impacts</u>. The data presented related predominately to marine mammal hearing and *not resonance*.

In comments received on the SURTASS LFA DSEIS, it was claimed that the two recent workshops, sponsored by NMFS and the Marine Mammal Commission (MMC) respectively, provided data that damage from resonance remains a "reasonably foreseeable" impact that must be considered in the Navy's environmental review and mitigation. In April 2002, NMFS sponsored a Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans with over 30 scientists (DOC, 2002). In 2004 the Marine Mammal Commission sponsored a workshop on understanding the impacts of anthropogenic sound on beaked whales (Cox et al., 2006).

In November 2002, NMFS provided its "Report of the Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans" (DOC, 2002). The report concluded that the tissue-lined air spaces most susceptible to resonance are too large in marine mammals to have resonance frequencies in the range used by either mid or low frequency sonar. Relating to the requirement for needed research, the report stated that it seemed unlikely that acoustic resonance in air spaces played a primary role in tissue trauma in the Bahamas and other marine mammal stranding events. Nevertheless, they then suggested continued research. The MMC workshop stated that acoustic resonance is highly unlikely in the lungs of beaked whales, but did recommend further studies to fully eliminate this hypothesized mechanism (Cox et al., 2006).

In their review of the potential for *in vivo* tissue damage from underwater sounds regarding tissue effects, Cudahy and Ellison (2002) indicated that the potential for *in vivo* tissue damage to marine mammals from exposure to underwater LF sound (100 to 500 Hz) will occur at a damage threshold on the order of 180 to 190 dB (RL). The paper noted that resonance does not necessarily equal damage, and that damage is not always linked to resonance. Their review included both areas. They concluded the following: (1) transluminal (hydraulic) damage to tissues at intensities on the order of 190 dB or greater; (2) vascular damage thresholds from cavitation at intensities in the 240-dB regime; (3) tissue shear damage at intensities on the order of 190 dB or greater; and (4) tissue damage in air-filled spaces at intensities above 180 dB. The results are primarily based on the Gerth and Thalmann (1999) presentation at the Underwater Sound Conference of January 25, 1999, and summary test data (along with more recent analysis) on animal sound exposure from the SURTASS LFA EIS Technical Report Number 3 (Cudahy et al., 1999). It should be noted that Drs. Cudahy and Ellison were participants in the 2002 NMFS Acoustic Resonance Workshop.

Since the FOEIS/EIS was published in early 2001, research has been published in a peer-reviewed journal that supports the 180-dB criterion for injury. Laurer et al. (2002) from the Department of Neurosurgery, University of Pennsylvania School of Medicine, exposed rats to 5 minutes of continuous high intensity, low frequency (underwater) sound (HI-LFS) either at 180 dB SPL re 1 µPa at 150 Hz or 194 dB SPL re 1 µPa at 250 Hz, and found no overt histological damage in brains of any group. Also blood gases, heart rate, and main arterial blood pressure were not significantly influenced by HI-LFS, suggesting that there was no pulmonary dysfunction due to prolonged exposures at 180 dB and 194 dB. This published paper was based on work performed in support of Technical Report #3 of the SURTASS LFA Sonar FOEIS/EIS.

The MMC workshop listed three possible areas where resonance effects on marine mammals would be useful. The first concerned beaked whale lung resonance, which the MMC workshop concluded was "highly unlikely." The second concerned the potential for other organs and structures to be affected by resonance. Based on the 2002 NMFS workshop report, *if* resonance explained the Bahamas stranding, then sonar operating at a different frequency (like LFA at 100 to 500 Hz) would be unlikely to stimulate resonance in the same structures or species as a mid-frequency (MF) sonar would (DOC, 2002). The third area was tissue shear. Cudahy and Ellison (2002) reported tissue shear damage at intensities on the order of 190 dB (RL) or greater. Therefore, experts in the field of bioacoustics have stated that two of the three MMC proposed research areas are based on impacts that are unlikely and that the third will not occur below an exposure level of 190 dB, which is well within LFA's 180-dB safety zone. Finally, the Ocean Studies Board of the National Research Council (NRC) in its report on <u>Marine Mammal</u>

Populations and Ocean Noise stated that resonance from air spaces is not likely to lead to detrimental physiological effects on marine mammals (NRC, 2005).

Analyses sponsored by the Navy (Cudahy and Ellison, 2002; Laurer et al., 2002), reports on two workshops on acoustic impacts (DOC, 2002; Cox, et al. 2006), and the NRC Ocean Studies Board (NRC, 2005) support the conclusion that resonance from LFA operations is not a “reasonably foreseeable” impact, providing the empirical and documentary evidence that resonance and/or tissue damage from LFA transmissions are unlikely to occur in marine mammals in the frequency range 330 to 500 Hz within or outside the LFA mitigation zone. As a result, the Navy has requested NMFS to lift this interim operational restriction in the new rule making.

2.5.2 Court’s Issues

The Court found the FOEIS/EIS lacking because the Navy: 1) should have considered training in areas that present a reduced risk of harm to marine life and the marine environment when practicable; 2) should have further considered extending the shutdown procedures beyond marine mammals and sea turtles to schools of fish; 3) failed to adequately consider potential impacts to fish; and 4) raised the question concerning the inclusion of requirements for additional monitoring and mitigation through the use of aircraft or small observational craft prior to operating close to shore.

2.5.2.1 Training in Areas of Reduced Risk

Subchapter 4.4 of the SEIS provides the risk assessment approach for addressing this issue presented by the Court. The identification of a SURTASS LFA operating area that is particularly devoid of marine life is not straightforward. The reason that certain areas are believed to have minimal marine mammal activity could very well be because of gaps in animal distribution, abundance and density data there. It usually is more feasible to identify areas of high marine life concentrations and avoid them when practicable. This sensitivity/risk process is the methodology applied to SURTASS LFA sonar operations.

The process starts with the Navy’s ASW requirements to be met by SURTASS LFA sonar. Based on this information, mission areas are proposed by the CNO and fleet commands. Thereupon, available published data are collected, collated, reduced and analyzed with respect to marine mammal populations and stocks, marine mammal habitat and seasonal activities, and marine mammal behavioral activities. Where data are unavailable, best scientific 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. If marine mammal densities prove to be high and/or sensitive animal activities are expected, the mission areas are changed and/or refined and the process is re-initiated for the modified area. Next standard acoustic modeling and risk analysis are performed, taking into account spatial, temporal or operational restrictions. Then standard mitigation is applied and risk estimates for 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 restrictions on marine mammal/ animal impacts from SURTASS LFA sonar. If not, the proposed mission area is changed or refined, and the entire 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 consistent with its operational readiness requirements.

This process is provided in detail in Subchapter 4.4.1 and 4.4.2.

2.5.2.2 Modification of Shutdown Procedures to Schools of Fish

Modifying the current SURTASS LFA shutdown protocols to include schools of fish must be weighed against the feasibility and practicality of such a mitigation procedure in the context of military readiness and training. First, based on recent field experimentation (see Subchapter 4.1.1 of this document) for a fish to suffer injury, it must be within 200 m (656 ft) for the LFA source array during transmission (nominally transmitting less than 10 percent of the time). The SURTASS LFA vessel travels at an average speed of 9.3 kph (3 knots) and fish travel at nominal speeds of 9.3 kph (3 knots) (e.g., herring, pike, carp) up to speed burst of 74 to 93 kph (40 to 50 knots) (e.g., tuna, swordfish) (Iwai and Hisada, 1998; Nagai, 1999). Thus, the opportunity for a fish or a school of fish to be exposed to sound pressure levels from SURTASS LFA transmissions that could cause harm must be considered to be negligible. Therefore, the implementation of fish mitigation procedures is not required. Visual monitoring (daylight only) cannot be relied upon to detect fish schools, passive acoustic detection is infeasible, and active acoustics would give so many false alarms that the impact on the effectiveness of the military readiness activity (and, hence impact on National Security) would be very high. Subchapter 4.1.1.6 of this document provides additional discussion on this issue.

2.5.2.3 Potential Injury to Fish

The Court also found the FOEIS/EIS lacking because the Navy failed to adequately consider potential impacts to fish. This issue is addressed in Subchapter 4.1 of this document.

2.5.2.4 Pre-Operational Surveys

In order to determine if pre-operational aerial or small boat surveys are feasible and necessary mitigation measures according to the MMPA's treatment of such considerations in military readiness context, an evaluation is presented in Subchapter 5.4. This evaluation considered the feasibility of these surveys based on the following factors: 1) weather conditions, 2) time of day, 3) availability of small craft or small aircraft, 4) proximity to hostile territory, 5) sea state, 6) logistics, 7) overall safety considerations, and 8) National Security.

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. However, the lead agency is not required to engage in speculation or contemplation about possible future plans that could influence the EIS's analysis of potential direct and indirect effects at some nebulous point in the future. 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 LFA, 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; Table 1-1; and Responses to Comments (RTCs) 1-1.3, 1-2.1, 1-2.2, and 1-2.3, whose contents are incorporated into the SEIS by reference. These were also addressed in the NMFS Final Rule (67 FR 46785) and the ROD (67 FR 48145). 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. It was concluded in the FOEIS/EIS 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 to be practical and/or feasible for technical and economic reasons.

This subchapter provides a description of the proposed alternatives for the employment of SURTASS LFA sonar as summarized in Table 2-3. These alternatives will be analyzed in Chapter 4. In addition to the No Action Alternative, the SEIS provide analyses of four alternatives. The analyses of these five alternatives are intended to address NEPA deficiencies identified in the District Court’s 26 August 2003 opinion, as well as to fulfill the Navy’s responsibilities under NEPA with regard to changes in the proposed action. Among other things, the SEIS considers mitigation measures including coastal standoff restrictions of 22 and 46 km (12 and 25 nm), seasonal restrictions, the designation of additional offshore biologically important areas (OBIAs)[1], and shutdown procedures for schools of fish. The five alternatives considered in the SEIS are as follows:

- No Action Alternative;
- Alternative 1—Same as the FOEIS/EIS Preferred Alternative;
- Alternative 2 (Preferred Alternative)—Alternative 1 with additional OBIAs;
- Alternative 3—Alternative 1 with extended coastal standoff distance to 46 km (25 nm); and
- Alternative 4—Alternative 1 with additional OBIAs, extended coastal standoff distance to 46 km (25 nm), and shutdown procedures for schools of fish.

2.6.1 No Action Alternative

Under this alternative, operational deployment of the active component (LFA) 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 the contents are incorporated by reference.

[1] As defined in the SURTASS LFA Sonar FOEIS/EIS Subchapter 2.3.2.1, offshore biologically important areas, or OBIAs, are defined as those areas of the world’s oceans outside of the geographic stand off distance 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.

Table 2-3. SURTASS LFA Sonar System Alternatives Matrix

Proposed Restrictions/ Monitoring	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Dive Sites	NA	145 dB	145 dB	145 dB	145 dB
Coastline Restrictions	NA	<180 dB at 12 nm	<180 dB at 12 nm	<180 dB at 25 nm	<180 dB at 25 nm
Seasonal Variations	NA	Yes	Yes	Yes	Yes
Original OBIAs	NA	Yes	Yes	Yes [1]	Yes [1]
Additional OBIAs	NA	No	Yes	No	Yes [1]
Shutdown Procedures for Schools of Fish	NA	No	No	No	Yes
Visual Monitoring	NA	Yes	Yes	Yes	Yes
Passive Acoustic Monitoring	NA	Yes	Yes	Yes	Yes
Active Acoustic Monitoring	NA	Yes	Yes	Yes	Yes
Reporting	NA	Yes	Yes	Yes	Yes

Note: 1. Only those OBIAs, or portion thereof, that are outside of coastal standoff distance.

2.6.2 Alternative 1

Alternative 1 is the same as Alternative 1 presented in Subchapter 2.3.2 of the FOEIS/EIS, which is incorporated into the SEIS by reference. This alternative proposes the employment of SURTASS LFA sonar technology with geographical restrictions to include maintaining sound pressure level below 180 dB within 22 km (12 nm) of any coastline and within the originally designated OBIAs (see Table 2.3 of the FOEIS/EIS and LOAs, as issued) that are outside of 22 km (12 nm). Restrictions for OBIAs are year-round or seasonal, as dictated by marine animal abundances. LFA sound fields will not exceed 145 dB 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 180-dB LFA mitigation zone.

2.6.3 Alternative 2 (The Preferred Alternative)

Alternative 2 is the Navy’s preferred alternative. This alternative is the same as Alternative 1, but with additional OBIAs, including seasonal restrictions, as listed in Table 2-4. OBIAs are defined in Subchapter 2.3.2.1 of the FOEIS/EIS and the content of that discussion is incorporated by reference. Table 2-4 lists seven additional OBIAs based on consultation with the NOAA’s Office of National Marine Sanctuaries and Presidential EO 13178. To determine an all inclusive list of OBIAs within the potential operating areas over the next five years would be infeasible, and because of constantly changing data, would require repeated reviews and updates. It is the intention in this SEIS alternative to propose that during the annual LOA process under the new MMPA rule that the Navy evaluate potential OBIAs within the proposed operating areas for each ship and incorporate restrictions, as required into the LOA applications for NMFS’s review and action.

2.6.4 Alternative 3

Alternative 3 is the same as Alternative 1, but with a greater coastal standoff distance. This alternative proposes the employment of SURTASS LFA sonar technology with geographical restrictions to include maintaining sound pressure level to below 180 dB within 46 km (25 nm) of any coastline and within designated OBIAs that are outside of 46 km (25 nm).

2.6.5 Alternative 4

Alternative 4 is the same as Alternative 1, but with additional OBIAs, extended coastal standoff distance to 46 km (25 nm), and shutdown procedures for fish.

Table 2-4. Offshore Biologically Important Areas

Area Number	Name of Area	Location of Area	Months of Importance
1	200 m isobath of North American East Coast[1]	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[2]	Centered at 21°N and 157° 30''W	November 1 through May 1
5	Cordell Bank NMS[2]	Boundaries IAW 15 CFR 922.110	Year Round
6	Gulf of the Farallones NMS[2]	Boundaries IAW 15 CFR 922.80	Year Round
7	Monterey Bay NMS[2]	Boundaries IAW 15 CFR 922.130	Year Round
8	Olympic Coast NMS[2]	Within 23 nm of coast from 47°07'N to 48°30'N latitude	December, January, March and May
9	Flower Garden Banks (NMS)[2]	Boundaries IAW 15 CFR 922.120	Year Round

Note: 1. OBIA boundaries encompass Northern Right Whale Critical Habitat, Stellwagen Bank NMS, Monitor NMS, and Gray's Reef NMS.
2. Office of National Marine Sanctuaries, National Ocean Service, NOAA, letter dated 15 May 2001.

2.7 Additional Research

NMFS's original LOA (67 FR 55818) and Final Rule (67 FR 46785) included recommendations for the conduct of additional research involving the topics listed in Table 2-5 below. The research activities listed would help to increase the knowledge of marine mammal species and the determination of levels of impacts from potential takes. In addition, because of the Court's concerns about potential impacts on fish, the Navy sponsored independent research through a fish controlled exposure experiment.

2.7.1 Research Status

Table 2-5 below provides the status of research that has been conducted, is underway or is being planned to address NMFS's research topics based on the eight recommended research topics provided in the preamble to the Final Rule (67 FR 46782).

2.7.2 Navy-Sponsored Research

The Office of Naval Research (ONR) sponsors significant research to study the potential effects of its activities on marine mammals. The Navy spends on average $10M annually on marine mammal research at universities, research institutions, federal laboratories, and private companies. In 2004 and 2005, Navy-funded research produced approximately 65 peer-reviewed articles in professional journals. Publication in open professional literature thorough peer review is the benchmark for the quality of the research. This ongoing marine mammal research include 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. These studies, though not specifically related to LFA operations, are crucial to the overall knowledge base on marine mammals and the potential effects from underwater anthropogenic noise.

In addition, ONR and the Strategic Environmental Research and Development Program (SERDP) have funded the development and fieldwork for sound-and-orientation recording tags (DTAGs), which have been successfully attached with suction cups to beaked whales and sperm whales (Tyack et al., 2006). In particular, these data are providing tremendous amounts of information on the movement and diving behavior of beaked whales, both of which are important to know in order to understand the acoustic exposure to which the animals may be subjected.

Under the NMFS Final Rule, the Navy is required to conduct research in accordance with 50 CFR § 216.185(e) and the LOAs, as issued. As demonstrated in Table 2-5, the Navy has and is continuing to meet these recommended research requirements (67 FR 46782). The SURTASS LFA Sonar LTM Program has been budgeted by the Navy at a level of approximately $1M per year for five years, starting with the issuance of the first LOA. Planning has commenced for a 2007-2008 deep-diving odontocetes behavioral response study (BRS) to determine the potential effects of LFA, MFA, and seismic sources on beaked whales and other deep diving odontocetes at an estimated cost of $3M per year.

Table 2-5. Research Status

NMFS Research Topics	Status
Systematically observe SURTASS LFA sonar training exercises for injured or disabled marine animals	As reported in the annual reports (DON, 2003b; 2004a; 2005b; 2006c), post-operational incidental harassment assessments demonstrate that there were no known marine mammal exposures to RLs at or above 180 dB (Subsection 4.2). These findings are supported by the results from the visual, passive acoustic and active acoustic monitoring efforts discussed in Subsection 4.1. In addition, a review of recent stranding data from the National Science Museum, Tokyo, Japan and Internet sources did not indicate any stranding events associated with the times and locations of LFA operations (Subsection 4.3)
Compare the effectiveness of the three forms of mitigation (visual, passive acoustic, HF/M3 sonar)	A summary of mitigation effectiveness is provided in Subsection 4.1.8.
Behavioral reactions of whales to sound levels that were not tested during the research phase, specifically between 155 and 180 dB.	Preliminary assessment of the feasibility of conducting such research indicates that a Scientific Research Permit (SRP) under the MMPA, backed up with a National Environmental Protection Act environmental assessment would be required. The potential for acquiring authorization to intentionally expose marine mammals to RLs up to 180 dB would be expected to be extremely low. Moreover, it should be noted that for the Low Frequency Sound SRP conducted in 1997-98, where the goal was to expose blue, fin, gray and humpback whales to RLs up to 160 dB, even with total control of placement of the LFA source in relation to known animal locations and movements, it was rare to achieve RLs at the animals greater than 150 dB. Intentions are to hold discussions with NMFS on the practicability of future research of this nature.
Responses of sperm and beaked whales to LF sonar signals.	• Expert marine biologist and bio-acousticians agree that the conduct of controlled exposure experiments (CEE) with sperm and/or beaked whales will prove to be extremely complicated and expensive. Nevertheless, the Navy and NMFS are going forward with the planning for beaked whale BRSs, using controlled exposures of LF, MF and seismic sources, with execution during the summer/fall of 2007 and 2008. • An April 2004 Beaked Whale Workshop organized by the Marine Mammal Commission in Baltimore, MD where there was unanimous support for CEEs as a top research priority to be used to gather critical information on beaked whale responses to sound. A Summary report of this workshop is available at: http://www.mmc.gov/sound/ and also in Cox et al. (2006). • A November 2004 Beaked Whale Research Planning Workshop at St. Andrews University, UK, jointly funded by the University's Sea Mammal Research Unit (SMRU) and the UK Ministry of Defence (MoD); where SMRU provided a strawman proposal for conducting CEEs with beaked whales. • A second SMRU/MoD meeting in October 2005 of leading scientists in the fields of marine bio-acoustics and whale research, in Oxford UK, produced a draft research strategy on The Effects of Anthropogenic Sound on Marine Mammals, which focuses on a risk assessment framework of 5 steps: 1) Hazard identification; 2) Animal exposure assessment; 3) Animal dose-response assessment; 4) Risk characterization; and 5) Risk management. Navy funding supported this research effort. • The Navy is funding SMRU and QinetiQ (UK) to help provide the framework for future national and international research on the responses of beaked whales to LF sonar signals. • The Navy and NMFS met the 2006 goal to develop an agreed-upon experimental plan for follow-on field research (e.g., BRSs) with beaked whales in 2007/2008. The Navy convened an *ad hoc* scientific working group meeting in April 2006 to

<table>
<tr><th>NMFS Research Topics</th><th>Status</th></tr>
<tr><td></td><td>concentrate on the details of a 2007 beaked whale BRS; independent scientists from Cornell University, Woods Hole Oceanographic Institution, and St. Andrews University attended, which developed a plan of action with milestones for the 2007/2008 experiments. Navy and industry funding is supporting this research effort.
• The Deep-Diving Odontocetes BRS Planning Meeting was held in Oct 2006 with participants from Cornell University, Woods Hole Oceanographic Institution, St. Andrews University, NMFS, Navy, and the seismic exploration industry. The primary objectives were to agree upon a plan for the BRS 2007 Scientific Research Permit (SRP) Application under the MMPA, and set the BRS organization.</td></tr>
<tr><td>Habitat preferences of beaked whales.</td><td>The ONR has funded the following research that has been published:

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.

The U.S. Navy/ONR and SERDP have funded the following research on predicting the distribution of marine mammal species, including beaked whales:

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.

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.

As part of the BRS planning, a Navy-funded draft document from SMRU has identified three “top-tier,” three “second-tier” and eight “third-tier” sites (i.e., habitat preferences of beaked whales), including discussion for each on: 1) scientific impact; 2) logistics and cost; 3) team qualifications; and 4) permits and politics.
• Top Tier: Bahamas, Azores, Canaries.
• Second Tier: Bay of Biscay, Hawaii, Ligurian Sea (Genoa Canyon).
• Third Tier: Alboran Sea, Baja California, Western Greece, New Zealand, Tasmania, Japan (Yokosuka Bay), Washington State (Quinault Canyon), Caribbean Sea (esp. eastern Puerto Rico and Virgin Islands).

These data will be further examined and beaked whale experts consulted in determining the oceanic area and specific sites for the conduct of the proposed BRS field research effort. Navy funding supports this research effort.</td></tr>
<tr><td>Passive acoustic monitoring for the possible silencing of calls of large whales using bottom-mounted hydrophones.</td><td>Four research efforts in the North Atlantic (NORLANT, 2004, 2005, 2006-01, 2006-02) have addressed this topic. The research reports for these tasks are classified; unclassified summary reports have been produced. Navy funding has supported and continues to support these research efforts.</td></tr>
</table>

NMFS Research Topics	Status
Continued research with the HF/M3 Sonar	Based on system component maintenance history and training experience with the HF/M3 sonars installed onboard the R/V *Cory Chouest* and the USNS IMPECCABLE, the HF/M3 sonar is being upgraded for integration into the installations of CLFA on the T-AGOS 19 Class vessels.
Long-term, cumulative effects on a stock of marine mammals that is expected to be regularly exposed to LFA and monitor it for population changes throughout the five-year period.	The overall topic of cumulative impacts to marine mammal stocks from LFA operations is addressed in Subsection 4.6. Detecting and scientifically validating a change in a marine mammal population (e.g, trend, demographics) is extremely difficult. It is unrealistic to expect that a single factor would explain population changes. Also, for LFA, research results indicate that some whales will respond to LFA over relatively short temporal periods and over small spatial areas, and it is recognized that this research was only capable of testing for responses over short time periods and spatial scales. There is no evidence that LFA could have an effect on individual survivorship or reproductive success, or population trends or demographics. However, research on the appropriate temporal and spatial scales has not been conducted to address this level of potential impact, so questions concerning the level of impact at such scales remain unanswered. For these reasons, no research in this area is presently planned.

2.7.3 Research on Fish

Although not directly related to the LFA regulatory process, the Navy has funded independent research to determine the potential for SURTASS LFA signals to affect fish, a prey species for marine mammals. Dr. Arthur Popper (University of Maryland), an internationally recognized fish acoustics expert, investigated the effects of exposure to LFA sonar on rainbow trout (a hearing non-specialist related to several endangered salmonids) and channel catfish (a hearing specialist) using an element of the standard SURTASS LFA source array (Popper et al., 2005a; 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 behavioral effects were observed with video monitoring.

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. TTS in catfish ranged from 6 to 12 dB at frequencies from 200 to 1000 Hz. Both species recovered from hearing loss in several days. Inner ear sensory tissues appeared unaffected by acoustic exposure.

Gross pathology indicated no damage to non-auditory tissues, including the swim bladder. There was no fish death attributable to sound exposure, even up to four days post-exposure. Both 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 RL) used in these experiments approached those that fish would encounter very close to an active LFA source array (within approximately 200 m [656 ft]). However, the exposure during 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 intensity as the ship moved away from exposed fish.

Therefore, based on recent field research results, the potential for a fish or schools of fish to be harmed (thus impacting fish stocks) by exposure to LFA signals above 193 dB RL (within approximately 200 m (656 ft) of the SURTASS LFA operational array) is considered negligible.

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3 AFFECTED ENVIRONMENT

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

- **Marine Environment**, including ambient noise in the oceans, physical environmental factors affecting acoustic propagation, ocean acoustic regimes, and oceanographic features affecting marine mammal distribution (Subchapter 3.1);
- **Marine Organisms,** including fish, sea turtles, and marine mammals (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).

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 Subchapter 3.1 (Marine Environment) in the FOEIS/EIS remains valid, and its contents are incorporated by reference herein.

In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (U.S.) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. On an annual basis, four SURTASS LFA systems are estimated to have a total energy output of 6.8×10^{11} Joules/yr. Seismic air gun arrays were two orders of magnitude greater with an estimated annual output of 3.9×10^{13} Joules/year. MFA and super tankers were both greater at 8.5×10^{12} and 3.7×10^{12} Joules/year, respectively (Hildebrand, 2004). He reported that the most energetic regularly-operated sound sources are seismic air gun arrays from approximately 90 vessels with typically 12 to 48 individual guns per array, firing about every 10 seconds. There are approximately 11,000 super tankers worldwide, each operating 300 days per year, producing constant LF noise at source levels of 198 dB (Hildebrand, 2004). Conversely, LFA signals are transmitted for a maximum of 432 hours (18 days) per vessel per year. The signal length is between 6 to 100 seconds with 6 to 15 minutes between transmissions with individual elements sources levels of 215 dB. Per this analysis, each LFA source adds approximately 1 percent more energy to that already produced by just the air gun arrays in the world. The actual percentage of the total anthropogenic acoustic energy budget added by each LFA source is actually closer to 0.5 percent per system (or less), when other man-made sources are considered. When combined with the naturally occurring and other man-made sources of noise in the oceans, LFA barely contributes a measurable portion of the total acoustic energy.

Hildebrand (2004) concluded that increases in anthropogenic 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. The use of SURTASS LFA sonar is not scheduled to increase past the originally analyzed four systems in the next five years.

3.2 Marine Organisms

3.2.1 Species Screening

An animal must be able to hear LF sound, and/or some organ or tissue must be capable of changing sound energy into mechanical effects in order 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.

Based on these considerations, a detailed analysis of only those organisms in the world's oceans that meet the following criteria has been undertaken:

- Does the proposed SURTASS LFA sonar geographical sphere of acoustic influence overlap the distribution of this species? If so,
- Is the species capable of being physically affected by LF sound? Are acoustic impedance mismatches large enough to enable LF sound to have a physical effect?
- Can the species hear LF sound? If so, at what thresholds?

In other words, to be evaluated for potential impact in this SEIS, 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 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. The evaluation process is summarized visually in Figure 3.2-1 (Species Selection Rationale) in the FOEIS/EIS. For example, phytoplankton and zooplankton species do have acoustic impedance differences from seawater due to tiny gas bubbles. However, Medwin and Clay (1998) have calculated resonance frequency ranges from 7 to 27 kHz at 100 m (328 ft). Because of the lack of acoustic impedance mismatches at low frequencies, the SURTASS LFA sonar pulse essentially would pass through them without being detected. Therefore, they do not have the potential to be physically affected by the operation of SURTASS LFA sonar, and were not evaluated for potential impacts (Croll, et al., 1999).

In cases where direct evidence of acoustic sensitivity is lacking for a species, reasonable indirect evidence was used to support the evaluation (e.g., there is no direct evidence that a species hears LF sound but good evidence that the species produces LF sound). In cases where important biological information was not available or was insufficient for one species, but data were available for a related species, the comparable data were used. Additional attention was given to species with either special protected stock status or limited potential for reproductive replacement in the event of mortality.

References to Underwater Sound Levels

1. 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.
2. References to underwater Sound Exposure Level (SEL) in this SEIS refer to the squared pressure over a duration of the sound referenced to the standard underwater sound reference level (1 μPa) expressed in dB, and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise stated.

Source: Urick (1983); ANSI S1.8-1989 (R 2006)

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) their 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 (lobster, shrimp, and crab) are known to sense LF sound (Offutt, 1970; Budelmann and Williamson, 1994). There are very limited data on invertebrates. Based on Budelmann and Williamson's measurements, the cephalopod threshold for hearing for far-field sound waves is estimated to be 146 SEL. Statocysts were analyzed when the hair cells were stimulated with water movements from different directions. The experiment indicated that cephalopod statocysts are directionally sensitive in a way that is similar to the responses of hair cells on vertebrate vestibular and lateral line systems. The hearing threshold for the American lobster has been determined to be approximately 150 SEL -- in the LF range of SURTASS LFA sonar (Offutt, 1970). Popper et al. (2003) also reviewed behavioral, physiological, anatomical, and ecological aspects of sound and vibration detection by decapod crustaceans. Decapod crustaceans are known to produce acoustic signals. Many decapods also have an array of hair-like receptors within and upon the body surface that potentially or 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).

While data are still very limited, they do suggest that some of the major cephalopods and decapods may not hear well, if they hear at all. We may cautiously suggest that given these high levels of hearing thresholds, 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 vessel 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 27,000 extant fish species (Nelson, 1994) 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 nm] 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, Lamniformes, Anguilliformes, Albutleiformes, Clupeiformes, Salmoniformes, Gadiformes, Beryciformes, Scorpaeniformes, and the Perciformes families Pomacentridae, Labridae, Lutjanidae, Serranidae, Sciaenidae, Scombridae, and Haemulidae. These are the fish groups evaluated for potential impacts in this SEIS.

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) state that seabirds spend 90 percent of their life at sea foraging over hundreds to thousands of kilometers. Some dive from the sea surface to several hundred meters. Ballance et al. (2001) further state 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 (please see FOEIS/EIS Subchapter 4.3.2.1). 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 below the water surface at least 2 m (6.6 ft) during the 7.5 percent of the time (active transmission duty cycle based on actual operations) that the LFA source would be transmitting. 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.

Therefore, there significant impacts to seabirds, including those that may be threatened or endangered, is highly unlikely,. For these reasons, 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 green turtle (*Chelonia mydas*) (including the black turtle [*C. agassizi*) is listed as threatened everywhere except Florida and the Pacific coast of Mexico, where they are endangered. The loggerhead turtle (*Caretta caretta*) is listed as threatened. The hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempi*), and leatherback (*Dermochelys coriacea*) are listed as endangered species. The olive ridley (*Lepidochelys olivacea*) is threatened everywhere except the Mexican breeding stocks, which are listed as endangered. The flatback turtle (*Natator depressus)* is unlisted and is restricted to nearshore waters off Australia. Consequently, it is excluded from further analysis. It is likely that all species of sea turtles hear LF sound as adults (Ridgway et al., 1969; O'Hara and Wilcox, 1990). Therefore, the other six species of sea turtles are considered for evaluation since they are likely to hear LF sound, occur in pelagic water, and/or dive deeply.

Baleen Whales (Mysticetes)

All 11 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. 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. However, only those that occur within the latitudes of proposed SURTASS LFA sonar operations are considered. This excludes the bowhead whale (*Balaena mysticetus*) that occurs only in Arctic waters, north of the area where the system would operate. Included for consideration are the remaining ten baleen whale species: blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), minke (*Balaenoptera acutorostrata*), Bryde's (*Balaenoptera edeni*), sei (*Balaenoptera borealis*), humpback (*Megaptera novaeangliae*), northern right (*Eubalaena glacialis*), southern right (*Eubalaena australis*), pygmy right (*Caperea marginata*), and gray (*Eschrichtius robustus*) whales.

Toothed Whales (Odontocetes)

There are at least 70 species of odontocetes (some species classifications are under study, and the exact number of beaked whales is not known) including dolphins, porpoises, beaked whales, long-finned pilot, short-finned pilot, pygmy killer, false killer, melon-headed whales, killer whales, and sperm whales. A number of these species inhabit ocean areas where SURTASS LFA sonar might operate. Many species are known to use HF clicks for echolocation. All odontocete species studied to date hear best in the mid- to high-frequency range, and so are less likely to be affected by exposure to LF sounds than mysticetes. Like mysticetes, odontocetes depend on acoustic perception and production for communication, food finding, and probably for navigation and orientation.

The following species of odontocetes do not meet the screening criteria described at the beginning of this subchapter, and thus are eliminated from further evaluation:

- Arctic specialists in the family Monodontidae including narwhal (*Monodon monoceros),* because SURTASS LFA sonar would not be employed in their range in the Arctic.
- Some porpoise species because they are coastal species with ranges well inshore of the areas where SURTASS LFA sonar would be employed, including: Burmeister's porpoise *(P. spinipinnis*), vaquita (*P. sinus),* and finless porpoise (*Neophocaena phocaenoides).*
- Dolphin species in the following families: Pontoporiidae (Chinese River dolphin [*Lipotes vexillifer],* fanciscana [*Pontoporia blainvillei]*); Iniidae (boto/Amazon River dolphin [*Inia geoffrensis]*); and Platanistidae (Ganges river dolphin [*Platanista gangetica]* and Indus River dolphin [*P. minor*]). They are eliminated because they are river dolphins that may enter coastal waters, but their ranges are well inshore of the areas where SURTASS LFA sonar would be employed.
- Dolphin species in the family Delphinidae that occur in shallow, coastal waters well inshore of the areas where SURTASS LFA sonar would be employed and are not known to hear sounds in the range of the system. This group includes Tucuxi/boto (*Sotalia fluviatilis),* Irrawaddy dolphin (*Oracella brevirostris),* Indo-Pacific humpbacked dolphin (*Sousa chinensis),* Atlantic humpbacked dolphin (S*ousa teuszii),* and humpback dolphin (*Sousa plumbea).*

Odontocetes that are further analyzed in this document are those species that have the potential to be found in deeper, offshore waters where SURTASS LFA sonar might operate. This includes pelagic dolphins, coastal dolphin species that also occur in deep water, beaked whales, killer whales, sperm whales, long-finned and short-finned pilot whales, pygmy killer whales, false killer whales, melon-headed whales, and belugas.

Seals, Sea Lions, and Walruses (Pinnipeds)

The suborder of Pinnipedia consists of "eared" seals (family Otariidae), "true" seals (family Phocidae), and walruses (family Odobenidae).

There are 14 species of otariids including sea lions and fur seals. They are found in temperate or sub-polar waters. Several of these species are listed as special status (northern sea lion, northern fur seal, and Guadalupe fur seal). All 14 species are further analyzed in this document.

There are 18 species of phocids, or "true" seals, nine of which occur in polar oceans or inland lakes and can therefore be excluded. The remaining nine phocid species, including two monk seal species that are listed as endangered, merit further evaluation. These include the Hawaiian and Mediterranean monk seals (*Monochas monachus* and *M. schauinslandi*); the northern and southern elephant seals (*Mirounga angustirostris* and *M. leonina*); the gray seal (*Halichoerus grypus*); three species in the genus *Phoca*: the ribbon, harbor, and spotted seals (*P. fasciata, P. vitulina,* and *P. largha*); and the hooded seal (*Cystophora csistata*).

The walrus can be excluded from further analysis since it is a polar species.

Phocids Excluded from Further Analysis	
ringed (*Phoca hispida*)	
baikal (*P. sibirica)*	crabeater (*Lobodon carcinophagus*)
Caspian (*P. caspica*)	Ross (*Ommatophoca rosii*)
harp (*P. groenlandica*)	leopard (*Hydrurga leptonyx*)
bearded (*Erignathus barbatus*)	Weddell (*Leptonychotes weddelli*)

Ursids

A marine mammal, the polar bear (*Ursus maritimus*) can be excluded from further analysis since it is a polar species

Mustelids

Two of the six species of otters in the world inhabit ocean waters: the sea otter (*Enhydra lutris*) and the chungungo (*Lutra felina*). The activities of both species occur almost exclusively in shallow waters. Therefore, these species are not considered for further evaluation.

Sirenians

The world has three manatee species, West Indian (*Trichechus manatus*), Amazonian (*T. inunguis*]) and West African *T. senegalensis*) and one dugong species (*Dugong dugon*). The manatees are primarily a fresh water and estuarine species. Therefore, they are eliminated from further evaluation.

Dugongs are usually found in calm, sheltered, nutrient-rich water less than 5-m (16.4 ft) deep, generally in bays, shallow island and reef areas which are protected against strong winds and heavy seas and which contain extensive sea grass beds. However, they are not confined to inshore waters. There have been sightings near reefs up to 80 km (43.2 nm) offshore in waters up to 23 m (75 ft) deep (Reeves et al., 2002). The average minimum water depth that the SURTASS LFA vessel will operate is 200 m (656.2 ft). The shallowest depth that it can operate is 100 m (328 ft). As a result of sound attenuation in shallow and shoaling water, dugongs are unlikely to be affected. Therefore, they are eliminated from further evaluation.

3.2.2 Fish

3.2.2.1 Background

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 27,000 extant species (Nelson, 1994). 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. Table 3.2-1 provides a listing and a general discussion of the hearing abilities of marine fish species that have been reported in the primary literature, as well as representative fresh water species that might provide some insight into hearing capabilities of marine species. The pelagic and demersal fish orders shown are of particular importance because of their demonstrated responses to LF sounds, protected status, and/or commercial importance. It is likely, however, that many other fish species produce and/or use sound for communication, but data are not available on additional species. For example, there is some reason to think that a number of deep-sea species that live where there is little or no light, such as myctophids (lanternfish) (Popper, 1980b; Mann and Jarvis, 2004), macrourids (rattails - relatives of cod) (Deng et al., 2003), 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.

3.2.2.2 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). The major components of the octavolateralis system (Figure 3.2-1a) are the inner ear and the lateral line. 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 humans (Coffin et al., 2004). Both components of the octavolateralis system, the ear and the lateral line, send their signals to the brain in separate neuronal pathways. However, at some levels the two systems 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) (see Figure 3.2-1a). 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). The pattern of the 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). 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).

Table 3.2-1. Selected Fish Orders

Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics[1]
Heterodontiformes	Bullhead sharks	Demersal	The horn shark, *Heterodontus francisci*, reportedly hears from 20-160 Hz (Kelly and Nelson, 1975).[2]
Lamniformes	Pelagic sharks	Pelagic	Hearing range for the bull shark, *Carcharhinus leucas*, reportedly is 100-1400 Hz (Kritzler and Wood, 1961), the lemon, *Negaprion brevirostris,* hears from 10-640 Hz (Banner, 1967; Nelson, 1967; Banner, 1972), and the hammerhead shark, *Sphyrna lewini*, from 250-750 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 need to be repeated.[2]
Rajiformes	Skates and rays	Demersal	The little skate, *Raja erinacea*, hears from 100-800 Hz, with best hearing at 200 Hz at approximately 122 dB re: 1 µPa at 1 m threshold (Casper et al., 2003).
Anguilliformes	Eels	Demersal	The upper audible limit of *Anguilla anguilla* hearing is reported to be about 600 Hz (Diesselhorst, 1938[2]) with best hearing at about 100 Hz at 95 dB re: 1 µPa at 1 m threshold (Jerko et al., 1989).
Albuleiformes	Bonefish	Pelagic and demersal	The bonefish (*Albula vulpes*) is able to detect sounds from 50-700 Hz (Tavolga, 1974).

[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 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 often 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 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 per cent 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 work is needed to replicate these results on both threshold and bandwidth.

Table 3.2-1. Selected Fish Orders

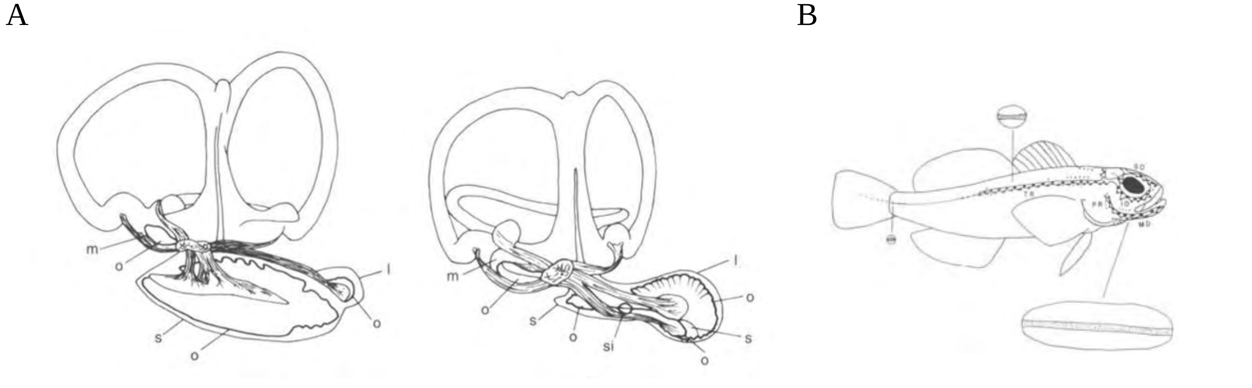
Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics[1]
Clupeiformes	Herrings/shads/sardines/ anchovies	Pelagic	Maximum hearing sensitivity for Pacific herring (*Clupea harengus pallasi*) is reportedly 125-500 Hz (reviewed in Croll et al., 1999), Pacific sardine (*Sardinops sagax*) best sensitivity is reported to be from 63-500 Hz (Sonalysts, 1995 – unpublished "gray" literature). Spotlined sardines (*Sardinops melanostictus*) are reported to hear from 256-2048 Hz, with maximum sensitivity near 1 kHz (Akamatsu et al., 2003). Spotted shad (*Clupanodon punctatus*) max sensitivity 125-500 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 some species in the genus *Alosa* can detect sounds to over 180 kHz (Mann et al.; 1998, Mann et al., 2001). There is a report that the twaite shad (*Alosa fallax*) avoided 200 kHz sound pulses (Gregory and Clabburn, 2003).
Salmoniformes	Salmons/trouts/ 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., In Prep.).
Gadiformes	Cods/hakes/haddock/ Pollock	Pelagic and demersal	Hearing range of the cod (*Gadus morhua)* is 10-500 Hz (Chapman and Hawkins, 1973), while that of the haddock (*Melanogrammus aeglefinus*) is from 30-470 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 60-1000 Hz, with best hearing at 120-200 Hz (Park et al., 1995). The ling (*Molva molva*) reportedly detects sounds from 40-550 Hz (Chapman, 1973).
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, 1992). *Paralichthys olivaceous* detects sounds from 70 Hz 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).

Table 3.2-1. Selected Fish Orders

Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics[1]
Beryciformes	Squirrelfish (Holocentridae)	Pelagic and demersal	One species of squirrelfish (*Myripriste kuntee*) can detect sounds between 100-3000 Hz with best sensitivity between 300-2000 Hz, while another (*Adioryx xantherythrus*) can only detect to about 100-1000 Hz (Coombs and Popper, 1979). The squirrelfish (*Holocentrus vexillaris*) and (*Holocentrus ascensionis*) can detect sounds from 100-1200 Hz (Tavolga and Wodinsky, 1963; Wodinsky and Tavolga, 1964). Large variability in hearing capabilities exists within this group of fish.
Batrachoidiformes	Toadfish (Batrachoididae)	Demersal	Oyster toadfish (*Opsanus tau*) reportedly detect sounds from 40-700 Hz, with best sensitivity between 40-200 Hz (Fish and Offutt, 1972) and this has been confirmed from neurophysiological studies (Fay and Edds-Walton, 1997)
Scorpaeniformes	Searobins (Triglidae)	Demersal	Slender searobin (*Prionotus scitulus*) detects sounds from 100-600 Hz, with best sensitivity from 200-400 Hz (Tavolga and Wodinsky, 1963).
Perciformes (note, 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 range 50-1100 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*), that 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 300-600 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 100-1200 Hz, with best sensitivity from 200-600 Hz (Tavolga and Wodinsky, 1963).
	Sea basses (Serranidae)	Pelagic and demersal	Only data are for the red hind (*Epinephelus guttatus*) which can hear from 100-1000 Hz, with best sensitivity from 200-400 Hz (Tavolga and Wodinsky, 1963).
	Snappers (Lutjanidae)	Pelagic and demersal	Schoolmaster (*Lutjanus apodus*) hears from 100-1000 Hz, with best sensitivity from 200-600 Hz. (Tavolga and Wodinsky, 1963).

Table 3.2-1. Selected Fish Orders

Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics[1]
	Drums (croakers) (Sciaenidae)	Pelagic and demersal	There is broad diversity in ear structure and in hearing in this group (Ramcharitar et al., 2001, 2004; Ramcharitar and Popper, 2004). Several species can detect sounds to over 2000 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 50-1000 Hz, with best hearing from 50-500 Hz (Tavolga and Wodinsky, 1963, 1965).
	Breams and porgies (Sparidae)	Pelagic	Ringed sea-bream (*Sargus annularis*) reportedly hears from 400-1200 Hz with best hearing from 400-800 Hz (Dijkgraaf, 1952). Red sea-bream (*Pagrus major*) hears from 50-1500 Hz, with best hearing at 200 Hz (Ishioka et al., 1988; Iwashita et al., 1999). Pinfish (*Lagodon rhomboides*) hears from 100-1000 Hz, with best sensitivity at 300 Hz (Tavolga, 1974).
	Jacks and mackerels (Carangidae)	Pelagic	Horse mackerel (*Trachurus japonicus*) hears 70-3000 Hz, with best hearing at 1000-1500 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 450-900 Hz (Maliukina, 1960).
	Mullet (Mugilidae)	Pelagic	Hearing ability in *Mugil* has an upper frequency limit of 1600-2500 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 50-1000 Hz, with best hearing from 100-400 Hz (Popper and Tavolga, 1981). *Amiurus nebulosus* hears from 60-10,000 Hz with best hearing at 400-1500 Hz (Poggendorf, 1952).

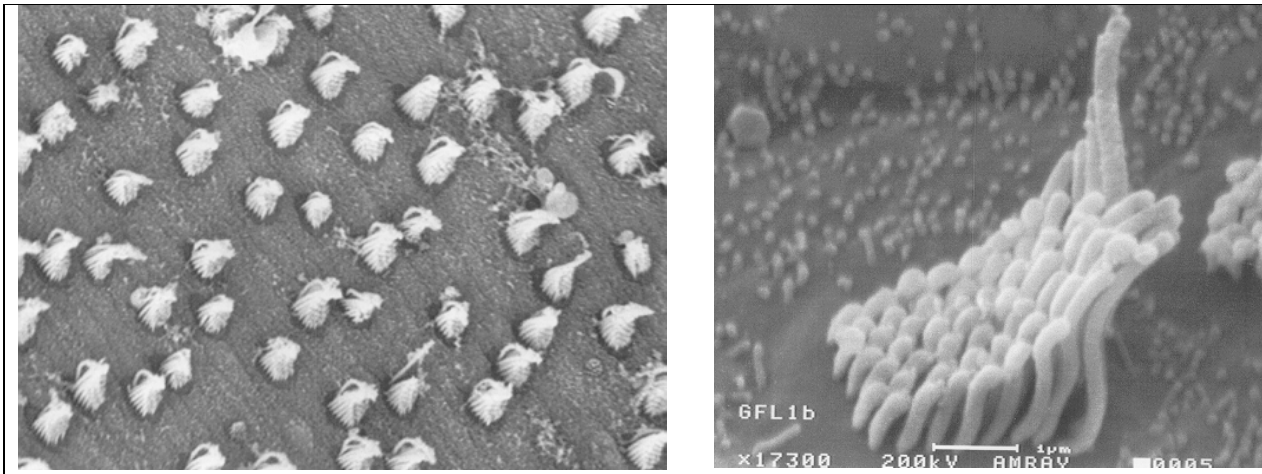


The octavolateralis system of fish includes the inner ear (A) and the lateral line system (B). (A) Drawing of the medial view of the inner ear of a zander (*Stizostedion lucioperca*) on the left and an ide (*Levciscus idus*) on the right (From Popper and Fay, 1973). l *Lagena*, m *utriculus*, o *otolith of each otolithic end organ*, s *sacculus*, si *transverse canal*. (B) Drawing of the canal and surface neuromasts on the body of the mottled sculpin (*Cottus bairdii*). The enlarged drawings show the dorsal surface of neuromasts found on the mandible, trunk, and a superficial neuromast, and stippling represents hair cells. MD *mandibular canal*; SO *supraorbital canal*; IO *infraorbital canal*; PR *preopercular canal*; TR *trunk canal*. (From Coombs, S. et al., *The Mechanosensory Lateral Line: Neurobiology and Evolution*, Springer-Verlag, New York, 1989, 301).

Figure 3.2-1a. Octavolateralis system.

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 one Hz to between 150 and 200 Hz (Coombs et al., 1992), 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). 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 styles 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). The sensory regions of the semicircular canals and otolith organs contain many sensory hair cells as shown in Figure 3.2-1b. In the otolith organs, the ciliary bundles, which project upward from the top surface of the sensory hair cells, contact a 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).



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 enlarged from the general area shown on the left. (Information at bottom of right image shows magnification [17,300x) and other record keeping information. The scale bar is 1 µm.)

Figure 3.2-1b. Electron micrograph of the sensory surface of a fish ear.

Hearing is better understood for bony fish than for other fish, such as 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 posses such capabilities are called “nonspecialists” (or “generalists”). Popper and Fay (1993) suggest that in the hearing specialists, 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 bear on the ear. In nonspecialists, however, the lack of a swim bladder, or its lack of coupling to the ear, probably results in the signal from the swim bladder attenuating before it gets to the ear. As a consequence, these fish detect little or none of the pressure component of the sound (Popper and Fay, 1993).

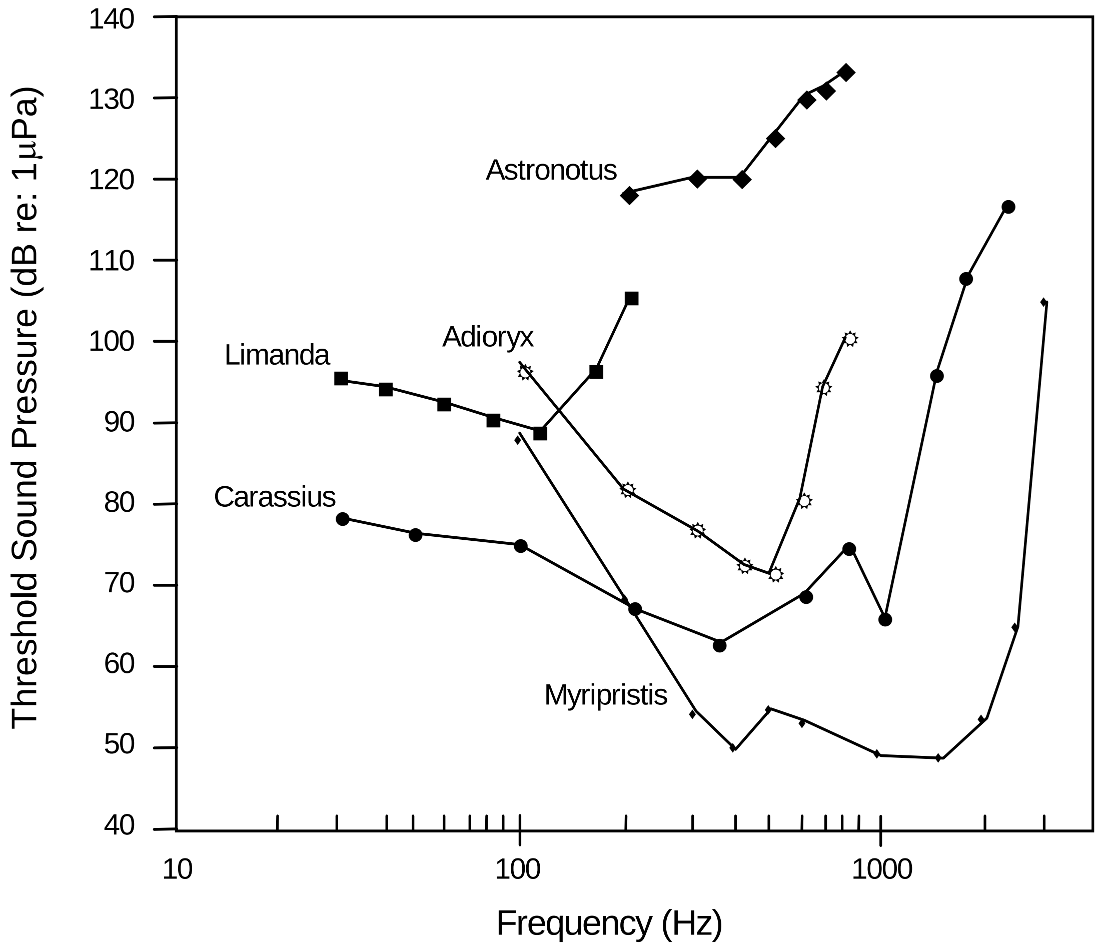
The vast majority of fish studied to date appear to be non-specialists (Schellart and Popper, 1992; Popper et al., 2003), and only a few species known to be hearing specialists inhabit the marine environment (although lack of knowledge of specialists in the marine environment may be due more to lack of data on many marine species, rather than on the lack of there being specialists in this environment). Some of the better known marine hearing specialists are found among the Beryciformes (i.e., soldierfish and especially Holocentridae, which includes the squirrelfish) (Coombs and Popper, 1979), and Clupeiformes (i.e., herring and shad) (Mann et al., 1998, 2001). Even though there are hearing specialists in each of these taxonomic groups, most of these groups also contain numerous species that are nonspecialists. In the family Holocentridae, for example, there is a genus of hearing specialists, *Myripristis*, and a genus of nonspecialists, *Adioryx* (Coombs and Popper, 1979).

Audiograms (measures of hearing sensitivity) have been determined for over 50 fish (mostly fresh water) and four elasmobranch species (Fay, 1988a; Casper et al., 2003). 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 hearing specialists detect sound pressure with greater sensitivity over a wider bandwidth (to 3 kHz or above) than the nonspecialists. Also, the limited behavioral data available suggest that frequency and intensity discrimination performance may not be as acute in nonspecialists (Fay, 1988a).

Behavioral audiograms for both freshwater and marine fish are presented in Figure 3.2-2a for two hearing specialists (goldfish [*Carassius auratus*] and squirrelfish [*Myripristis kuntee*]), two nonspecialists that have a swim bladder (another squirrelfish [*Adioryx xantherythrus*] and an oscar [*Astronotus ocellatus*]), and one nonspecialist without a swim bladder (lemon sole [*Limanda limanda*]). 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, hearing specialists 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 3.2-2b provides data for additional marine species.

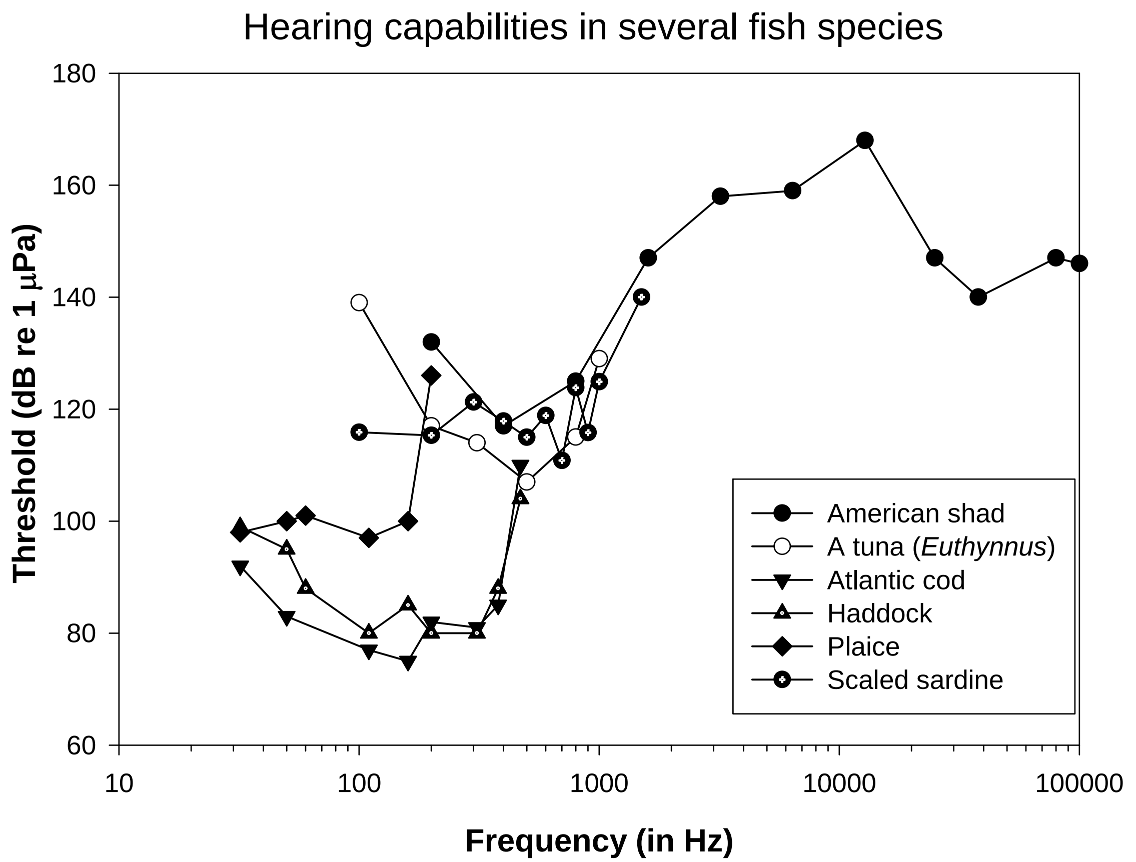
The specialists whose best hearing is below about 1000 Hz appear well adapted to this particular range of frequencies, possibly because of the characteristics of the signals they produce and use for communication, or the dominant frequencies that are found in the general underwater acoustic environment 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 available 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.

As for sound production in fish, Myrberg (1980) 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 and Popper, 1999). 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 bladder drumming muscles are correspondingly specialized for rapid contractions (Zelick et al., 1999). 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 throughout the year often produce sounds regardless of season, particularly during periods of high-level aggression (Myrberg, 1981).



Two hearing specialists: *Carassius auratus* (goldfish)(Fay, 1969) *and Myripristis kuntee* (squirrelfish)(Coombs and Popper, 1979); two hearing nonspecialists having a swimbladder, *Adioryx xantherythrus* (another squirrelfish)(Coombs and Popper, 1979), and *Astronotus ocellatus* (the Oscar)(Yan and Popper, 1992); and a nonspecialist without a swimbladder, *Limanda limanda* (lemon sole)(Chapman and Sand, 1974)

Figure 3.2-2a. Behavioral audiograms for marine and freshwater species.



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); Scaled sardine (*Harengula jaguana*) (Mann et al., 2001)

Figure 3.2-2b. Behavioral audiograms for selected marine species.

3.2.2.3 Sharks

Sharks are also of interest because of their low frequency sound detection ability, a capability that is particularly important for detecting sounds that are produced by potential prey (Nelson and Gruber, 1963; Myrberg et al., 1976; Nelson and Johnson, 1976; Myrberg, 1978). There are hearing data on very few species, and it is not yet clear whether sharks and rays are sensitive to sound pressure or to particle velocity (or displacement), or to both. In general, sharks appear to only detect frequencies that are in a range that is similar to that of fish that are classified as hearing generalists, and hearing sensitivity (the lowest sound levels detectable) is probably poorer than hearing generalist fish (Banner, 1967; Nelson, 1967; Kelly and Nelson, 1975). The function of the lateral line system of sharks is likely, as in fish, to respond to low frequency hydrodynamic stimuli.

Data on shark hearing are very limited and in need of replication and expansion to include more species and more specimens. Some representative data indicate that hammerhead sharks are able to detect sounds below 750 Hz, with best sensitivity from 250 to 275 Hz (Olla, 1962). Kritzler and Wood (1961) reported that the bull shark responded to signals at frequencies between 100 and 1,400 Hz, with the band of greatest sensitivity occurring at 400 to 600 Hz. Lemon sharks responded to sounds varying in frequency from 10 to 640 Hz, with the greatest sensitivity at 40 Hz. However, the lowest frequency may not accurately represent the lower limit of lemon shark hearing due to limitations in the range of frequencies that could be produced in the test tank due to the nature of the tank acoustics. Moreover, lemon sharks may have responded at higher frequencies, but sounds of sufficiently high intensity that 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. The lowest particle motion threshold was at 60 Hz. The most recent study was that of the little skate, *Raja erinacea* (Casper et al., 2003). Results suggest that this species is able to detect sounds from 100 to over 800 Hz, with best hearing up to and possibly slightly greater than 500 Hz. However, these authors, as several others working with elasmobranchs, report thresholds in terms of pressure, whereas it is highly likely that all of these species are detecting particle motion (van den Berg and Schuijf, 1983), and so the thresholds are possibly quite different than those reported since particle motion was not calibrated.

Researchers doing field studies on shark behavior found that several shark species appear to exhibit withdrawal responses to broadband noise (500-4,000 Hz, although it is not clear that sharks heard the higher frequencies in this sound). 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 raised 18 dB at an onset rate of 96 dB/sec 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. Klimley (unpublished data) also noted the increase in tolerance of lemon sharks during successive sound playback tests. 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 of shark 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 25-500 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 with all data collected with sharks is that they are generally obtained from studies of a single animal, and it is well known that sound detection ability (both sensitivity and hearing bandwidth) varies considerably among different species, and even among members of the same species. Moreover, it is known that hearing ability changes with age, health, and many other variables. Thus, while the thresholds reported for sharks give an indication of the sounds they detect, it would be of great value to replicate these analyses using modern methods and several animals. A similar observation may be made for some fish studies, but generally those are done with several animals and are replicated far more than is possible with the larger and more difficult-to-handle sharks. But it is important to note that in virtually all fish studies there is some variation in hearing sensitivity among fish, reflecting the normal variation found in hearing in all vertebrates.

3.2.2.4 Threatened and Endangered Fish Stocks

The following fish species have been listed by NMFS as threatened (T) or endangered (E) under ESA:

Threatened and Endangered Fish Stocks

- Coho salmon (*Oncorhynchus kisutch*) (T): central California coast, northern California/southern Oregon, and Oregon Coast;
- Chinook salmon (*Oncorhynchus tshawytscha*) (E): North Pacific Ocean basin;
- Sockeye salmon (*Oncorhynchus nerka*) (E): North Pacific Ocean basin;
- Cutthroat trout (Umpqua River)(*Oncorhynchus clarki clarki*) (E): U.S. and Canadian coastal zone from southeast Alaska to northern California (within 18.5 km [10 nm] of coast);
- Steelhead trout (*Oncorhynchus mykiss*) (T): Washington, Oregon, and North California coastal and inland waters;
- Shortnose sturgeon (*Acipenser brevirostrum*) (E): U.S. and Canadian North Atlantic Ocean coast;
- Gulf sturgeon (*Acipenser oxyrinchus desotoi*) (T): U.S. Gulf of Mexico coasts from Mississippi River to Tampa Bay; and
- Totoaba (*Cynoscion macdonaldi*) (E): Gulf of California.

As noted above, fish species are listed as endangered, threatened or protected in fresh water, estuarine or near-shore waters habitats, where SURTASS LFA sonar would not operate.

3.2.3 Sea Turtles

3.2.3.1 Background

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 the oceans. All sea turtles have a protected status (with respect to the U.S. Endangered Species Act [ESA] and the Convention on International Trade in Endangered Species [CITES]). Other attributes of the sea turtle species selected for study are summarized in Table 3.2-2. Following is a brief summary of each species.

The distribution of most species of sea turtle is limited by water temperature and varies by season. Most sea turtle species are distributed in water temperatures above 18 deg C (64 deg F), but they can survive in waters as cool as 10 deg C (50 deg F). If the water temperature drops below 8 to 10 deg C (46 to50 deg F), cold stunning occurs and turtles lose their ability to swim and dive, and they float to the surface (Spotila et al., 1997). Sea turtle distribution is mostly limited to between 40 deg N and 35 deg S longitude, although during warmer seasons this range is substantially expanded (Davenport, 1997). The exception to this distribution is the leatherback sea turtle, which is found from 71 deg N to 47 deg S longitude, and seems to prefer water temperatures between 14 and 16 deg C (57 and 61 deg F) for foraging, but also spends extended periods in tropical waters for breeding (Marquez, 1990; Plotkin, 1995).

Sea turtles are highly migratory and therefore have a wide geographic range in tropical, sub-tropical, and temperate waters. When they are active, they must swim to the ocean surface to breathe every 5 to 10 minutes (Keinath, 1993), but can remain underwater for 30 to 40 minutes when they are resting. Diving behaviors are discussed in the text of each sea turtle species, as well as in Table 3.2-2 of the FOEIS/EIS. Sea turtles are capable of making repetitive dives in search of food, and migrating turtles usually dive to less than 20 m (65.6 ft) (Luschi et al., 2003).

Hawksbill sea turtle *(Eretmochelys imbricata)*, green sea turtle (*Chelonia mydas*), olive ridley sea turtle (*Lepidochelys olivacea*), and Kemp's ridley sea turtle (*Lepidochelys kempi*) adults are generally coastal species, whereas the young of some or all of these species are believed to be distributed in the open ocean. Upon emerging from their nests, hatchlings rely on the light on the horizon to find the ocean. After entering the water, both magnetic orientation and the oncoming direction of sea swell guide them away from shore (Ernst et al., 1994). Marine turtle species then remain pelagic for many years and may travel through a large range of habitats before returning to coastal environments to reside (excluding the leatherback). Once in coastal waters, juvenile turtles continue to grow and move among developmental environments, migrating to different habitats at different life stages until maturity. Their pattern of movement then becomes more regular, with adult turtles migrating hundreds to thousands of miles between established foraging and breeding areas (Wyneken, 1997; Plotkin, 2003).

Most adult females return to their natal beaches in order to lay eggs. The females come ashore two or more times a season to lay a hundred or more eggs in a deep nest cavity dug with the hind flippers. After filling the nests, the adult females return to the sea and generally remain near the nesting area until they have deposited their last clutch of eggs for the season.

Migratory behavior of adult sea turtles is much better understood than that of hatchlings and juveniles due to the development and use of satellite telemetry. Many females have been tracked after nesting. Some species have been tracked to a neritic environment where they sometimes stay for one to four years. The neritic environment is defined as a shallow water environment or the nearshore marine zone extending from the low-tide level to a depth of 200 m (656 ft). Juvenile sea turtles complete their development in the neritic habitat and adult sea turtles use it for feeding. Migratory routes and currents have been modeled and show that currents are often utilized during migration to increase their speed. However, the comparison between turtle migration routes and modeled data may not be accurate because the models of currents only show the average of the currents over large areas and periods of time. It is possible that the currents also produce feeding grounds (Luschi et al., 2003).

Leatherback turtles (*Dermochelys coriacea*) are listed as critically endangered under the IUCN and as endangered throughout their range under the ESA, and are protected under CITES. The primary threats to their recovery include incidental take by fisheries (particularly longline fisheries), killing of nesting females, and the collection of eggs. An estimate of population size worldwide has come from estimates of breeding females. Plotkin (1995) estimated 115,000 adult females worldwide in 1982. However, due to recent declines, it is estimated that only 20,000 to 30,000 female leatherback turtles exist (Plotkin, 1995). Leatherbacks are declining in all Pacific basin rookeries (NMFS and USFWS, 1998a). It is also considered by most authorities to be the most endangered of the sea turtles due to the rapid decline in global population during the last 15 years (Ferraroli et al., 2004). Recent data indicate that there may be important migratory corridors and habitats used by the species in the Pacific Ocean (Morreale et al., 1996; Eckert, 1999).

They are the largest, most pelagic, and most widely distributed of any sea turtle, found between 71 deg N and 47 deg S latitude (Plotkin, 1995). In the North Atlantic, leatherback sea turtles range from Cape Sable, Nova Scotia south to Puerto Rico and the U.S. Virgin Islands. They are also found throughout the Pacific Ocean.

As stated previously, information indicates that leatherbacks inhabit regions with water temperatures between 14 and 16 deg C (57 and 61 deg F) for foraging, though they exhibit extraordinary thermal tolerance and are often observed in much colder water. They feed primarily on cnidarians, and tunicates, mostly in deeper waters, but have also been observed at the surface (Plotkin, 1995). They are deep, nearly continuous divers (Eckert et al., 1996). The deepest dive recorded was to 1,230 m (4,035 ft), but they usually dive to depths around 250 m (820 ft) (Hays et al., 2004). They rarely stop swimming and individuals have been documented to swim greater than 13,000 km (7,015 nm) per year (Eckert, 1998; Eckert, 1999).

Nesting grounds are found circumglobally between 40 deg N and 35 deg S latitude. The beaches of French Guiana and Suriname (5 deg N, 54 deg W) are the last large nesting sites in the Atlantic for leatherback turtles (Ferraroli et al., 2004). In the Atlantic, leatherback turtles have smaller nesting grounds in the U.S. Caribbean on St. Thomas, St. Croix, and St. John islands. In Puerto Rico, nesting grounds occur at Islas Culebra, Vieques, and Mona. Playas Rasaca and Brava on Isla Culebra and Sandy Point on St. Croix support the largest nesting colonies in the United States and its territories. Sandy Point Beach is designated as critical habitat under the ESA. There are no leatherback turtle nesting grounds under U.S. jurisdiction in the Pacific Ocean.

The Pacific coast of Mexico, particularly Michoacan, Guerrero, and Oaxaca, were once the largest nesting grounds of the Pacific leatherback turtles. Today, however, sea turtles do not nest there regularly. Nesting in the Pacific is widespread in the western Pacific, including China, Indonesia, Southeast Asia, and Australia (NMFS and USFWS, 1998a).

Green turtles (*Chelonia mydas*) are protected under CITES and are listed as endangered under both the IUCN and the ESA throughout their ranges in the eastern Pacific Ocean, the Pacific coast of Mexico, as well as the breeding population in Florida. They are listed as threatened under the ESA throughout the rest of the Pacific and Atlantic oceans. Critical habitat for green turtles has been designated around Culebra Island, Puerto Rico. In the eastern Pacific, green turtles have historically been abundant. However, due to commercial exploitation, the numbers of nesting females has significantly decreased. While exploitation is a major threat to green turtles in the Pacific Ocean, their primary threats in the Atlantic Ocean are from coastal development, incidental take by commercial fisheries, and pollution (NMFS and USFWS, 1991a). Green sea turtles are known to return to their natal beaches for nesting, which has made them an easy target for exploitation (NMFS and USFWS, 1998c).

The eastern Pacific green turtle is sometimes referred to as the “black turtle,” *C. mydas agassizi*. The most recent literature states that there is still a controversy as to whether the black turtle is a subspecies of green turtles or its own species (Pritchard, 1997). Under the ESA, the black turtle is listed as a subspecies under the green sea turtle; therefore, for the purposes of this analysis, the black turtle will be considered as a subspecies of the green turtle.

Green turtles are widespread throughout tropical and subtropical waters above 20º C (51.8º F). Green sea turtles are commonly found between 15 deg N and 5 deg S latitude along the 90 deg W longitude line, between the Galapagos Islands and the Central American coast. They are the second-most sighted turtle during tuna fishing cruises. They have been reported as being as far north as British Columbia (48.15 deg N) (NMFS and USFWS, 1998b). The black sea turtle ranges from Baja California south to Peru and west to the Galapagos Inlands (Pritchard, 1997). Their regular migration patterns, however, are unknown (NMFS and USFWS, 1998b). They are primarily coastal as juveniles and adults, but make long pelagic migrations between foraging and breeding areas (Bjorndal, 1997; Pritchard, 1997).

Adult turtles are mainly herbivorous, eating algae and sea grasses. They are also known to eat mollusks, polychaetes, jellyfish, amphipods, sardines, and anchovies. They regularly dive to 20 m (65.6 ft) (NMFS and USFWS, 1998b).

Green turtle nesting grounds are found in the Pacific and Atlantic oceans. In the Mediterranean Sea, nesting grounds were studied from 1979 to 2000 to assess the state of sea turtles along the coastline of Turkey (Canbolat, 2003). This study found that the Turkish coastline and Cyprus are the most important nesting areas for green sea turtles in the Mediterranean, particularly the beaches of Kazani and Akyatan. An estimated 115 to 580 female green sea turtles nest in the Mediterranean annually (Canbolat, 2003). In the United States, large numbers of nests are found on the east coast of Florida, and small numbers of nests are found throughout the U.S. Virgin Islands and Puerto Rico. The main nesting site in the eastern Pacific Ocean is located in Michoacán, Mexico, which supports approximately a third of the east Pacific green sea turtle population. Other nesting sites include Guerrero, Jalisco, Oaxaca, Chiapas, and the islands of Clarion and Socorro in Mexico and along the Central American Pacific coastline (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998b).

Loggerhead turtles (*Caretta caretta*) are listed as endangered under the IUCN, threatened under the ESA, and are protected under CITES. The primary threat to loggerhead populations is incidental capture by commercial trawlers and longline fishing nets. Coastal development is also a serious threat to their nesting (NMFS and USFWS, 1991b).

Loggerhead turtles are large, found in temperate, tropical, and subtropical waters, coastal and pelagic habitats, and in both the northern and the southern hemispheres. They are found in the Atlantic, Pacific, and Indian oceans (NMFS and USFWS, 1998d). Juvenile loggerhead sea turtles are known to forage in the Chesapeake Bay, entering in the spring and leaving in the fall, migrating south towards Cape Hatteras. Their migration may be temperature-influenced; loggerhead turtles generally occur in waters of 13.3 to 28 deg C (55 to 82 deg F) (Coles and Musick, 2000). In the spring, summer, and fall months, juvenile loggerheads are commonly found in coastal inlets, sounds, estuaries, bays, and lagoons along the eastern United States (Bolten and Witherington, 2003). Loggerhead turtles both reside and nest in subtropical to temperate areas (e.g., North Carolina to Florida, Oman, Northeastern Australia, Japan). Some stocks have long cross-basin migrations between feeding and nesting areas.

In the Pacific Ocean, loggerhead habitats include ocean and island areas around Polynesia, Micronesia, Melanesia, Indonesia, the Philippines, Australia, China, Japan, Mexico, and the United States (NMFS and USFWS, 1998d).

Loggerhead turtles feed primarily on benthic invertebrates such as gastropods, mollusks, as well as decapod crustaceans (NMFS and USFWS, 1991b; Ernst et al., 1994; Bjorndal, 1997). According to Bolten (2003), oceanic loggerheads spend 75 percent of their time in the top 5 m (16.4 ft) of the water column and 80 percent of their dives are within 2 to 5 m (6.6 to 16.4 ft). The maximum depth recorded during a dive was 233 m (764 ft) Oceanic turtles studied in the Azores swam at speeds of 0.2 m/s (0.7 ft/s) (Bolten, 2003).

Their largest known nesting beaches are in Masirah, Oman and on the Kuria Muria Islands, Oman in the Arabian Sea. More recent reports show that loggerheads are also nesting, however in smaller numbers, in the Caribbean (NMFS and USFWS, 1991b). Atlantic loggerhead sea turtles primarily nest in Florida, but nest in smaller numbers in South Carolina, Georgia, and North Carolina (NMFS and USFWS, 1991b). More nests are laid on Bald Head Island in North Carolina than anywhere else in the state and are therefore critically important to the stability of the northern rookery (Webster and Cook, 2001). In the Pacific, loggerhead sea turtles nest in warm temperate and subtropical regions, primarily in Japan and Australia (NMFS and USFWS, 1998d).

The migration of all sea turtles is poorly understood, including the migration of loggerhead turtles. However, loggerhead sea turtles have been documented as traveling from eastern Florida towards the East Atlantic using the Eastern Florida Current and the Gulf Stream. Loggerheads in Japan are also known to migrate across the Pacific to California, carried by the California Current (Luschi et al., 2003). Hatchlings undertake long developmental migrations. For example, turtles hatched in Japan cross the Pacific to spend some years living off the U.S. and Mexican coasts. Hatchlings on the eastern coast of the U.S. cross the Atlantic before they return to the coastal waters near where they were hatched (Wyneken, 1997).

Hawksbill turtles *(Eretmochelys imbricata)* are listed as critically endangered under the IUCN, endangered throughout their range under the ESA, and are protected by CITES. Their numbers have declined significantly due to commercial harvesting, which uses hawksbill turtles for their shells, meat, and eggs (NMFS and USFWS, 1993).

They occur in tropical and subtropical waters in the Atlantic, Pacific, and Indian oceans, generally between 30 deg N and 30 deg S longitude (NMFS and USFWS, 1998e). They are commonly found along the Gulf states, Florida and Texas in particular. Sightings north of Florida are rare; however, sightings have been made as far north as Massachusetts. Primarily near-shore reef dwellers, hawksbill turtles feed on benthic sponges, which make them highly susceptible to deteriorating coral conditions (Witzell, 1983). Hawksbill turtles are known to dive to depths of 7 to 10 m (23 to 32.8 ft) (NMFS and USFWS, 1998e).

Some adults make long migrations between feeding and nesting areas, but juveniles are relatively sedentary on shallow reefs (Bjorndal, 1997). The most important nesting beaches in the Atlantic Ocean under U.S. jurisdiction include Mona Island in Puerto Rico, Buck Island in St. Croix, and the U.S. Virgin Islands (NMFS and USFWS, 1993). Mona Island has been designated as critical habitat under ESA. Hawksbills were once common in the nearshore waters from Mexico to Ecuador but are now rare or nonexistent in these areas. They have been reported in the island groups of Oceania and nest in the islands and mainland of southeast Asia, particularly China and Japan, through the Philippines, Malaysia, and Indonesia, to Papua New Guinea, Solomon Islands, and Australia. Their largest nesting grounds occur in the Torres Strait and the Republic of the Seychelles (NMFS and USFWS, 1998e).

Olive ridley turtles (*Lepidochelys olivacea*) are the most abundant sea turtle worldwide. The global population is protected by CITES, classified as endangered under the IUCN, and listed as threatened under the ESA everywhere except the Mexican breeding stocks, which are listed as endangered. The Mexican population is severely depleted due to over-harvesting in Mexico; however, the population may be stabilizing. The main threats to olive ridley sea turtles are incidental takes by fisheries, boat collisions, and the harvesting of eggs and turtles in Central America. Harvested turtles are mostly sold for leather, bait, bone meal, and fertilizer, but also for meat (NMFS and USFWS, 1998f).

Olive ridley turtles are found throughout the tropics and warm temperate oceans, but are concentrated around several very limited nesting beaches in Costa Rica, Mexico, and India (Musick and Limpus, 1997). It is believed that many olive ridley turtles migrate seasonally south for feeding and north for breeding and nesting. Olive ridley turtles are omnivorous, feeding on benthic organisms such as bottom fish, crab, oysters, sea urchins, snails, tunicates, shrimp, and algae and pelagic species such as jellyfish medusae, red crabs, and salps. Olive ridley turtles are recorded diving to a maximum depth of 290 m (951 ft) (NMFS and USFWS, 1998f).

Olive ridley turtles prefer to nest around continental margins, with the largest nesting aggregation in the Indian Ocean along the northeast coast of India. The Pacific coast of Mexico and Central America, between Baja California and Peru, and particularly around Costa Rica, are the second most important nesting grounds. Most mating occurs near the nesting beaches, but copulating pairs have been seen at distances over 1,000 km (540 nm) from the nearest nesting beach. They are thought to nest throughout the year in the Eastern Tropical Pacific Ocean, with peak nesting months from September through December (NMFS and USFWS, 1998f).

Kemp's ridley turtles (*Lepidochelys kempi*) are the rarest sea turtles worldwide and have the most restricted distribution. They are classified as critically endangered under the IUCN, as endangered throughout their range under the ESA, and are protected by CITES. The biggest threats to Kemp's ridley sea turtles have been the harvest of eggs and incidental take by the trawling industry, particularly from shrimp trawlers (NMFS and USFWS, 1992).

Kemp's ridley turtles are found primarily in the Gulf of Mexico and, to a lesser extent, along the Atlantic coast of the United States as far north as Long Island, New York (Musick and Limpus, 1997).

Juvenile Kemp's ridley sea turtles are known to forage in the Chesapeake Bay, entering in the spring and leaving in the fall, migrating south toward Cape Hatteras. Their migration may be temperature-influenced, generally occurring in waters greater than 11 deg C (58 deg F) (Coles and Musick, 2000). Juvenile and subadult sea turtles are found along the eastern coast of the United States and the Gulf of Mexico, traveling north with seasonal warming to feed in waters from Georgia up to New England and then migrating south again in the winter. They feed on benthic animals, primarily portunid crabs (Bjorndal, 1997). Kemp's ridley turtles are known to dive to depths of 50 m (164 ft) (NMFS and USFWS, 1992).

Kemp's ridley turtles exhibit mass nesting behavior where 100 to 10,000 or more females emerge from the water to nest at one time, primarily at Rancho Nuevo, Mexico in the Gulf of Mexico (only rarely has significant nesting been observed at any other beaches). There are consistent reports of large concentrations of mating adults at sea, suggesting breeding aggregations well offshore (NRC, 1990).

3.2.3.2 Sea Turtle Hearing Capabilities and Sound Production

Data on sea turtle sound production and hearing are few. There is little known about the mechanism of sound detection by turtles, including the pathway by which sound gets to the inner ear and the structure and function of the inner ear of sea turtles (Bartol and Musick, 2003). However, assumptions have been made based on research on other species of turtles. Based on the structure of the inner ear, there is some evidence to suggest that marine turtles primarily hear sounds in the low frequency range and this hypothesis is supported by the limited amount of physiological data on turtle hearing. Bartol and Musick (2003) said that the amount of pressure needed to travel through the bone channel of the ear increases with an increase in frequency. For this reason, it is believed that turtles are insensitive to high frequencies and that they primarily hear in a low frequency range. A description of the ear and hearing mechanisms can be found in Bartol and Musick (2003). The few studies completed on the auditory capabilities of sea turtles also 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).

Underwater sound was recorded 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-September timeframe. During this time period, RLs at the data collection hydrophone system in the 200-700 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, their coastal habitats are flooded with underwater noise. The sea turtles are undoubtedly exposed to high levels of noise, most of which is anthropogenic. Results suggest that continued exposure to existing high levels of pervasive anthropogenic noise in vital sea turtle habitats and any increase in noise could affect sea turtle behavior and ecology (Samuel et al., 2005). However, there were no data collected on any behavioral changes in the sea turtles due to anthropogenic noise or otherwise during this study.

Ridgway et al. (1969) used airborne and direct mechanical stimulation to measure the cochlear response in three juvenile green sea turtles. The study concluded that the maximum sensitivity for one animal was 300 Hz, and for another 400 Hz. At the 400 Hz frequency, the turtle's hearing threshold was about 64 dB in air (re: 20 µPa). At 70 Hz, it was about 70 dB (re: 20 µPa) in air. 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.

Bartol et al. (1999) measured the hearing of juvenile loggerhead sea turtles using auditory evoked potentials to LF tone bursts and found the range of hearing via Auditory Brainstem Response[3] (ABR) recordings from LF tone bursts indicated the range of hearing to be from at least 250 to 750 Hz. The lowest frequency tested was 250 Hz and the highest was 1000 Hz.

More recently, Streeter and colleagues (pers. comm., 2005) were able to train a female green sea turtle to respond to acoustic signals. The results from this study showed a hearing range of at least 100 to 500 Hz (the maximum frequency that could be used in the study, as opposed to what

[3] ABR is a method in which recordings are made, non-invasively, of the brain response while the animal is presented with a sound. This is a method that is widely used to rapidly assess hearing in new-born humans, and which is being used more and more in studies of animal hearing, including hearing of marine mammals. The advantages of ABR 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 ABR only reflects the signal that is in the 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 ABR. 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 ABR, 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, ABR does give an excellent indication of basic hearing loss, and is an ideal method to quickly determine if there is TTS right after sound exposure when results are compared with those from controls.

may be a wider hearing range) with hearing thresholds of 120-130 dB RL. However, there are several important caveats to these results. First, the study was done in a relatively noisy oceanarium. Thus, the thresholds reported may have been masked by the background noise and the "absolute thresholds" (the lowest detectable signal within a noisy environment) may be several dB lower than the reported results. Second, data are for a single animal who is well into middle age (over 50 years old) and who had lived in an oceanarium all its life. While there are no data on effects of age on sea turtle hearing, data for a variety of mammals (including humans) show there is a substantial decrement in hearing with age, and this may have also happened in this animal. This too may have resulted in thresholds being higher than in younger animals (as used by Ridgway et al., 1969). Finally, the data are for one animal and so nothing is known about variability in hearing, or whether the data for this animal are typical of the species.

Table 3.2-2. Information Summary for Sea Turtles

Species	Protected Status	Distribution	Abundance/ Population	Diving Behavior And Travel Speeds
Leatherback Turtle (*Dermochelys coriacea*)	ESA endangered; CITES protected ; IUCN Critically Endangered	- Tropical and temperate pelagic waters; - Range between 71° N and 47° S - Nest between 40° N and 35° S - May aggregate at concentrations of jellyfish and areas of coastal upwelling; - Most significant nesting areas: Mexico, Costa Rica, Trinidad, Surinam/French Guiana, Indonesia, Culebra, Puerto Rico, and St. Croix U.S. VI - No nesting in the U.S. Pacific; nest mostly in China, Indonesia, Southeast Asia, and Australia -Water temps 14° to 16° C for foraging	- Recent global population estimates for mature female turtles 20,000-30,000; - Gulf of Mex: 5 turtles per 1,000 sq km	- Routinely dive to 250 m ; - Typical durations 9-15 min; - Maximum dive time 37 min.; - Maximum depth 1230 m; - Dive and swim throughout day and night; - Nearly continuous divers - During long movements or migration: 45-65 km per 24 hours; - Average swim speed: 2.21 km/h (0.614 m/s); - Hatchlings: 30 cm/sec below surface

Table 3.2-2. Information Summary for Sea Turtles

Species	Protected Status	Distribution	Abundance/ Population	Diving Behavior And Travel Speeds
Green Turtle (*Chelonia mydas*)	ESA threatened everywhere except FL and Pac. Coast of Mexico where listed as endangered; CITES protected; IUCN Endangered	- Found throughout tropics and subtropics; - Nests on tropical beaches throughout the world; - Commonly found between 15° N and 5° S along the 90° W longitude line, between the Galapagos Islands and the Central American coast -Found in waters <20° C -Seen in waters as far north as British Columbia -Regular migrations unknown -Critical habitat around Culebra Island, Puerto Rico	- An estimated 115 to 580 female green sea turtles nest in the Mediterranean annually; - In the eastern Pacific, green turtles have historically been abundant. However, due to commercial exploitation, the numbers of nesting females has significantly decreased. - Consensus that numbers have been declining since 1950s	- Routinely dive to 20 m; - Average dive time > 40 min.; - Maximum dive time of 66 min - Average swim speed: 0.95 km/ h and have been measured at 1.4-2.2 kph; - Adults migrate between foraging grounds and nesting grounds; migrations cover distances greater than 100 km
Loggerhead Turtle (*Caretta caretta*)	ESA threatened; CITES protected; IUCN Endangered	- Temperate, tropical and subtropical waters of the Atlantic, Pacific, and Indian oceans; - Relatively solitary except when aggregating on food concentrations or near nesting beaches; - About 88% of all nesting occurs on beaches in the S/E U.S., Oman, and Australia -Found in waters 13.3° - 28°C -Found around Poynesia, Micronesia, Melanesia, Indonesia, the Philippines, Australia, China, Japan, Mexico, and the United States	- In the Atlantic, a total of 127 female loggerhead sea turtles were photographed and tagged during the 1991 and 1992 nesting seasons, laying a total of 318 nests; - Estimated 250,000 females worldwide; - Estimated total population over 500,000 worldwide.	- Routinely dive to 2-5 m; - Average dive time 17-30 min.; - Maximum recorded dive is 233 m; - 75% time spent in upper 5 m of water column - Average swim speed: 1.2-1.7 km/ h and have been measured at 0.02 - 3.01 km/h - Turtles in the Azores documented at traveling at speeds of 0.2 m/s

Table 3.2-2. Information Summary for Sea Turtles

Species	Protected Status	Distribution	Abundance/ Population	Diving Behavior And Travel Speeds
Hawksbill Turtle (*Eretmochelys imbricata*)	ESA endangered; CITES protected; IUCN Critically Endangered	- Worldwide tropical and subtropical waters in the Atlantic, Pacific, and Indian oceans; -Found along the Gulf states, Florida and Texas in particular and as far north as Massachusetts - Hatchlings pelagic, but older juveniles and adults live in clear shallow waters over reefs; - Range of 30° N to 30° S -Most important beaches at Mona Island in Puerto Rico, Buck Island in St. Croix, and U.S. Virgin Islands -Reported around island groups of Oceania, China, Japan, Philippines, Malaysia, Indonesia, Papua New Guinea, Solomon Islands, and Australia	Population estimates not available	- Routinely dive to 7-10 m; - Average dive time 56 min.; - Dive during day and night - Average swim speed: 0.74 km/h
Olive Ridley Turtle (*Lepidochelys olivacea*)	ESA threatened (Mexican population endangered); CITES protected; IUCN Endangered	- Worldwide tropical and warm temperate waters; - While large juveniles and adults reside primarily within 100 km of the coast, and aggregate in large concentrations in coastal waters during the nesting season, olive ridleys will often range far out to sea (>100 km) in certain areas of the world (e.g. Eastern Tropical Pacific and Indian Ocean).	Most abundant sea turtle worldwide, though population estimates not available	- Average dive time 29-54 min.; - Maximum recorded dive is 290 m - Average swim speed: 1.2-3.6 km/ h

Table 3.2-2. Information Summary for Sea Turtles				
Species	Protected Status	Distribution	Abundance/ Population	Diving Behavior And Travel Speeds
Kemp's Ridley Turtle (*Lepidochelys kempi*)	ESA endangered; CITES protected; IUCN Critically Endangered	-Primarily in Gulf of Mexico but also along the east coast of the United States -As far north as Long Island, New York -Found in waters >11°C	Most rare sea turtle in the world, though population estimates not available	- Routinely dive to 50 m; - Average dive time 13-18 min.; - Average swim speed: 1.0-1.4 km/ h

3.2.4 Cetaceans

Cetaceans (whales, dolphins, and porpoises in the order Cetacea) are the most aquatically adapted marine mammals found in all the world's seas and oceans. They vary in distribution and abundance in a variety of aquatic habitats, from freshwater to bathypelagic. Cetaceans are ecologically diverse and range in size from approximately one meter (3 ft) to 33 m (108 ft) in length (Ballance, 2002).

The order Cetacea includes over 80 species that are classified under two suborders: baleen whales, or Mysticeti; and toothed whales, dolphins and porpoises, or Odontoceti (Fordyce, 2002). Mysticetes are distinguished by their large body size and specialized feeding method using keratinous baleen plates to strain a large quantity of small food organisms from seawater.

In comparison, odontocetes show greater foraging diversity. Toothed whales are capable of emitting high frequency sound and receiving echoes by the process of echolocation. They have the ability to select individual prey items and use echolocation for foraging and navigation purposes.

Fossil records dating back to the Middle Eocene, show cetaceans existing more than 50 million years ago (Fordyce, 2002). Cetaceans evolved from terrestrial ancestors and formed lineages through a long-term change in structure based on adaptations to the aquatic environment. The evolution of Cetacea was potentially influenced by the physical evolution of the oceans with emphasis on the global distribution and abundance of food resources and geographical changes in habitat.

Cetaceans have evolved to exploit virtually all productive marine, estuarine, and many riverine habitats. Many cetaceans feed upon fish, squid or crustaceans in pelagic waters. Several species undergo seasonal north-south migrations that track peaks in prey availability, but others may reside year-round in areas bounded by tens of kilometers.

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 several hundred years. The reduction in population abundance causes need for concern towards the potential risk of extinction. The ESA, along with CITES and IUCN, designate a protected status generally based on natural or manmade factors affecting the continued existence of species.

Cetaceans are generally long-lived with estimates of longevity ranging from 2 to over 20 decades (George et al., 1999; Chivers, 2002). There are several methods for determining the age of cetaceans. A common method of determining age in mysticetes is by analyzing tissues collected during postmortem examination, examining the growth layers of the horny epithelium which forms on the external surface of the tympanum in the external auditory meatus. However, this method does not work for all cetaceans. Age can also be estimated by counting the oscillations in the stable carbon isotopes in the baleen. However, this method only works for bowhead whales greater than 11 years of age. Another method was developed to determine age by measuring the degree of racemization of aspartic acid, an amino acid in the eye lens and teeth

(George et al., 1999). Age determination is important to ascertain if a cetacean is sexually mature. Age of sexual maturity ranges from a few years in smaller species to more than a decade in some larger species. Female cetaceans give birth to a single calf annually every few years, depending on species. Long maturation intervals and low annual reproductive capacity limit the ability of cetaceans to recover from depressed population levels.

Social systems range from relatively solitary to large social groups. Whales form aggregations for feeding, protection, and for social reasons. The size of the aggregations may correlate with resource availability and predation pressure (Balance, 2002).

Hearing and sound production is highly developed in all cetacean species studied to date. Cetaceans rely heavily on sound and hearing for communication and sensing their environment (Norris, 1969; Watkins and Wartzok 1985; Frankel, 2002). 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 of most cetacean species (Ketten, 1994).

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. The function of sound production is not completely understood, but may be used for communication, navigation and food finding in some species (Ellison et al., 1987; George et al., 1989; Clark, 1994; Tyack and Clark, 1997; Clark and Ellison, 2004).

3.2.4.1 Mysticete Species

The mysticetes, which potentially could be affected by SURTASS LFA sonar, include four families containing 12 species. Of the 12 species, 11 species will be considered for evaluation (see text box below). Mysticetes can be distinguished by their lack of functional teeth and paired blowholes. Baleen whales include the largest animal ever to live on earth, the blue whale, which can reach over 30 m (100 ft) in length and 170 tons (154,221 kg) in weight (Bannister, 2002).

All mysticetes produce low frequency sounds, although no direct measurements of auditory (hearing) thresholds have been made (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. However, it is not known if mysticete low-frequency sounds are used for other functions such as orientation, navigation, or detection of predators and prey.

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 1,000 Hz (Ketten, 2000).

Table 3.2-3 provides species-specific information on the protected status (according to the ESA, CITES, and IUCN), distribution, abundance, diving behavior, hearing and sound production of mysticetes.

Mysticetes	
Family: Balaenopteridae (Rorquals)	**Family: Eschrichtiidae**
Blue whale (*Balaenoptera musculus*)	Gray whale (*Eschrichtius robustus*)
Fin whale (*B. physalus*)	
Sei whale (*B. borealis*)	
Bryde's whale (*B. edeni*)	
Minke whale (*B. acutorostrata*)	
Humpback whale (*Megaptera novaeangliae*)	
Family: Balaenidae (Right whales)	**Family: Neobalaenidae**
North Atlantic right whale (*Eubalaena glacialis*)	Pygmy right whale (*Caperea marginata)*
North Pacific right whale (*E. japonica*)	
Southern right whale (*E. australis*)	

Balaenopteridae (Rorquals)

The family Balaenopteridae contains five whales of the genus *Balaenoptera*: blue whale (*B. musculus)*, fin whale (*B. physalus*), Bryde's whale (*B. edeni*), sei whale (*B. borealis*) and minke whale (*B. acutorostrata*). The humpback whale (*Megaptera novaeangliae*) is also part of Balaenopteridae. Balaenopterids are also known as "rorquals" (Bannister, 2002).

The **blue whale (*Balaenoptera musculus*)** is currently 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 about 11,200-13,000 individuals (Maser et al., 1981; U.S. DOC, 1983). The most recent regional stock assessments estimate approximately 1,500 animals in the eastern North Pacific (Carretta et al., 2005) and 300 animals in the western North Atlantic (Waring et al., 2002).

Blue whales occur in all oceans of the world. They are primarily pelagic but are often found along continental shelf breaks during feeding (Yochem and Leatherwood, 1985; Sigurjonsson, 1995). Traditionally, it was assumed that distribution and movement patterns consisted of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving (Mackintosh, 1965; Lockyer, 1984). However, data from the Pacific indicate that some summer feeding takes place at low latitudes in "upwelling-modified" waters and that some whales remain year-round in low latitudes (Yochem and Leatherwood, 1985; Reilly and Thayer, 1990; Clark and Charif, 1998). No specific breeding areas are known for this species.

NMFS reported on one blue whale population that feeds in California waters from June through November and migrates south to waters off Mexico and as far south as the Costa Rica Done (10 deg N) in the winter and spring. The best estimate of abundance for this blue whale population is 1,744 individuals. The minimum population estimate is 1,384 (NMFS, 2005a).

Similar to the report from NMFS, Calambokidis and Barlow (2004) report that blue whales feed off of California from May through November and migrate to waters off Mexico as far as 6 deg

N at the Costa Rica Dome in the winter and spring. Blue whales can be found year-round at the Costa Rica Dome and in the Eastern Tropical Pacific. However, it is unknown if there are any non-migratory population segments of the blue whales at the Costa Rica Dome. The estimated summer abundances using the capture-recapture method for the California, Oregon, and Washington study area were highly variable, ranging from 525 to 1,244 individuals. However, these estimates seem low compared to abundance estimates from past years. Estimates based on pooled three-year periods with one sample from systematic surveys that covered both coastal and offshore waters showed more realistic abundance estimates ranging from 1,167 to 2,357 individuals. The estimated summer abundance using the line-transect method for the California, Oregon, and Washington study area is 3,000 individuals (Calambokidis and Barlow, 2004).

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/h (2.4 knots) (with a maximum speed of 7.2 km/h (3.9 knots) (Mate et al., 1999). Dive times range from 4 to 15 min (Laurie, 1933; Croll et al., 2001b). Dive depths average 140 m (460 ft). Blue whales typically make 5 to 20 shallow dives at 12 to 20-second intervals followed by a deep dive of 3 to 30 min (Yochem and Leatherwood, 1985; Croll et al., 1999). The dive depth of foraging blue whales averages 67.6 m (222 ft) (Croll et al., 2001b). Blue whales foraging off California were found to have a mean dive duration ranging from 4 to near 10 min (Strong, 1990). Blue whales feed almost exclusively on euphausiids, or krill (Fiedler et al., 1998; Sears, 2002).

There is no direct measurement of auditory threshold for the hearing sensitivity of blue whales (Ketten, 2000; Thewissen, 2002). In one of the only studies to date, no change in blue whale vocalization pattern or movement relative to an LFA sound source was observed for RLs of 70 to 85 dB (Aburto et al., 1997).

Blue whales produce a variety of LF sounds in a 10 to 200 Hz band (Edds, 1982; Thompson and Friedl, 1982; Alling and Payne, 1991; Clark and Fristrup, 1997; Rivers, 1997; Stafford et al., 1998, 1999a, 1999b, 2001; Frankel, 2002). These low frequency calls may be used as communicative signals, as it is difficult to determine actual demonstrations of communication in the strict sense of the term (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 signals are very long, patterned sequences of tonal infrasonic sounds in the 15 to 20 Hz range. The seasonality and structure of the sounds suggest that these are male song displays for attracting females and/or competing with other males.

Blue whales produce long, patterned hierarchically organized sequences of sounds (song). These occur throughout most of the year with peak period of singing overlapping with the general period of functional breeding. Blue whales also produce a variety of transient sound (that is, 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), which 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).

Croll et al. (2001a) studied the effects of anthropogenic low-frequency noise on the foraging ecology of blue and fin whales off San Nicolas Island, California. Blue and fin whales produce long, intense patterned sequences of signals in the band of 10 to 100 Hz. These signals have been recorded over ranges of hundreds of miles. This study examined the response of blue and fin whales to human-produced low-frequency sounds at RLs greater than 120 dB produced by SURTASS LFA sonar. The blue and fin whale sightings did not appear to be randomly distributed and did not appear to be related to the sound source. No clear trends appeared in vocalization rates. There was no significant change in vocal activity in the study area or obvious responses of blue or fin whales in the presence of low frequency sound. It is possible that the brief interruption of normal behavior or short-term physiological responses to LF noise at RLs of approximately 140 dB have few implications on survival and reproductive success. Long-term effects, however, could have more significant effects, but these effects are harder to identify and quantify (Croll et al., 2001a).

The call characteristics of blue whales vary geographically and seasonally (Stafford et al., 2001). In temperate waters, intense bouts of long, patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. The blue whale is one of the loudest baleen whales with estimated SLs as high as 180 to 190 dB (Cummings and Thompson, 1971; Aroyan et al., 2000).

The **fin whale** (***Balaenoptera physalus***) is listed endangered under the ESA, depleted under the MMPA, protected under CITES, and classified as endangered by the IUCN. The global population estimate is about 100,000-150,000 (Maser et al., 1981; DOC, 1983). Recent regional stock assessments report approximately 2,500 animals in the eastern North Pacific and 2,800 animals in the western North Atlantic (Waring et al., 2004; Carretta et al., 2005).

Fin whales are widely distributed and found in all oceans of the world. They are primarily found in temperate and cold waters with animal densities slightly higher on the outside of the continental slope than inside. Like blue whales, it is assumed that distribution and movement patterns consist of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving (Mackintosh, 1965; Lockyer, 1984). Panigada (1999) studied fin whale distribution in the Ligurian Sea. The study primarily covered the continental shelf and the offshore waters of the Western Ligurian Sea which maintains low surface temperatures and enhances strong up-welling currents. Whales were found to aggregate in small groups. The whales appeared to be evenly distributed in the study area to exploit food resources (Panigada, 1999). Specific breeding areas are unknown and mating is assumed to occur in pelagic waters, presumably some time during the winter when whales are in mid-latitudes. Foraging grounds tend to be near coastal upwelling areas and recent data indicate that some whales remain year-round at high latitudes (Clark and Charif, 1998).

Swimming speeds average between 1 to 16 km/h (Watkins, 1981). Fin whales have a mean dive time of 4.2±1.67 min at depths averaging 60 m (197 ft) (Panigada, 1999; Croll et al., 2001a). Maximum dive depths have been recorded deeper than 360 m (1,181 ft) (Charif et al., 2002). Similar to blue whales, fin whales typically make 5-20 shallow dives at 13-20 second intervals, followed by a deep dive of 1.5-15 min (Strong, 1990; Croll et al., 1999). Fin whales forage at dive depths close to 100 m (328 ft) deep. Foraging dive times range from 5 to 8 min and fin whales feed primarily upon planktonic crustaceans (particularly euphausiids), fish and squid (Gambell, 1985a; Aguilar, 2002).

There is no direct measurement of auditory threshold for the hearing sensitivity of fin whales (Ketten, 2000; Thewissen, 2002).

Fin whales produce a variety of LF sounds in the 10 to 200 Hz band (Watkins, 1981; Watkins et al., 1987; Edds, 1988; Thompson et al., 1992). Short sequences of rapid FM calls in the 20-70 Hz band are associated with animals in social groups (Watkins, 1981; Edds, 1988; McDonald et al., 1995). The most typical signals are long, patterned sequences of low and infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton, 1964; Watkins et al., 1987; Clark et al., 2002). This sound is referred to as a "20-Hz pulse." The seasonality of the pattern of bouts suggests that these are male reproductive displays or displays associated with food resources (Watkins et al., 1987; Clark et al., 2002; Croll et al., 2002) while the individual counter-calling sounds suggest that the more variable calls are contact calls (McDonald et al., 1995).

Croll et al. (2001a) studied the effects of anthropogenic low-frequency noise on the foraging ecology of blue and fin whales off San Nicolas Island, California. This study is described above in the blue whale section.

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 very 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 fins also produce higher frequency down sweeps ranging from 100 to 30 Hz (Frankel, 2002). Estimated SLs are as high as 180 to 190 dB (Patterson and Hamilton, 1964; Watkins et al., 1987; Thompson et al., 1992; McDonald et al., 1995; Charif et al., 2002; Croll et al., 2002).

The sei whale (*Balaenoptera borealis*) is currently endangered under the ESA, depleted under the MMPA, protected under CITES, and classified as endangered by the IUCN. Allen (1980) estimated the abundance of sei whales as 14,000 for the North Pacific and 37,000 for the Southern Hemisphere populations. The status of the North Atlantic population is estimated at near 10,000 in the central and northeastern Atlantic Ocean (Horwood, 2002).

Sei whales are primarily found in temperate zones of all oceans. As with other members of the family *Balaenopteridae*, they are assumed to migrate to the subpolar higher latitudes where they feed during the late spring through early fall and then migrate to lower latitudes where they breed and calve during the fall through winter (Mackintosh, 1965; Lockyer, 1984). 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 California to the Gulf of Alaska in the east and from Japan to the Bering Sea in the west. Specific breeding grounds are not known for this species.

Swim speeds have been recorded at 4.6 km/h (2.5 knots). Dive times range from 0.75 min 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, 1985b). They feed predominantly on copepods in the higher latitudes and schooling fish in the lower latitudes (Jonsgård and Darling, 1977; Rice, 1977; Nemoto and Kawamura, 1977; Kawamura, 1994; Sigurjonsson, 1995).

There is no direct measurement of auditory threshold for the hearing sensitivity of sei whales (Ketten, 2000; Thewisson, 2002).

Few sounds have been recorded from sei whales. Knowlton et al. (1991) and Thompson et al. (1979) recorded rapid sequences of FM pulses in the 1.5 to 3.0 kHz range near groups of feeding sei whales during the summer off eastern Canada. Seasonal and geographical differences and sound level range have not been identified for sei whales.

The **Bryde's whale (*Balaenoptera edeni*)** is currently protected under CITES and classified as a data deficient species by the IUCN. In the western North Pacific, abundance estimates are approximately 24,000 (IWC, 1997). Estimates for Bryde's whales occurring in eastern tropical Pacific waters are 13,000 (Wade and Gerrodette, 1993). Fifty six whales were sighted in the northern Gulf of Mexico in 2003 (Waring et al., 2004). Population estimates for most other regions are not available.

Bryde's whales are found in low densities throughout the tropical and subtropical waters of the world (Omura, 1959; Kato, 2002). They are most commonly encountered in waters between 40 deg N and 40 deg S latitude, with average water temperatures of 16.3 deg C (61.3 deg F) (Kato, 2002). 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 have also been known to breed off South Africa (Best, 1960; 1975). Foraging grounds are not well known for this species.

The swim speed of a Bryde's whale has been recorded at 20 km/h (10.8 knots) (Cummings, 1985), and they dive for as long as 20 min, although dive depths are not known. Bryde's whales feed primarily on euphausiids, copepods, and schooling fish such as sardines, herring, pilchard, and mackerel (Best, 1960; Nemoto and Kawamura, 1977; Cummings, 1985; Tershy, 1992; Tershy et al., 1993).

There is no direct measurement of auditory threshold for the hearing sensitivity of Bryde's whales.

Bryde's whales are known to produce a variety of LF sounds in the 20 to 900 Hz band (Cummings, 1985; Edds et al., 1993; Olson et al., 2003), and animals off California produce moaning sounds concentrated at 124 to 250 Hz. A pulsed moan has also been recorded in frequencies ranging from 100 to 900 Hz. Olson 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 700-900 Hz (Edds et al., 1993). The function of these sounds is unknown, but is assumed to be used for communication. SLs range between 152 to 174 dB (Frankel, 2002).

The **minke whale (*Balaenoptera acutorostrata*)** is protected under CITES and classified as IUCN lower risk/near threatened species. Populations are estimated at 200,000 in the Southern Hemisphere. Minke whale population estimates range from 60,500 to 186,000 (best estimate 113,000) in the North Atlantic and 17,000 to 28,000 in the North Pacific. Regional stock assessments report approximately 4,000 animals off the Canadian east coast and 1,015 animals of the coasts of California, Oregon, and Washington (Waring et al., 2004; Carretta et al., 2005). NMFS (2003) estimates that there are 1,015 minke whales (based off of surveys from 1996 through 2001) off the coasts of California, Oregon, and Washington, with a minimum estimate of 585 (NMFS, 2003).

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 deg longitude, and the third is referred to as the "remainder" stock. 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 shelves, 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. Minke whales occur year-round off California and in the Gulf of California. They are also present in the summer and fall along the Baja California peninsula (NMFS, 2003).

Minke whales are difficult to sight, as they produce small blows that are not easily observed. They are typically pelagic and encountered in small groups, but are found throughout all oceans of the world, particularly in the North Atlantic (Stewart and Leatherwood, 1985). As with other balaenopterids, minke whales migrate to higher latitudes where they feed during the late spring through early fall and to lower latitudes where they breed during the fall through winter. Breeding appears to take place during the winter in warmer waters, but the exact breeding locations are poorly known (Kasamatsu et al., 1995; Perrin and Brownell, 2002).

Normal swimming speeds have been reported as 6.1 km/h (3.3 knots) (Lockyer, 1981). Dive times range from 1.5 to 7 min (Stewart and Leatherwood, 1985), but dive depths are not well known. Minke whales generally feed on small schooling fish, euphausiids, and copepods. They specialize their diet both seasonally and geographically based on prey availability (Stewart and Leatherwood, 1985).

There is no direct measurement of auditory threshold for the hearing sensitivity of Bryde's whales (Ketten, 2000; Thewisson, 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, 2002). 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 200 Hz band (Winn and Perkins, 1976). Complex vocalizations recorded from Australian minke whales involved pulses ranging between 50 and 9,400 Hz, followed by pulsed tones at 1,800 Hz and tonal calls shifting between 80 and 140 Hz (Gedamke et al., 2001)

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-second 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 seconds. Similar sounds with a frequency range from 396 to 42 Hz have been recorded in the St. Lawrence Estuary (Edds-Walton, 2000 *in* Gedamke et al., 2001).

Short, mid-frequency clicks with energy between 3 and 12 kHz for 1 to 20 ms were recorded in the presence of one animal south of Newfoundland (Beamish and Mitchell, 1973 *in* Gedamke et al., 2001); however, these sound may have been produced by an unseen species (Gedamke et al., 2001).

Gedamke et al. (2001) described vocalizations of the dwarf minke whale in the winter months just north of the Great Barrier Reef in Australia, where they are generally found from May to September. Gedamke et al. (2001) reports the dwarf minke whale making a complex and stereotyped sound sequence which is referred to as the “star wars” vocalization. The measurements of transmission loss produced an empirical equation of 18 log (R). The broadband (100 Hz to 10 kHz) RLs of three units of the sequence reached 145 dB. SLs of between 150 and 165 dB were calculated.

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).

The **humpback whale (*Megaptera novaeangliae*)** is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and classified as vulnerable by the IUCN. Population estimates for the North Pacific stocks are 1,300 in the eastern North Pacific and 4,000 in the central North Pacific (Carretta et al., 2002; Carretta et al., 2005). Estimates for the Southern Hemisphere population south of 30 deg S are on the order of 13,000 to 15,000 (Butterworth et al., 1993). The best estimate for the North Atlantic population is 10,600 (Smith et al., 1999).

Humpback whales are distributed throughout the world’s oceans. Primarily a coastal species in which most populations travel over deep pelagic waters during migrations, humpback whales typically feed at higher latitudes and breed at lower latitudes. Almost all feeding occurs during the late spring through early fall in mid-to-high-latitude areas in shallow coastal waters or near the edge of a continental shelf. Calving takes place in shallow waters in isolated tropical areas from late fall through late winter. Breeding is assumed to take place in or near these calving areas during the same period. 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).

Calambokidis and Barlow (2004) reported on the abundance of humpback whales in the eastern North Pacific. Humpback whales that feed off of California, Oregon, and Washington migrate seasonally to wintering grounds off Baja California and mainland Mexico. Photographic identification data showed a separation of populations of humpback whales that feed from California to southern Washington and those that feed off British Columbia and Alaska. Using the capture-recapture method of estimation, the abundance of humpback whales in the California, Oregon, and Washington study area is estimated to range from 569 to 914 individuals. The estimated humpback whale abundance, using the line-transect method of estimation, in the California, Oregon, and Washington study area is 1,000 individuals (Calambokidis and Barlow, 2004).

Barco et al. (2002) reported on humpback whale population identity in the waters off of 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 St. Lawrence, Greenland, Iceland, and Norway. This fidelity is maternally directed and in some areas, is reflected in the genetic structure of the population. 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. Humpback whales have been documented in waters from New Jersey to North Carolina with the majority of sightings from January to April, although some sightings are made in the summer. Results from this study have shown a minimum of 44 individuals in the U.S. mid-Atlantic from 1990 to 2000, although it is possible that some individuals were documented more than once or not at all. Existing data support the hypothesis that humpback whales use the U.S. mid-Atlantic waters primarily during the winter, mixing while migrating from their summer feeding grounds, with some additional occupation of the waters at other times of the year (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; around the main Hawaiian Islands; off the tip of Baja California; and off the Revillagigedo Islands.

Mean swim speeds during migration are near 4.5 km/h (2.4 knots) (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) (Hamilton et al., 1997). Dives on feeding grounds ranged from two to five min (Dolphin, 1987; Croll, et al., 1999). Dive depths average near 40 m (131 ft). Humpbacks eat a wide variety of prey including schooling fish and krill, which are likely found above 300 m (1,000 ft) (Hamilton et al., 1997).

There is no direct measurement of auditory threshold for the hearing sensitivity of humpback whales (Ketten, 2000; (Thewissen 2002). Because of this lack of auditory sensitivity information, Houser et al. (2001a) developed a mathematical function to describe the frequency sensitivity by integrating position along the humpback basilar membrane with know 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 115-124 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 2002). 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 extend from 50 Hz to more than 10,000 Hz with most energy below 3000 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 have shown to elicit reactions from animals up to 9 km (4.9 nm) 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 nm) (Au et al., 2000). Singing males are typically solitary and maintain spacing of 5 to 6 km (2.7 to 3.2 nm) apart (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 in 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. The 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 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 the male humpback whales prior to the migration to the winter grounds (Gabriele and Frankel, 2002).

Humpback whale songs have also been recorded off of Cape Cod, Massachusetts. Clark and Clapham (2004) have studied singing on an almost daily basis by humpback whales between May and June in the Georges Bank off of Cape Cod, Massachusetts. Song occurrence decreased in the late spring. There was, however, no pronounced diurnal pattern in the occurrence of singing. Portions of the songs were detectable in the band of 80 to 400 Hz. It is possible that these songs represent an advertisement of males as well as an assessment by females of males. Males may establish a bond in the summer at the feeding grounds which may have a possible pay-off on the breeding grounds in the winter. The songs may also be an intra-sexual display between the males. There is a hypothesis that singing is driven by elevated testosterone levels and, therefore, song would be rare in the mid-summer. Since the detection of songs declined in June, this study is consistent with the hypothesis (Clark and Clapham, 2004).

Balaenidae (Right whales)

Balaenids are also known as “right whales”. The family Balaenidae includes three whales of the genus *Eubalaena*: **North Atlantic right whale (*Eubalaena glacialis*)**, **North Pacific right whale (*E. japonica*)** and **southern right whale (*E. australis*)**.

All right whale species (*Eubalaena spp*.) are listed as endangered under ESA, depleted under the MMPA, and protected under CITES. The North Atlantic and North Pacific right whales are classified as endangered by the IUCN. The southern right whale is classified by the IUCN as lower risk/conservation dependent. Three geographically isolated populations are recognized as separate species. The **North Atlantic right whale** stock **(*Eubalaena glacialis*)** is nearly extinct or extremely endangered with an approximate abundance estimate of about 300. The **North Pacific right whale (*E. japonica*)** has no available abundance estimate. The **southern right whale (*E. australis)*** is located in the Southern Ocean and has the largest abundance, currently estimated at 7,000 (Kenney, 2002). The southern right whale is recovering more successfully than the northern right whale.

Historically, right whales have occurred from temperate to subpolar latitudes. However, due to exploitation, the right whale distribution is limited. Right whales occur around coastal or shelf waters, but are also found over abyssal depths. For most of the year, their distribution is correlated to the distribution of their prey. Whales have been observed calving during the winter in the northern and southern hemispheres in the coastal waters of the lower latitudes and then migrate to the higher latitudes in the spring and summer. Critical habitat is designated in five locations: 1) coastal Florida and Georgia; 2) the Great South Channel, east of Cape Cod; 3) Cape Cod and Massachusetts Bays; 4) the Bay of Fundy; and 5) and Browns and Baccaro Banks, south of Nova Scotia (NMFS and USFWS, 2004a).

From late fall to early spring, right whales breed and give birth in temperate shallow areas, migrating 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 extend in distribution primarily between Florida and Nova Scotia (Croll et al., 1999). They calve between the northeast coast of Florida and southeastern Georgia and forage in the Bay of Fundy (IFAW, 2001; Vanderlaan et al., 2003). The North Pacific population is primarily sighted in the Sea of Okhotsk and the eastern Bering Sea. Breeding grounds for this species are unknown. Southern right whales are predominately found off Argentina, South Africa, and Australia (Kenney, 2002). 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 evidence indicating that North Atlantic right whales are losing their genetic variability. The results, in conjunction with behavioral data, which shows that North Atlantic right whales may have reduced fertility, fecundity, and juvenile survivorship, support the hypothesis that inbreeding depression is influencing the recovery of the species (Schaeff et al., 1997).

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 (2.2 mi/hr) while those that remained in the Bay of Fundy had a swim speed average of 1.1 km/hr (0.7 mi/hr). The three whales that did not leave the Bay of Fundy still traveled more than 2,000 km (1,243 mi) each before returning to their original tagging area. Most of the areas traveled by the northern right whales were along bank edges, in basins, or along the continental shelf. Eighty percent of the locations visited by the right whales had water depths greater than 183 m (597 ft). All of these whales were in or near shipping lanes and moved along areas identified as right whale habitat (Mate et al., 1997).

The most obvious social interaction of the North Atlantic right whale is surface active groups (SAGs). They are generally composed of an adult female and two or more males and engage in social behavior near the surface of the water. There is evidence that females make distinct calls while participating in the SAGs. A playback experiment from 1999 to 2001 in the Bay of Fundy showed that of the 36 trials carried out, 27 of 31 SAG playbacks resulted in male whales approaching the recordings (Parks, 2003).

Feeding areas are not well known for the Southern right whale species. Right whales feed primarily on copepods and occasionally on euphausiids (krill) along coastal areas (Kenney, 2002). Right whales are not regarded as deep divers since they find their prey near the surface (Leatherwood and Reeves, 1983). Average dive times for North Atlantic right whales range between two and seven minutes (CETAP, 1982). The average dive depth was 7.3 m (24 ft) (Winn et al., 1994), although they can dive as deep as 306 m (1,000 ft) (Mate et al., 1992). North Atlantic right whales were recorded diving over 150 m (492 ft) while foraging (Matthews et al., 2001). Maximum dive duration for southern right whales is 20 min (Croll et al. 1999). Information on the dive patterns of North Pacific right whales is unknown.

There is no direct measurement of auditory threshold for the hearing sensitivity of right whales (Ketten, 2000; Thewissen, 2002). However, based on the thickness or width measurements of the basilar membrane from slide samples, their frequency range is estimated to be 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2001).

North Atlantic right whales produce LF moans with frequencies ranging from 70 to 600 Hz (Clark, 1982; Matthews et al., 2001; 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). Source levels for North Pacific right whales were not available from these studies.

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).

Parks and Tyack (2005) describe North Atlantic right whale vocalizations from SAGs. Recordings were made of SAGs 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.

Geographic variation is evident in comparing North Atlantic right whale vocalizations to both North Pacific and southern right whale vocalizations. North Pacific right whales produce a call type increasing in frequency from 90 to 150 Hz (McDonald and Moore, 2002). During feeding observations near the eastern Bering Sea, intense bouts of patterned moans were recorded lasting for 5 to 10 min.

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 seconds and are thought to function in long-distance contact (Clark, 1983). Tonal down sweeps are also produced by this species. Sounds are used as contact calls and for communication over distances of up to 10 km (5.3 nm) (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).

Neobalaenidae

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, 2002).

The **pygmy right whale (*Caperea marginata)*** is protected under CITES and classified as lower risk/least concern under IUCN. There are no available data on abundance estimates for this species. It is found only in the Southern Hemisphere between 30 and 60 deg S (Kemper 2002). It has been recorded in coastal and oceanic temperate and sub-Antarctic regions including 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. Mating and calving seasons are unknown (Ross et al., 1975; Lockyer, 1984; Baker, 1985).

Records show this species swims at a speed of 5.4 to 9.4 km/h (2.9 to 5.1 knots) and dives up to 4 min (Kemper, 2002). There is no information available on the dive depths of pygmy right whales. The available literature suggests that copepods and euphausiids make up its diet.

There is no direct measurement of auditory threshold for 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 down sweep in frequency to 60 Hz. No geographical or seasonal differences in sounds have been documented. Estimated SLs were between 153 and 167 dB (Frankel, 2002).

Eschrichtiidae

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, 2002).

The **gray whale (*Eschrichtius robustus*)** 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 lower risk/conservation dependent under IUCN. Based on the population estimate for the most recent survey taken in 1997-1998, the eastern Pacific stock is approximately 26,600 (Jones and Swartz, 2002).

Gray whales are confined to the shallow waters of the North Pacific ranging from the continental shelf off the Bering and Chukchi seas south to southern Japan in the west, and the tip of Baja California in the east. Every year most of the population makes a large north-south migration from high latitude feeding grounds to low latitude breeding grounds.

The western North Pacific population migrates along Korea, Honshu, Kyushu and the east coast of Japan. The Seto Sea and South China Sea may be potential calving grounds (Jones and Swartz, 2002). Most gray whales in the eastern Pacific breed or calve during the winter in areas of shallow water along southern California (Jones and Swartz, 2002).

Swim speeds during migration average 4.5 to 9 km/h (2.4 to 4.9 knots) and when pursued may reach about 13 km/h (7 knots) (Jones and Swartz, 2002). 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, and the maximum dive depth recorded is 170 m (557 ft) (Jones and Swartz, 2002).

Gray whales are mainly bottom feeders, foraging during the summer and fall in the high latitudes. They feed off the ocean floor over the continental shelves in depths of 4 to 120 m (13 to 394 ft). Prey items primarily consist of benthic invertebrates and crustaceans (Jones and Swartz, 2002). Average dive times of foraging whales are 4–5 min (Rice and Wolman, 1971).

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 nm) from shore. However, this response was extinguished when the source was moved out of their migration path, but with the SL increased to duplicate the animals' RL within their migration corridor (Clark et al., 1999).

Gray whales produce a variety of sounds from 15 Hz to 20 kHz (Dahlheim et al., 1984; Moore and Ljungblad, 1984). 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 327-825 Hz (Richardson et al. 1995). Tonal moans are produced during migration in frequencies ranging between 100 and 200 Hz (Jones and Swartz, 2002). A combination of clicks and grunts have also been recorded from migrating gray whales in frequencies ranging below 100 Hz to above 10 kHz (Frankel, 2002). 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 calving/breeding ground. The SLs for these sounds range between 167 and 188 dB (Frankel, 2002).

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. Short-term responses of gray whales to the playback of noise from oil and gas development were studied in 1983 to 1984 in Central California (Malme et al., 1984 *in* Moore and Clarke, 2002), in 1985 near the Bering Sea (Malme et al., 1985 *in* Moore and Clarke, 2002), and in San Ignacio Lagoon, Baja California, Mexico from 1981 to 1984 (Dahlheim, 1987 *in* Moore and Clarke, 2002). 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 and 1988) also conducted experiments using air gun arrays and single air guns (*in* Moore and Clarke, 2002). The gray whale responses from the noise playback experiments and from the air gun shots include changes in swimming speed and direction away from the sound sources (Malme et al., 1984 *in* Moore and Clarke, 2002), changes from feeding with a resumption of feeding after exposure (Malme et al, 1988 *in* Moore and Clarke, 2002), changes in call rates and structure (Dahlheim, 1987 *in* Moore and Clarke, 2002), and changes in surface behavior (Moore and Clarke, 2002).

Table 3.2-3. Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/ Sound Production
Blue Whale (*Balaenoptera musculus*)	ESA endangered; CITES protected; IUCN endangered	- All oceans; along edge of continental shelf in temperate and tropical zones - Higher latitudes in summer, lower latitudes in winter	Global estimates: 11,200 to 13,000 Eastern North Pacific: 1,500 Western North Atlantic: 300	Dive duration: 4-15 min Average dive depth: 140 m Average dive depth during foraging: 67.6 m Average speed: 4.5 km/hr Max speed: 7.2 km/hr Diving intervals of 5-20 shallow dices at 12-20 s followed by deep dives of 3-30 min	Hearing - No direct data available Sound Production frequency range:10-200 Hz signal type: -LF calls from 10-110 Hz -FM calls: < 90 Hz -Songs: 15-20 Hz source levels: 180-190 dB
Fin Whale (*Balaenoptera physalus*)	ESA endangered; CITES protected; IUCN endangered	- All oceans - Higher latitudes in summer, lower latitudes in winter -Temperate and cold waters	Global estimates: 100,000 - 150,000 Eastern North Pacific: 2,500 Western North Atlantic: 2,800	Dive duration: 4.2 ±1.67 min Average dive depth: 60 m Maximum dive depth: 360 m Forage depth: <100 m for 5-8 mi Average swim speed: 1-16 km/hr Diving intervals of 5-20 shallow dices at 12-20 s followed by deep dives of 3-30 min	Hearing - No direct data available Sound Production frequency range: 10-200 Hz signal type: -FM call: 20-70 Hz -Pulses: 18-35 Hz source levels: high as 180-190 dB

Table 3.2-3. Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/ Sound Production
Sei Whale (*Balaenoptera borealis*)	ESA endangered; CITES protected; IUCN endangered	All oceans; concentrated in temperate zones; - Higher latitudes in summer, lower latitudes in winter -In North Atlantic, located off Nova Scotia and Labrador in the summer and as far south as Florida in the winter - In the North Pacific, range from California to the Gulf of Alaska in the east and from Japan to the Bering Sea in the west	- 14,000 in N. Pacific - 37,000 in Southern Hemisphere - 10,000 in N. Atlantic	Dive duration: 0.75-15 min Average duration: 1.5 min Dive depths: foraging dives 20 to 30 m Duration deep dives: 15 minutes 4.6 km/hr	Hearing - No direct data available Sound Production frequency range: 1.5 – 3.0 kHz signal type: FM pulse source levels: no direct data available
Bryde's Whale (*Balaenoptera edeni*)	IUCN- Data deficient species; CITES protected	- Tropical and subtropical; - Primarily between 40° N and 40° S latitudes in water temperatures of 16.3ºC	- Data unavailable for most regions - Western N. Pacific: 24,000 -Eastern tropical Pacific: 13,000 -Gulf of Mexico: 56 in 2003	Dive duration: up to 20 min Dive depths unavailable Speed: 20 km/hr	Hearing - No direct data available Sound Production frequency range: 20-900 Hz signal type Moans: 124-250. Pulse: 100-900 Hz, and below 69 Hz source levels: 152-174 dB Calves Pulses: 700-900 Hz Source levels 152-174 dB

Table 3.2-3. Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/ Sound Production
Minke Whale (*Balaenoptera acutorostrata*)	IUCN - lower risk/near threatened species; CITES protected	- All oceans - Higher latitudes in summer, lower latitudes in winter - Found most often in the North Atlantic	NE Atlantic: 60,500-186,000 N. Pacific: 17,000-28,000 Southern Hemisphere: 200,000 Canadian east coast: 4,000 Coasts of California, Oregon, and Washington: 1,015	Dive duration: 1.5-7 min Dive depths unavailable Speed: 6.1 km/hr	Hearing - No direct data available Sound Production frequency range: 80-20,000 Hz Down sweeps from 250 to 50 Hz Signal type Thump trains: 100-200 Hz Pulses: 50-9,400 Hz followed by puses at 1,800 Hz Tonal: 80-140 Hz Rachets: 80-850 Hz Pings/clicks: 3.3-20 kHz Source levels: 150-165 dB re: 1 µPa at 1 m

Table 3.2-3. Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/ Sound Production
Humpback Whale (*Megaptera novaeangliae*)	ESA endangered; CITES protected; IUCN vulnerable	- All oceans - Higher latitudes in summer, lower latitudes in winter	N. Atlantic: 10,600 Eastern N. Pacific: 1,300 Central N. Pacific: 4,000 Southern Hemisphere: 13,000-15,000	- Dives duration: 3-4 min in Alaska; 3.5 min in Gulf of California Average depth: 40 m Maximum dive depth: 240 m Foraging depth: <300 m for 2-5 min Speed: 4.5 km/h	Hearing - Predicted audiograms: 700 Hz – 10 kHz - Maximum sensitivity at 2-6 kHz Sound Production -frequency range: 20-10,000 Hz -signal type calls: 20-2,000 Hz Dominant frequency: 500 Hz songs: 20-10,000 Hz Social sounds: 50 Hz to 10 kHz with most energy below 3000 Hz Mean source level of a male song: 165 dB
North Atlantic Right Whale (*Eubalaena glacialis*)	ESA endangered; CITES protected; IUCN Endangered	-Primarily in temperate and subpolar waters of North Atlantic ocean -Range from Florida to Nova Scotia	NW Atlantic: Approx. 300	Dive duration: 2-7 min Average dive depth: 7.3 m Maximum dive depth: 306 m Max dive duration: 20 min Not deep divers since they feed on the surface Speed: 1.1-3.5 km/h	Hearing - No direct data available Sound Production frequency range: 70-600 Hz signal type LF calls: 70 Hz source levels: 140-190 dB re: 1 µPa at 1 m

Table 3.2-3. Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/ Sound Production
North Pacific Right Whale (*Eubalaena japonica*)	ESA endangered; CITES protected; IUCN Endangered	-Primarily in temperate and subpolar waters of North Pacific ocean -Distributed between the Sea of Othotsk and the eastern Bering Sea	N. Pacific: nearly extinct, no estimate	No direct data available Not deep divers since they feed on the surface	Hearing - No direct data available Sound Production frequency range: 90-150 Hz signal type: songs source levels: No direct data available
Southern Right Whale (*Eubalaena australis*)	ESA endangered; CITES protected; IUCN - lower risk/conservation dependent	-Southern Ocean - Found in Argentina, South Africa, and Australia	Global estimate: 7,000	Dive duration: 20 min Average dive depth: no direct data available Not deep divers since they feed on the surface Speed: <11.9 km/h	Hearing - No direct data available Sound Production frequency range: 50-500 Hz with HF near 1,500 Hz signal type: calls source levels: 172-187 dB re: 1 µPa at 1 m
Pygmy Right Whale (*Caperea marginata*)	CITES protected; IUCN - lower risk/least concern species	-Temperate waters of S. Hemisphere 30°-60°S -Coastal and oceanic temperate and sub-Antarctic regions including southern Africa, South America, Australia, and New Zealand	No direct data available	Dive duration: 4 min Average dive depth: No direct data available Speed: 5.4-9.4 km/h	Hearing - No direct data available Sound Production frequency range: 60-300 Hz signal type pulses: 90-135Hz with a down sweep to 60 Hz source levels: 153-167 dB re: 1 µPa at 1 m

Table 3.2-3. Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/ Sound Production
Gray Whale (*Eschrichtius robustus*)	ESA - Western Pacific population listed as endangered; Eastern Pacific population delisted; CITES protected; IUCN – lower risk/conservation dependent	-Usually in coastal N. Pacific, however during summer feeding seasons may be found far off coast. - From continental shelf off the Bering and Chukchi seas south to southern Japan in the west and the tip of Baja California in the east.	Western Pacific: nearly extinct Eastern Pacific: 26,600	Dive depths: forage on continental shelf at depths of 4-120 m Dive duration: 3-5 min and 7-10 min Maximum dive depth: 170 m Not deep divers Speed: 4.5-9 km/h and up to 13 km/h	Hearing Hearing sensitivity: 800-1500 Hz Sound Production frequency range: 15 Hz-20 kHz signal type knocks/pulses: <100-2 kHz with the most energy at 327-825 Hz moans: 100-200 Hz clicks/grunts: 100-10,000 Hz source levels: 167-188 dB re: 1 µPa at 1 m
Source: Richardson et al., 1995; Croll et al., 1999; Rugh, et al, 1999. Evans, 1987; Au et al., 2000; Houser et al. 2001a; Olson et al. 2003; Frankel, 2002; Jones and Swarz, 2002; Dahlheim and Ljungblad, 1990.					

3.2.4.2 Odontocetes Species

The odontocetes being evaluated include six families containing over 54 species (see text box below). Odontocetes can be distinguished from mysticetes by the presence of functional teeth and a single blowhole and range in size from the sperm whale at 16 m (52 ft) and 45 tons (40,823 kg) to the harbor porpoise at 1.45 m (4.8 ft) and 50 kg (Bjorge and Tolley, 2002; Whitehead, 2002).

Odontocetes have a broad acoustic range with recent hearing thresholds measuring between 400 Hz and 100 kHz (Richardson et al., 1995; Finneran et al., 2002). Many odontocetes produce a variety of click and tonal sounds for communication and echolocation purposes (Au, 1993). It is generally believed that odontocetes communicate mainly above 1,000 Hz and echolocate above 20 to 30 kHz (Wursig and Richardson, 2002). Little is known about the details of most sound production and auditory thresholds for many species (Frankel, 2002). Table 3.2-4 provides species-specific information on the protected status (according to ESA, CITES and IUCN), distribution, abundance, diving behavior, hearing and sound production of odontocetes.

Physeteridae

The family Physeteridae includes a single known genus and species, the sperm whale (*Physeter macrocephalus),* which is the largest species of all the odontocetes (Whitehead, 2002).

The **sperm whale** is currently endangered under the ESA, depleted under the MMPA, classified by IUCN as vulnerable, and classified as protected under CITES. There is much uncertainty associated with global population estimates of sperm whales. Estimates vary from 300,000 (Whitehead, 2002) to almost 2 million (Rice, 1989; Reeves and Whitehead, 1997). Survey estimates in the eastern tropical Pacific were 39,200 based on acoustic detection (Carretta et al., 2002). Estimates were 1,400 for the Eastern Pacific, 4,700 for the Northern Atlantic, and 1,350 for the Gulf of Mexico (Carretta et al., 2002; Waring et al., 2004). The best abundance estimates for the sperm whale in the western north Pacific Ocean is 102,112 individuals (CV=0.155) (Angliss and Outlaw, 2006).

Sperm whales are primarily found in deeper ocean waters and distributed in polar, temperate and tropical zones of the world (Reeves and Whitehead, 1997) and have the largest range of all cetaceans except killer whales (Rice, 1989). They are commonly found near the Equator and in the North Pacific (Whitehead, 2002). The migration patterns of sperm whales are not well-studied.

The sperm whale has a prolonged breeding season extending from late winter through early summer. In the Southern Hemisphere, calving season is between November and March (Simmonds and Hutchinson, 1996), although specific breeding and foraging grounds are not well known for this species.

Family: Physeteridae	
Physeter macrocephalus	Sperm whale
Family: Kogiidae	
Kogia breviceps	Pygmy sperm whale
Kogia simus	Dwarf sperm whale
Family: Ziphiidae (Beaked Whales)	
Hyperoodon ampullatus	Northern bottlenose whale
Hyperoodon planifrons	Southern bottlenose whale
Berardius bairdii	Baird's beaked whale
Berardius arnuxii	Arnoux's beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Indopacetus pacificus	Longman's beaked whale
Mesoplodon species	13 species
Tasmacetus shepherdi	Shepherd's beaked whale
Family: Monodontidae	
Delphinapterus leucas	Beluga or white whale
Family: Delphinidae (Dolphins)	
Orcinus orca	Killer whale (orca)
Pseudorca crassidens	False killer whale
Feresa attenuata	Pygmy killer whale
Peponocephala electra	Melon-headed whale
Globicephala macrorhynchus	Short-finned pilot whale
Globicephala melas	Long-finned pilot whale
Grampus griseus	Risso's dolphin
Delphinus delphis	Common dolphin (short beaked)
Delphinus capensis	Common dolphin (long-beaked)
Lagenodelphis hosei	Fraser's dolphin
Steno bredenansis	Rough-toothed dolphin
Stenella attenuata	Pantropical spotted dolphin
Stenella clymene	Clymene dolphin
Stenella coeruleoalba	Striped dolphin
Stenella frontalis	Atlantic spotted dolphin
Stenella longirostris	Spinner dolphin
Tursiops truncatus	Bottlenose dolphin
Lagenorhynchus acutus	Atlantic white-sided dolphin
Lagenorhynchus albirostris	White-beaked dolphin
Lagenorhynchus australis	Peale's dolphin
Lagenorhynchus cruciger	Hourglass dolphin
Lagenorhynchus obliquidens	Pacific white-sided dolphin
Lagenorhynchus obscurus	Dusky dolphin
Lissodelphis borealis	Northern right whale dolphin
Lissodelphis peronii	Southern right whale dolphin
Cephalorhynchus commersonii	Commerson's dolphin
Cephalorhynchus eutropia	Black or Chilean dolphin
Cephalorhynchus heavisidii	Heaviside's dolphin
Cephalorhynchus hectori	Hector's dolphin
Family: Phocoenidae (Porpoises)	
Phocoena phocoena	Harbor porpoise
Phocoenoides dalli	Dall's porpoise

Swim speeds of sperm whales range from 1.25 to about 4 km/h (0.7 to 2.2 knots) (Jaquet et al., 2000; Whitehead, 2002). Dive durations range between 18.2 to 65.3 min (Watkins et al., 2002). Sperm whales may be the longest and deepest diving mammals, having been recorded diving for over 2 hours to depths of 3,000 m (9,842 ft) (Clarke, 1976; Watkins et al., 1985). 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 et al., 1989; Wahlberg, 2002). Sperm whales mostly feed on squid, but also include demersal and mesopelagic fish in their diet, although, their feeding habits are region-specific (e.g., Iceland) (Reeves and Whitehead, 1997; Whitehead, 2002).

Recent audiograms measured from a sperm whale calf resulted in an auditory range of 2.5 to 60 kHz, 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; Thode 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 (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, 2002). SELs of clicks have been measured between 202 and 236 dB (Madsen and Møhl, 2000; Mohl et al., 2000; Thode et al., 2002; Mohl et al., 2003).

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. 2000). Mohl et al. (2003) further described the directionality of the clicks and that 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).

Thode et al. (2002) reported on depth-dependent acoustic features of diving sperm whales in the Gulf of Mexico. The correlation between the sperm whale’s depth and inter-click interval is a characteristic behavioral pattern of other echolocating animals when they are getting close to a target. The returns were always detected when the animal was descending toward the ocean bottom, but were never detected once the animal initiated what was presumed to be foraging behavior. Even during the initial descent phase, the detection of bottom returns was sporadic. After long periods during which only direct and surface-reflection paths were recorded, the bottom returns often faded within seconds, with a 10-dB increase in signal energy that is typically accompanied by energy variation in the direct signal arrival of less than 3 dB. These observations suggest that sperm whale signals have directional properties (Thode et al., 2002).

Zimmer et al. (2005b) discuss the three-dimensional beam pattern of regular sperm whale clicks. Regular clicks have several components by which the whale produces a narrow, high-frequency sonar beam to search for prey, a less-directional backward pulse which provides orientation cues, and a low-frequency component of low directionality which 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 a 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. (2005b) propose that the initial backward pulse is produced by the phonic lip and activates air volumes connected to the phonic lips, which generates the low-frequency component. The two dominant frequencies in the low-frequency component indicate either one resonator with aspect-dependent radiation patterns or that two resonators exist with similar volumes at the surface but different rates at which the volumes are reduced by increasing static pressure. 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, 2002)**.** Abundance estimates of the global population size are unknown. However, there are estimates for specific geographic regions. Wade and Gerrodette (1993) derived an abundance estimate of 11,200 (CV=0.294) for the dwarf sperm whale in the eastern tropical Pacific (ETP). The best estimate for the California/Oregon/Washington pygmy and dwarf sperm whale stock is 247 (CV=1.06) with the minimum abundance estimate of 120 (Carretta et al., 2005).

Pygmy and dwarf sperm whales are distributed worldwide, primarily in temperate to tropical deep waters from 40°S to 60°N. They are especially common along continental shelf breaks (Evans, 1987; Jefferson et al., 1993). Dwarf sperm whales have generally been sighted in warmer waters than pygmy sperm whales (Caldwell and Caldwell, 1989). Breeding areas for both species include waters off of Florida (Evans, 1987). There is little evidence of whether pygmy and dwarf sperm whales have a seasonal migration pattern (McAlpine, 2002).

Swim speeds vary and were found to reach up to 11 km/h (5.9 knots) (Scott et al., 2001). In the Gulf of California, *Kogia* species have been recorded with an average dive time of 8.6 min and a maximum dive time of 43 min for dwarf sperm whales in the Gulf of Mexico (Breese and Tershy, 1993; Willis and Baird, 1998). *Kogia* spp. consume a variety of cephalopod species and occasionally feed on fish and crustaceans (McAlpine, 2002).

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).

Recent recordings from captive pygmy sperm whales indicate that they produce sounds between 60 and 200 kHz with peak frequencies at 120-130 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 a LF sweep between 1,300 and 1,500 Hz from a captive pygmy sperm whale in Hawaii. Richardson et al. (1995) reported pygmy sperm whale frequency ranges for clicks to be between 60 and 200 kHz with the dominant frequency at 120 kHz. No geographical or seasonal differences in sounds have been documented. Estimated source levels were not available.

Ziphiidae (beaked whales)

The family Ziphiidae is divided into two subfamilies (Ziphiinae and Hyperoodontinae) containing twenty species of whales in five genera (Mead, 2002a). Ziphiidae are protected under the MMPA and CITES. In the IUCN Redlist (www.iucnredlist.org), Arnoux's beaked whale, Baird's beaked whale, northern bottlenose whale, and southern bottlenose whale are listed as LR/cd (Lower Risk/conservation dependent) indicating that they are not critically endangered, endangered, or vulnerable, but that they are the target of a conservation program that if ended, would result in the taxon qualifying for one of the threatened categories within five years. The *Mesoplodon* spp., Shepherd's beaked whale, and Cuvier's beaked whale are listed as Data Deficient under the IUCN Redlist, indicating there is insufficient information to assess the taxon's risk of extinction and acknowledges that future research may show that threatened classification is appropriate.

Subfamily Ziphiinae

In the subfamily Ziphiinae, *Berardius* spp. includes Baird's beaked whale (*Berardius bairdii)* and Arnoux's beaked whale (*B. arnuxii*). In the genus *Tasmacetus* spp., there is one species,, Shepherd's beaked whale, (*T. shepherdi*). One species of *Ziphius* spp. exists, Cuvier's beaked whale (*Z. cavirostris*).

Both the **Baird's (*Berardius bairdii)*** and **Arnoux's beaked whales (*B. arnuxii*)** are currently classified as lower risk/conservation dependent IUCN. Abundance estimates of the global population size for either species are unknown. In the northwest Pacific, Baird's beaked whales are estimated near 7,000 (Kasuya, 2002). During the summer and fall of 1991, 38 Baird's beaked whales were recorded off California (Barlow, 1995). The minimum abundance estimate in the eastern North Pacific (California, Oregon, and Washington waters) is 228 Baird's beaked whales (Carretta et al., 2005).

Arnoux's beaked whales are distributed around Antarctic waters and have been sighted near northern New Zealand, South Africa, and southeastern Australia (Ponganis and Kooyman, 1995). Baird's beaked whales occur in the North Pacific ranging from the continental shelf off the Bering and Okhotsk seas south to southern Japan in the west and northern Baja California in the east (Kasuya, 1986; Kasuya, 2002). 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 have only been documented to have an inshore-offshore movement off California beginning in July and ending in September through October (Dohl et al., 1983). 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. They primarily feed on benthic fish and cephalopods (Kasuya, 2002). Arnoux's beaked whales have only been found to feed on squid. No foraging dive data are available for *Berardius* spp.

Ohizumi et al. (2002) reports that Baird's beaked whales migrate to the coastal waters of the western North Pacific and the southern Sea of Okhotsk in the summer. Few analyses have been conducted on their stomach contents. In this study, most of the whales had little in their stomachs. The prey items mostly found were rat-tail fish, and hakes, but also mesopelagic and deep-sea squids, unidentified crabs. However, the crabs were also found in the stomachs of prey fish which suggests that the crabs were secondarily introduced. The abundance of demersal fish found in the whales' stomachs suggest that Baird's beaked whales dive to the bottom to forage. Whales were caught at water depths of approximately 1,000 m (3281 ft). However, trawl data and sighting surveys also state that Baird's beaked whales have been observed in waters from 1,000 to 3,000 m (3281 to 9843 ft) deep (Ohizumi et al., 2002).

Swim speeds for ziphiids have averaged 5 km/h (2.7 knots) (Kastelein and Gerrits, 1991). Baird's beaked whales were recorded diving between 15 and 20 min, with a maximum dive duration of 67 min (Barlow, 1999; Kasuya, 2002). 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 depth data are available for either species.

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, 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.

The **Shepherd's beaked whale** (***Tasmacetus shepherdi***) is currently classified as a data deficient species by IUCN. Abundance estimates of this species are not available.

Shepherd's beaked whales are distributed around temperate Antarctic waters. Records show they exist in the waters off Brazil, the Galapagos Islands, New Zealand, Argentina, Australia, and the south Sandwich Islands (Evans, 1987; Mead, 2002b). No data are available to confirm seasonal migration patterns for Shepherd's beaked whales, nor breeding and calving grounds.

General swim speeds for ziphiids have averaged 5 km/h (2.7 knots) (Kastelein and Gerrits, 1991). No data are available on dive times or dive depths of Shepherd's beaked whales. Their diet consists of small squid, euphausiids, crustaceans, and fish; (Mead and Payne, 1975; Evans, 1987).

There is no direct measurement of auditory threshold for the hearing sensitivity of Shepherd's beaked whales (Ketten, 2000; Thewissen, 2002). No literature is available on the sound production of this species.

Cuvier's beaked whale (*Ziphius cavirostris*) is currently classified as a data deficient species by the IUCN. Abundance estimates of the global population size for this species are unknown. A survey estimate for the eastern North Pacific (California, Oregon, and Washington waters) was 1,900 individuals (Carretta et al., 2005). The best data available are from the eastern tropical Pacific with estimates of 90,725 Cuvier's beaked whales (Ferguson and Barlow, 2003).

Cuvier's beaked whales are found in deep, offshore waters of all oceans, from 60 deg N to 60 deg S (Jefferson et al., 1993), but are more common in subtropical and temperate waters than in the tropical and subpolar waters of their range (Evans, 1987). They are common in offshore deep waters near the Mediterranean, British Isles, Caribbean seas, the Sea of Japan, western North America, and off of Hawaii (Omura et al., 1955; Caldwell et al., 1971; Houston, 1991; Blanco and Raga, 2000; Waring et al., 2001; Baird et al., 2004). No data on breeding and calving grounds is available.

Swim speeds of Cuvier's beaked whale have been recorded between 5 and 6 km/h (2.7 and 3.3 knots) (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). Dive depths for this species are inconclusive. Cuvier's beaked whales consume squid and deep-sea fish (Clarke, 1996).

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 have been recorded producing HF clicks between 13 and 17 kHz (Frantzis et al., 2002). These sounds were recorded during diving activity and may be associated with echolocation purposes. There is no available data regarding seasonal or geographical variation in the sound production of Cuvier's beaked whales. Beaked whales are capable of producing SLs of 200 to 220 dB (peak-to-peak) (Johnson et al., 2004).

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 (656.2 ft) of the surface. The Cuvier's beaked whale started clicking at an average depth of 475 m (1,558.4 ft), ranging from 450 to 525 m (1,476 to 1,722 ft), and stopped clicking when they started their ascent at an average depth of 850 m (2,789 ft), with a range of 770 to 1,150 m (2,526 to 3,773 ft). The intervals between regular clicks were approximately 0.4 second. Trains of clicks often end in a rapid increase in the click rate, which is also called a buzz. According to these studies, both the Cuvier's beaked whale and the Blainville's beaked whale have a somewhat flat spectrum that was accurately sampled by Johnson et al. (2004)

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).

Zimmer et al. (2005a) also studied Cuvier's beaked whales and their echolocation clicks. The highest measured SL was 214 dB (peak-to-peak). It is recognized in this study that it is possible that Cuvier's beaked whales cannot produce any higher source levels, but it is more likely that the full capabilities of the Cuvier's beaked whales are underestimated by this study. Therefore, the maximum SL shown in this study may be the result of the whale's reducing the volume when ensonifying at each other (Zimmer et al., 2005a).

Subfamily Hyperoodontinae

The subfamily Hyperoodontinae, *Hyperoodon* spp. includes animals from 3 genuses: *Hyperoodon*, *Indopacetus*, and *Mesoplodon*. The *Hyperoodon* genus is composed of the northern bottlenose whale (*Hyperoodon ampullatus)* and the southern bottlenose whale (*H. planifrons*). Longman's beaked whale (*Indopacetus pacificus*) is the only species in the *Indopacetus* genus. The genus *Mesoplodon* includes 13 species: Bahamonde's beaked whale (*Mesoplodon bahamondi*)[4], Sowerby's beaked whale (*M. bidens*), Andrew's beaked whale (*M. bowdoini*), Hubb's beaked whale (*M. carlhubbsi*), Blainville's beaked whale (*M. densirostris*), Gervais' beaked whale (*M. europaeus*), ginkgo-toothed beaked whale (*M. ginkgodens*), Gray's beaked whale (*M. grayi*), Hector's beaked whale (*M. hectori*), strap-toothed whale (*M. layardii*), True's beaked whale (*M. mirus*), pygmy beaked whale (*M. peruvianus*), and Stejneger's beaked whale (*M. stejnegeri*). Most of the beaked whale species in the family Ziphiidae, including in the subfamily Hyperoodontinae. are poorly known and insufficiently studied.

Northern bottlenose whales (*Hyperoodon ampullatus)* and **southern bottlenose whales (*H. planifrons*)** are currently classified as lower risk/conservation dependent status by IUCN. Abundance estimates of the global population size are unknown. The Gully, southeast of Sable Island, Nova Scotia, has approximately 230 northern bottlenose whales (Whitehead et al., 1997). Estimates taken during January show close to 600,000 southern bottlenose whales present south of the Antarctic Convergence (Kasamatsu and Joyce, 1995).

The northern bottlenose whale is found only in the cold temperate-to-subarctic latitudes of the North Atlantic (35 to 80°N). They mostly congregate mostly seaward of the continental shelf in water deeper than 1,000 m (3,300 ft) (Leatherwood and Reeves, 1983; Jefferson et al., 1993). Northern bottlenose whales are commonly found foraging in the Gully, off the coast of Nova Scotia, Canada (Gowans, 2002). There is sparse evidence that this species migrates north in the spring and south in the fall (Leatherwood and Reeves, 1983). Calving and breeding grounds are unknown.

[4] Reyes et al. (1995) recently described Bahamonde's beaked whale through phylogenetic analysis of mitochondrial. DNA. This species, which was named in 1996, was recognized as the most recent new cetacean species. However, Van Helden et al., (2002) have shown *Mesoplodon traversii* to be a senior synonym of this recently described species.

The Scotian Shelf population of northern bottlenose whale was listed as endangered under Canada's Species at Risk Act (SARA) and designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2002. The Scotian Shelf population appears to be non-migratory, unlike other northern bottlenose whale populations. For example, the Labrador population migrates to the southern portion of their range, between New York and the Mediterranean, for winter months.

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

Swim speeds for ziphiids have averaged 5 km/h (2.7 knots) (Kastelein and Gerrits, 1991). Hooker and Baird (1999) documented northern bottlenose whales with regular dives from 120 m (394 ft) to over 800 m (2625 ft), with a maximum recorded dive depth of 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, 2002), and the deeper dives of northern bottlenose whales have been associated with foraging behavior (Hooker and Baird, 1999).

There is no direct measurement of auditory threshold for the hearing sensitivity of 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 k Hz 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, and no seasonal or geographical variation is known for the sound production of southern bottlenose whales. Estimated source levels are not documented.

Longman's beaked whale (*Indopacetus pacificus*) is currently classified as data deficient by IUCN. Abundance estimates of this species are not available.

It is believed that Longman's beaked whale is limited to the Indo-Pacific region (Leatherwood and Reeves, 1983; Jefferson et al., 1993). Recent groups of whales sighted in the equatorial Indian and Pacific oceans have tentatively been assigned to this species (Ballance and Pitman, 1998; Pitman et al., 1998). No data is available to confirm seasonal migration patterns for Longman's beaked whales. No data of breeding and calving grounds is available.

General swim speeds for ziphiids have averaged 5 km/h (2.7 knots) (Kastelein and Gerrits, 1991). No data is available on dive times or dive depths of Longman's beaked whales. There is no literature available on the diet of this species.

There is no direct measurement of auditory threshold for the hearing sensitivity of Longman's beaked whales (Ketten, 2000; Thewissen, 2002). No literature is available on the sound production of this 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. Estimates of 25,300 in the eastern tropical Pacific 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 3200 whales (Waring et al, 2004)., and a minimum estimate of 1250 whales was reported in the eastern North Pacific (Carretta et al, 2005).

Mesoplodon whales are distributed in offshore, pelagic waters between 72°N and 60°S (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Wade and Gerrodette, 1993; Carlstrom et al., 1997). Sowerby's beaked whale, Blainville's beaked whale, Gervais beaked whale, and True's beaked whale regularly occur in the North Atlantic (MacLeod, 2000). Ginkgo-toothed beaked whales have been sighted in the northwestern Pacific, Blainville's beaked whale has been recorded in the western North Pacific, and Stejneger's beaked whale is commonly found near the Aleutian Islands (Evans, 1987; Kasuya and Nishiwaki, 1971). The breeding season for Sowerby's beaked whales occurs in late winter or spring (Jefferson et al., 1993). This is the only *Mesoplodon* species for which any information associated with breeding is known.

General swim speeds for ziphiids have averaged 5 km/h (2.7 knots) (Kastelein and Gerrits, 1991). Dives of Blainville's beaked whales averaged 7.47 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.

Mesoplodon whales are deep diving species which consume small cephalopods and bentho-pelagic fish (Sullivan and Houck, 1979; Leatherwood et al., 1988; Mead, 1989; Jefferson et al., 1993; MacLeod et al., 2003). Blainville's beaked whales diving to depths near 900 m (2625 ft) for 20 min or longer are most likely foraging (Leatherwood et al., 1988; Baird et al., 2004).

There is no direct measurement of auditory threshold for the hearing sensitivity of *Mesoplodon* species (Ketten, 2000; Thewissen, 2002). There is sparse data available on the sound production of *Mesoplodon* species.

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, both *in*: Richardson et al., 1995). A stranded Blainville's beaked whale in Florida produced chirps and whistles below 1 kHz up to 6 kHz (Caldwell and Caldwell, 1971a). There are no available data regarding seasonal or geographical variation in the sound production of *Mesoplodon* species.

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 (656.2 ft) of the surface. The Blainville's beaked whale started clicking at an average depth of 400 m (1312.3 ft), ranging from 200 to 570 m (656.2 to 1870.1 ft), and stopped clicking when they started their ascent at an average depth of 720 m (2362.2 ft), with a range of 500 to 790 m (1640.4 to 2591.9 ft). The intervals between regular clicks were approximately 0.4 second. Trains of clicks often end in a rapid increase in the click rate, which is also called a buzz. Both the Cuvier’s beaked whale and the Blainville’s beaked whale have a somewhat flat spectrum that was accurately sampled by Johnson et al. 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 *(Delphinapterus leucas)*. Belugas are also known as “white whales” (O'Corry-Crowe, 2002).

The **beluga** *(Delphinapterus leucas)* is classified as a vulnerable species by the IUCN, and the Cook Inlet stock is a proposed candidate species under the ESA. The worldwide abundance size is estimated near 100,000. Estimates ranging between 12,000 and 14,000 have been documented off Western Greenland.

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 in North America extend from Alaska across the Canadian western arctic to the Hudson Bay (Sergeant and Brodie, 1969). Occasional sightings and strandings occur as far south as the Bay of Fundy (Atlantic). In the Pacific, migratory belugas summer in the Okhotsk, Chukchi, Bering, and Beaufort seas, the Anadyr Gulf, and off Alaska. Other beluga populations reside in Cook Inlet year round (Hansen and Hubbard, 1998; Rugh et al., 1998). Mating is believed to occur primarily in late winter to early spring when most belugas are still on their wintering grounds or on spring migration (O’Corry-Crowe, 2002). Calving season can range from late spring to early summer.

The beluga is not a fast swimmer, with maximum swim speeds estimated between 16 and 22 km/h (8.6 and 11.9 knots) and a steady swim rate in the range of 2.5 to 3.3 km/h (1.3 to 1.8 knots) (Brodie, 1989; O’Corry-Crowe, 2002). 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 minute. Deep dives last for 9 to 18 min, and dive depths range between 300 and 600 m (984 and 1968 ft). In deep waters beyond the continental shelf, belugas may dive in excess of 1000 m (3281 ft), remaining submerged for up to 25 min (O’Corry-Crowe, 2002).

Belugas feed mostly on shallow water fish, but may also consume squid and a variety of crustaceans and euphausiids (Gaskin, 1982). No foraging dive data is available.

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.

Belugas produce tonal calls or whistles in the 260 to 20,000 Hz 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 2002). There are a variety of 50 different call types including “groans”, “whistles”, “buzzes”, “trills” and “roars” (O'Corry-Crowe 2002). 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 et al., 1985, 1987; Au, 1993). There is supportive evidence of geographical variation from distinctive calls used for individual recognition among beluga whales (Bel’kovich and Sh’ekotov, 1990).

Delphinidae

The family Delphinidae includes five subfamilies containing over 30 species of dolphins (Perrin, 1989; LeDuc, 2002).

Subfamily Globicephalinae

The subfamily Globicephalinae contains the killer whale or orca (*Orcinus orca)*, the false killer whale (*Pseudorca crassidens)*, the pygmy killer whale *(Feresa attenuata)*, the melon-headed whale (*Peponocephala electra*), the long-finned pilot whale (*Globicephala melas)* and the short-finned pilot whale (*Globicephala macrorhynchus*).

The **killer whale (*Orcinus orca)*** is classified as lower risk (conservation dependent) by the IUCN. The worldwide abundance size is estimated near 100,000 (Reeves and Leatherwood, 1994). Estimates of 8,500 individuals have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). Shipboard surveys in the Antarctic gave a rough estimate of nearly 70,000 killer whales. Two thousand (2000) killer whales have been estimated in the eastern North Pacific Ocean, and 445 whales have been identified in Norwegian waters (Ford, 2002; Carretta et al., 2005). A minimum of 133 killer whales was reported in the Gulf of Mexico (Waring et al, 2004). Resident killer whales occur in large pods with a range of 10 to approximately 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 (70 FR 69903).

On November 18, 2005, the NMFS published a final determination to list the Southern Resident killer whales (*Orcinus orca*) distinct population segment (DPS) as endangered under the Endangered Species Act of 1973 which is effective as of February 16, 2006 (70 FR 69903). Critical habitat has not yet been designated for the Southern Resident killer whales.

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 (Leatherwood and Dahlheim, 1978; Ford, 2002). However, they appear to be more common within 800 km (430 nm) of major continents in cold temperate to subpolar waters (Mitchell, 1975).

Swimming speeds usually range between 6 to 10 km/h (3.2 to 5.4 knots), but they can achieve speeds up to 37 km/h (20 knots) in short bursts (Lang, 1966; LeDuc, 2002). In southern British Columbia and northwestern Washington State, killer whales spend 70 percent 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 recorded range from 1 to 10 min (Norris and Prescott, 1961; Lenfant, 1969; Baird et al., 1998).

Killer whales have perhaps the most diverse food habits of any marine mammal, feeding on a variety of fish species, cephalopods, pinnipeds, sea otters, whales, dolphins, seabirds, and marine turtles (Hoyt, 1981; Gaskin, 1982; Jefferson et al., 1991). In the Bering Sea there is some suggestion that killer whales prey on fish at water depths of 200 to 300 m (660-990 ft) or more (Yano and Dahlheim, 1995a and b).

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 1-20 kHz (Schevill and Watkins, 1966; Diercks et al., 1971, 1973; Evans, 1973; Steiner et al., 1979; Awbrey et al., 1982; Ford and Fisher, 1983; 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, 2002). 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, 2002; Frankel, 2002). 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 whales (*Pseudorca crassidens)* are classified as lower risk (least concern) by the IUCN. The global population for this species is unknown. Estimates of 39,800 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). In the northwestern Pacific, an estimate of near 17,000 has been documented (Miyashita, 1993).

False killer whales are found in tropical to warm temperate zones in deep, offshore waters from 60 deg S to 60 deg N (Stacey et al., 1994; Odell and McClune, 1999; Baird 2002a). Although typically a pelagic species, they approach close to the shores of oceanic islands and regularly mass strand (Baird, 2002a).There are no available data on specific breeding grounds. Calving season may be considered year-round with a peak in late winter (Baird, 2002a).

False killer whales have an approximate swim speed of 3 km/h (1.6 knots), although a maximum swim speed has been documented as 28.8 km/h (11.9 knots) (Brown et al. 1966; Rohr et al., 2002). No data is available on diving (Baird 2002a). Their diet consists primarily of fish and squid and on occasion, other small odontocetes (Evans and Raga, 2001; Baird, 2002a).

False killer whales hear underwater sounds in the range of <1 to 115 kHz (Johnson, 1967; Awbrey et al., 1988; Au, 1993). Their best underwater hearing occurs at 17 kHz, where the threshold level ranges between 39 to 49 dB RL (Sauerland and Dehnhardt, 1998).

Au et al. (1997) conducted a survey on the effects of the Acoustic Thermometry of Ocean Climate (ATOC) program on false killer whales and on Risso's dolphins, which will be discussed later. The ATOC program broadcast a low-frequency 75-Hz phase modulated, 195 dB SL signal through ocean basin-sized water masses to study ocean temperatures on a global scale. The hearing sensitivity was measured for false killer whales. The hearing thresholds for false killer whales were 140.7 dB RL, plus or minus 1.2 dB for the 75-Hz pure tone signal and 139.0 dB RL plus or minus 1.1 dB for the ATOC signal. The results of this study concluded that small cetaceans, such as false killer whales and Risso's dolphins, swimming directly over the ATOC source do not seem to hear the transmitted sound unless the animals dove to a depth of approximately 400 m (1312 ft). If these animals were at a horizontal range greater than 0.5 km (0.3 mi), the level of the ATOC signal would be below their hearing threshold at any depth. Also, this study indicates that for ranges greater than 0.5 km (0.3 mi), the maximum sound-pressure level above a depth of 560 m (1837.3 ft) is approximately 130 dB RL. As the range increases beyond 2 km (1.2 mi), the sound-pressure level will become progressively lower (Au et al., 1997).

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 between 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 is 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 whales *(Feresa attenuata)* are classified as a data deficient species by the IUCN. They are one of the least known cetacean species. The global population for this species is unknown. Estimates of 39,800 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). An estimated 408 pygmy killer whales was reported in the Gulf of Mexico (Waring et al., 2004).

The pygmy killer whales have been recorded in oceanic tropical and subtropical waters around the world from about 40°S to 40°N (Caldwell and Caldwell, 1971b; Donahue and Perryman, 2002). It is sighted relatively frequently in the eastern tropical Pacific, the Hawaiian Archipelago and off Japan (Leatherwood et al., 1988; Donahue and Perryman, 2002). 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 is not available. No dive data are available. Pygmy killer whales feed on cephalopods and small fish (Donahue and Perryman, 2002). They are also suspected of feeding on small marine mammals (Evans and Raga, 2001).

There is no direct measurement of auditory threshold for the hearing sensitivity of pygmy killer whales (Ketten, 2000; Thewissen, 2002). 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 whales (*Peponocephala electra*) are classified as a lower risk (least concern) species by the IUCN. The global population for this species is unknown. Estimates of 45,400 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). An estimate of 3,451 whales was reported for the Gulf of Mexico (Waring et al., 2004).

The melon-headed whale occurs in pelagic waters near tropical and subtropical climate regions, but records range between 20°S to 20°N (Jefferson and Barros, 1997). Breeding areas and seasonal movements of this species have not been confirmed.

General swim speeds for this species is not available. No data is available on dive depths and dive times of melon-headed whales. 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).

There is no direct measurement of auditory threshold for the hearing sensitivity of 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 8-12 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 for click bursts (Watkins et al., 1997).

Pilot whales include the **long-finned pilot whale (*Globicephala melas*)** and the **short-finned pilot whale (*G. macrorhynchus*).** Long-finned pilot whales are classified as a lower risk species by the IUCN. The global population for this species is unknown. Estimates of 778,000 and 200,000 exist in the northeast Atlantic and south of the Antarctic Convergence in January, respectively (Olson and Reilly, 2002). An estimate of 14,524 long-finned pilot whales was reported for the western North Atlantic (Waring et al, 2004).

Short-finned pilot whales are classified as a lower risk (conservation dependent) species by the IUCN. The global population for this species is unknown. In the northwest Pacific, abundance estimates are found near 54,000 (Miyashita, 1993). Estimates of 160,000 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). Estimates of 2,388 and 14,524 short-finned pilot whales were reported for the Gulf of Mexico and western North Atlantic, respectively (Waring et al, 2004; Waring et al., 2002).

Pilot whale distribution is wide ranging with short-finned pilot whales having a tropical and subtropical distribution and long-finned pilot whales occurring outside of tropical waters (Olson and Reilly, 2002). There is little overlap in their ranges. Overlaps do occur at about 30° to 40° N in the North Atlantic and at around 35° S in the Southern Atlantic (Evans and Raga, 2001).

Long-finned pilot whales occur off shelf edges in deep pelagic waters and in temperate and subpolar zones from 20° to 75°N and from 5° to 70°S, 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 which may be correlated to breeding season lasting from May to November (Nelson and Lien 1996; Sergeant 1962).

Short-finned pilot whales are found in warmer waters of temperate and tropical zones of the world from 50°N to 40°S (Leatherwood and Dahlheim, 1978; Kasuya and Marsh, 1984). There appears to be little seasonal movement of this species. Some short-finned pilot whales staying year-round near the California Channel Islands while 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/h (1.1 to 6.5 knots) (Shane, 1995). Long-finned pilot whales have an average speed of 3.3 km/h (1.8 knots) (Nelson and Lien, 1996). Short-finned pilot whales have swim speeds ranging between 7 and 9 km/h (3.8 and 4.6 knots) (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). Long-finned pilot whales range in dive depths from 16 m (52 ft) during the day to 648 m (2126 ft) during the night (Baird et al., 2002a). The dive times varied between 2 and 13 min. A short-finned pilot whale was recorded as diving to 610 m (2,000 ft) (Ridgway, 1986).

There is no direct measurement of auditory threshold for the hearing sensitivity of either long- or short-finned pilot whales (Ketten, 2000; Thewissen, 2002).

Pilot whales echolocate with a precision similar to bottlenose dolphins and also vocalize with other school members (Olson and Reilly, 2002). Long-finned pilot whales produce sounds as low as 500 Hz and as high as 18 kHz, with dominant frequencies between 1 to 11 kHz (Schevill, 1964; Busnel and Dziedzic, 1966; Taruski, 1979; Steiner, 1981; McLeod, 1986). These sounds include double clicks and whistles with a mean frequency common among this species at 4,480 Hz (Olson and Reilly, 2002; Frankel, 2002). Sound production of long-finned pilot whales is correlated with behavioral state and environmental context (Taruski, 1979; Weilgart and Whitehead, 1990; Frankel, 2002). 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, 2002). There is 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 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). Sounds produced by this species average near 7,870 Hz, higher than that of a long-finned pilot whale (Olson and Reilly, 2002). 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 and Reilly, 2002).

Subfamily Delphininae

The subfamily Delphininae includes Risso's dolphin (*Grampus griseus*), both short-beaked (*Delphinus delphis)* and long-beaked (*Delphinus capensis)* common dolphins, Fraser's dolphin (*Lagenodelphis hosei*) and bottlenose dolphin (*Tursiops truncatus*). The genus, *Stenella* contains five species: pantropical spotted dolphin (*Stenella attenuata)*, Clymene dolphin (*Stenella clymene*), striped dolphin (*Stenella coeruleoalba*), Atlantic spotted dolphin (*Stenella frontalis*), and spinner dolphin (*Stenella longirostris*). The genus, *Lagenorhynchus*, contains six species: the Atlantic white-sided dolphin (*Lagenorhynchus acutus*), white-beaked dolphin (*Lagenorhynchus albirostris*), Peale's dolphin (*Lagenorhynchus australis*), hourglass dolphin (*Lagenorhynchus cruciger*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and dusky dolphin (*Lagenorhynchus obscurus)*.[5]

Risso's dolphin (*Grampus griseus*) is classified as a data deficient species by the IUCN. The global population for this species is unknown. In the ETP, estimates of 175, 800 have been documented (Wade and Gerrodette, 1993). Ship surveys give an estimate of approximately 8,500 Risso's dolphins off California (Barlow, 1995). Estimates of 12,748 and 29,110 were reported for the eastern North Pacific and western North Atlantic, respectively (Carretta et al., 2005; Waring et al., 2002).

Risso's dolphin inhabits deep oceanic and continental slope waters from the tropics through the temperate regions from 55°S to 60°N (Leatherwood et al., 1980; Jefferson et al., 1993; Baird, 2002b). They occur predominantly at steep shelf-edge habitats, between 400 and 1000 m (1300 and 3281 ft) deep with water temperatures commonly between 15 and 20°C and rarely below 10°C (Baird, 2002b). 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 is available, and Risso's dolphins have been known to calve year round, peaking in the winter (Baird, 2002b).

Swim speeds from Risso's dolphins were recorded at 2 to 12 km/h (1.1 to 6.5 knots) off Santa Catalina Island (Shane, 1995). Risso's dolphins feed on squid species found more than 400 m (1,300 ft) deep (Gonzalez et al., 1994 *in* Croll et al., 1999). Behavioral research suggests that

[5] The classification was taken from Perrin (1989) and reflects a traditional view of species interrelationships. This classification is not based on molecular systematic analysis.

Risso’s dolphins primarily feed at night (Baird, 2002b). There are currently no known studies on diving behavior.

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 (Nachtigal et al, 1995 *in* Nedwell et al., 2004). Phillips et al. (2003) report that Risso’s dolphins are capable of hearing frequencies up to 80 kHz. Best underwater hearing occurs between 4 and 80 kHz with hearing threshold levels from 63.6 to 74.3 dB RL. Hearing thresholds from this study were tested between 1.6 and 110 kHz and were approximately 125 dB down to approximately 65 dB RL (Nachtigall et al., 1995 *in* Croll et al., 1999 and Nedwell et al., 2004). Other audiograms obtained on Risso’s dolphin (Au et al., 1997) confirm previous measurements and demonstrate hearing thresholds of 140 dB RL for a one-second 75 Hz signal (Au et al., 1997; Croll et al., 1999).

Au et al. (1997) conducted a survey on the effects of the ATOC program on false killer whales and on Risso’s dolphins, which will be discussed later. The ATOC program broadcasted a low-frequency 75-Hz phase modulated, 195 dB SL acoustic signal over ocean basins to study ocean temperatures on a global scale. The hearing sensitivity was measured for Risso’s dolphins and their thresholds were found to be 142.2 dB RL, plus or minus 1.7 dB for the 75-Hz pure tone signal and 140.8 dB RL plus or minus 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 at 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* Croll et al., 1999). 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, 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.

The three **common dolphin species,** the **short-beaked (*Delphinus delphis)*** and **long-beaked (*Delphinus capensis)*,** and the **very long-beaked (*Delphinus tropicalis*),** are classified as lower risk/least concern species by the IUCN. The global population for all species is unknown. Common dolphins are the most abundant species at an estimate of 365,617 short-beaked common dolphins in the eastern Pacific (Carretta et al., 2005). Ship surveys give an estimate of 225,821 short-beaked common dolphins in California (Barlow, 1995). An estimate of 31,000 has been documented in the northwestern Atlantic (Waring et al., 2004). There is little data available on abundance estimates of long-beaked common dolphins. The only regional estimate is from the coast of California at 25,163 long-beaked common dolphins (Carretta et al., 2005).

Short-beaked and long-beaked common dolphins are distributed worldwide in temperate, tropical, and subtropical oceans, primarily along continental shelf and bank regions from about 60°N to 50°S (Perrin, 2002b; Jefferson et al., 1993). They seem to be most common between 40°N to 40°S 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, 2002b). Short-beaked common dolphins occur from southern Norway to West Africa in the eastern Atlantic Ocean (including the Mediterranean and Black Seas), from Newfoundland to Florida in the western Atlantic, from Canada to Chile along the coast and pelagically in the eastern Pacific, and in the central North Pacific (excluding Hawaii) from central Japan to Taiwan. Short-beaked common dolphins are also found around New Caledonia, New Zealand, and Tasmania in the western Pacific, and possibly in the South Atlantic and Indian Oceans. 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, South Africa. There is a possibility that they also occur off Oman in the Indian Ocean. Very long-beaked common dolphins are only known to occur in the northern Indian Ocean and in Southeast Asia.

Seasonal abundance estimates of short-beaked common dolphins in the North Pacific suggests that their migrations north to south, and/or inshore to offshore may vary with oceanographic conditions (Perrin, 2002b). In the eastern Pacific, they primarily occupy upwelling-modified habitats with less tropical characteristics compared to surrounding waters (Perrin, 2002b). Calving peaks during May and June both in the northeastern Atlantic and North Pacific. No breeding grounds are known for common dolphins (Croll et al., 1999).

Swim speeds for *Delphinus* spp. have been measured regularly at 5.8 km/h (3.1 knots) with maximum speeds of 16.2 km/h (8.7 knots) (Hui, 1987). During 7-second intervals, they have been recorded as swimming up to 37.1 km/hr (20 knots) (Croll et al., 1999). Dive depths range between 9 and 200 m (30 and 656 ft), with a majority of dives being 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 (Perrin, 2002b). The deepest foraging dive recorded was 200 m (656 ft) (Evans, 1994 *in* Perrin, 2002b). Common dolphins feed on a variety of prey including mesopelagic fish and squids in the deep scattering layer and on epipelagic schooling species such as small scombroids, clupeoids, and squid (Evans, 1994; Perrin, 2002b). However, their diet varies depending on the region.

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, 1980a; Au, 1993; Moore and Ridgway, 1995 *in* Croll et al., 1999). Signal types consist of clicks, squeals, whistles, and creaks (Evans 1994 *in* Croll et al., 1999). Whistles of short-beaked common dolphins range between 7.4 and 13.6 kHz, while long-beaked common dolphins have a frequency range of 7.7 and 15.5 kHz for their whistle production (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*)** is classified as a data deficient species by the IUCN. The global population for this species is unknown. Estimates of 289,300 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993; Dolar, 2002). An estimate of 726 animals was reported in the Gulf of Mexico (Waring et al., 2004).

Fraser's dolphins occur primarily in tropical and subtropical waters from 50°N to 40°S, although most documentation shows distributions from 30°N to 30°S (Dolar, 2002; Croll et al., 1999). This species is commonly found near central Visayas, Philippines in near-shore waters, along the outer continental shelf, and in deep oceanic waters (Watkins et al., 1994; Leatherwood et al., 1993 *in* Croll et al., 1999), as well as Indonesia and the Lesser Antilles where they can be observed 100 m (328 ft) from shore (Dolar, 2002). They were observed 15 km (9.3 mi) offshore in the eastern tropical Pacific, as well as in the high seas at 45 to 110 km (28 to 68.3 mi) from the coast, where the water depths are between 1500 and 2000 m (4921 and 6562 ft). In the Sulu Sea, Fraser's dolphins were observed in water depths up to 5000 m (16404 ft) and in shallower waters adjacent to the continental shelf. They are more common in the Gulf of Mexico compared to anywhere else, and they are commonly seen in waters with depths around 1000 m (3280.8 ft) (Dolar, 2002). Fraser's dolphins are occasionally seen in the Atlantic Ocean (Watkins et al., 1994). 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, 2002).

Swim speeds of Fraser's dolphin have been recorded between 4 and 7 km/h (2.2 and 3.8 knots) with swim speeds up to 28 km/hr (15 knots) 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 eastern tropical Pacific. 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 (1968.5 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. They feed on mesopelagic fish, crustaceans, and cephalopods, particularly Myctophidae, Chauliodontidae, and Oplophoridae (Croll et al., 1999; Dolar, 2002).

There is no direct measurement of auditory threshold for 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.

The **bottlenose dolphin (*Tursiops truncatus*)** is classified as a data deficient species by the IUCN. The global population for this species is unknown. Estimates of 243,500 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). In the western North Pacific, 169,000 bottlenose dolphins were estimated (Miyashita, 1993). A total of 6,900 bottlenose dolphins was estimated in the Black Sea, and a minimum of 2,000-3,000 animals have been estimated for Shark Bay, Australia (Croll et al., 1999). Additionally, approximately 30,000 and 35,000 animals have been estimated for the western North Atlantic and Gulf of Mexico (including the shelf) (Waring et al., 2004).

The bottlenose dolphin is distributed worldwide in temperate to tropical waters, mostly between 50 °S to 45°N and up to 60°N around the United Kingdom and northern Europe (Croll et al., 1999). In North America, they inhabit waters with temperatures ranging from 10 to 32°C (Wells and Scott, 2002). They are primarily coastal, but they also occur in very diverse habitats ranging from rivers and protected bays (Scott and Chivers, 1990; Sudara and Mahakunlayanakul, 1998) to oceanic islands and the open ocean (Scott and Chivers, 1990), over the continental shelf, and along the shelf break (Wells and Scott, 2002). Bottlenose dolphins are common in the southern Okhotsk Sea, the Kuril Islands, and along central California in the North Pacific. In the Atlantic, they are found inshore during the summer months in New England north to Nova Scotia and have been sighted in Norway and the Lofoten Islands. The southern range extends as far south as Tierra del Fuego, South Africa, Australia, and New Zealand (Wells and Scott, 2002). Seasonal movements vary between inshore and offshore locations and year-round home ranges (Croll et al., 1999; Wells and Scott, 2002). Calving season is generally year-round with peaks occurring from early spring to early fall (Scott and Chivers, 1990 *in* Croll et al., 1999). Data on breeding grounds is not available.

Sustained swim speeds for bottlenose dolphins range between 4 and 20 km/h (2.2 and 10.8 knots). Speeds commonly range from 6.4 to 11.5 km/h (3.4 to 6.2 knots) and may reach speeds as high as 29.9 km/h (16.1 knots) for 7.5 seconds (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 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).

The diet of the bottlenose dolphin is diverse in nature, ranging from coastal squid and fish to small mesopelagic fish and squid (Croll et al., 1999), with a preference for sciaenids, scombrids, and mugilids (Wells and Scott, 2002). Seasonal and geographical variation may influence the diet of bottlenose dolphins (Evans, 1994). There is also some evidence that dolphins feed in different areas depending on sex and size. Lactating females and calves have been reported foraging in the near-shore zone, while adolescents feed farther offshore. Females without young and male adults may feed still farther offshore (Wells and Scott, 2002). Bottlenose dolphins appear to be active during both the day and night. Their activities are influenced by the seasons, time of day, tidal state, and physiological factors such as reproductive seasonality (Wells and Scott, 2002).

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 kHz, where the threshold level range is 42 to 52 dB RL (Sauerland and Dehnhardt, 1998). Bottlenose dolphins also have good sound location abilities and are most sensitive when sounds arrive from the front (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, 1980a; McCowan and Reiss, 1995; Schultz et al., 1995; Croll et al., 1999; Oswald et al., 2003). The maximum SL 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 *in* Helweg et al., 2003; Jones and Sayigh, 2002). According to Au (1993), sonar clicks are broadband, ranging in frequency from a few kHz 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 percent of the peak frequency (Houser et al., 1999 *in* Helweg et al., 2003).

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.

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 (Frankel, 2002; Sayigh, 2002). Maximum sound levels can reach 228 dB. Stereotypically, 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 a SL of 125 to 140 dB (3.3 ft) (Croll et al., 1999).

McCowan et al. (1999) discusses bottlenose dolphins and their structure and organization of communication mathematically. They apply Zipf's law, which examines the first-order entropic relation and evaluates the signal composition of a repertoire by examining the frequency of use of signals in a relationship to their ranks. It measures the potential capacity for information transfer at the repertoire level by examining the optimal amount of diversity and redundancy necessary for communication transfer across a noisy channel. The results from this experiment suggest that Zipf's statistic can be applied to animal vocal repertoires, specifically in this case, dolphin whistle repertoires, and their development. Zipf's statistic may be an important comparative measure of repertoire complexity both inter-species and as an indicator for vocal acquisition or learning of vocal repertoire structure within a species. The results also suggest that dolphin whistles contain some higher-order internal structure, enough to begin to predict statistically what whistle types might immediately follow the same or another whistle type. A greater knowledge of the higher-order entropic structures could allow the reconstruction of dolphins whistle sequence structure, independent of additional data inputs such as actions and non-vocal signaling (McCowan et al., 1999).

In contrast to the signature whistle theory, McCowan and Reiss, (2001) stated that predominant whistle types produced by isolated dolphins were the same whistle types that were predominant for all adult subjects and for infant subjects by the end of their first year in both socially interactive and separation contexts. No evidence for individually distinctive signature whistle contours was found in the bottlenose dolphins studied. Ten of 12 individuals produced one shared whistle type as their most predominant whistle during contexts of isolation. The two other individuals produced two other predominant whistle types that could not be considered signature whistles because both whistle types were shared among many different individuals within and across independent captive social groups (McCowan and Reiss, 2001).

Jones and Sayih (2002) reported geographic variations in behavior and in the rates of vocal production. Both 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).

The genus ***Stenella*** contains 5 species of dolphins: clymene, Atlantic spotted, striped, pantropical spotted, and spinner dolphins. Clymene and Atlantic spotted dolphins are classified as data deficient species status and the striped, pantropical, spotted and spinner dolphins are classified as lower risk status under the IUCN.

The worldwide population size for all species of *Stenella* spp.are unknown. Striped dolphins are known to be the most abundant species in the Mediterranean Sea (Archer, 2002). Pantropical, spinner and striped dolphins are estimated to be the most abundant cetaceans in the eastern tropical Pacific. Estimates of 2,059,100 pantropical spotted dolphins, 1,651,100 spinner dolphins, and 1,918,000 striped dolphins are reported for the eastern tropical Pacific (Croll et al., 1999). Estimates of 91,300 pantropical spotted dolphins, 12,000 spinner dolphins, 17,300 clymene dolphins, 31,000 Atlantic spotted dolphins, and 6,500 striped dolphins are reported for the Gulf of Mexico (Waring et al., 2004).

The five species of ***Stenella*** inhabit coastal and oceanic tropical and subtropical waters from 40°S to 40°N (Perrin and Gilpatrick, 1994; Perrin and Hohn, 1994). Pantropical, clymene, spotted and spinner dolphins are particularly found in tropical waters, while striped dolphins occur in more temperate waters with seasonal upwelling and seasonal changes (Perrin and Hohn, 1994). Spotted dolphins tend to be distributed coastally in depths of less than 400 m (1312 ft), while the other four species of *Stenella* stay offshore in depths greater than 700 m (2297 ft) (Croll et al., 1999). There has been some evidence of migration from seasonal and annual shifts in abundance of pantropical, spotted and spinner dolphins in the eastern tropical Pacific. Pantropical and spinner dolphins are considered seasonal breeders (Perrin and Hohn, 1994; Croll et al., 1999). There are no specific breeding areas.

Very little information is known about clymene dolphins because they are one of the most recently recognized species of dolphins. They are only found in the tropical to warm-temperate waters of the South and mid-Atlantic Ocean. Most sightings of clymene dolphins have been in deep, offshore waters. Very little is known about their ecology. They feed mostly on mesopelagic fish and squid (Jefferson, 2002a).

The Atlantic spotted dolphin is found only in the tropical and warm-temperate waters of the Atlantic Ocean. They range from approximately 50°N to 25°S, and are commonly found around the southeastern United States 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. Atlantic spotted dolphins eat a variety of prey, including epipelagic and mesopelagic fish and squids, and benthic invertebrates (Perrin, 2002a).

Striped dolphins are common in tropical and warm-temperate waters, usually below 43°N. 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. Striped dolphins forage at depths of 200 to 700 m (656 to 2297 ft), and feed on a variety of pelagic or benthopelagic fish and squid. Off the coast of Japan and South Africa, striped dolphins feed on fish in the family Myctophidae. In the Mediterranean, they eat more squid (Archer, 2002). In the Ligurian Sea, striped dolphins are commonly found along the Ligurian Sea Front, which has water depths of 2000 to 2500 m (6562 to 8202 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).

Pantropical spotted dolphins occur throughout the tropical and sub-tropical Indo-West Pacific. Their distribution is generally between 30 and 40°N and 20 to 40°S (Perrin, 2002d). They range from South Africa to the Red Sea and Persian Gulf, east to Australia, the Indo-Malayan Archipelago, and the Philippines, and north to southern Japan (Rudolph and Smeenk, 2002). 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 of their feeding is at night (Stewart, 2002). Their prey includes small epipelagic fish, squids, and crustaceans, flying fish (Perrin, 2002d).

Spinner dolphins are pantropical. They occur in all tropical and most subtropical waters, and range between 30 and 40°N and 20 to 30°S. Spinner dolphins are common in the high seas, but coastal populations do exist in Hawaii, the eastern Pacific, Indian Ocean, and Southeast Asia. They dive to 600 m (1969 ft) or deeper to feed mainly on mesopelagic fish and squids. The dwarf species in Southeast Asia is found in shallower waters in the Gulf of Thailand, Timor Sea, and Arafura Sea. These dolphins eat mostly benthic and reef fish and invertebrates (Perrin, 2002c).

Average swim speeds of 11 km/h (5.9 knots) were measured from striped dolphins in the Mediterranean (Archer and Perrin, 1999). Hawaiian spinner dolphins have swim speeds ranging from 2.6 to 6 km/h (1.4 to 3.2 knots) (Norris et al., 1994). Pantropical spotted dolphins have been recorded swimming up to 39.7 km/hr (21.4 knots) for 2 seconds, although, this may be an overestimate. Other individuals have been recorded as swimming at speeds of 4 to 19 km/hr (2.2 to 10.3 knots) with bursts up to 22 km/hr 12 knots) (Perrin, 2002d). 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 with depths as deep as 100 m (Scott et al., 1993). Dives of up to 3.4 min have been recorded (Perrin, 2002d). An Atlantic spotted dolphin was documented with a maximum dive duration of 3.5 min (Davis et al., 1996).

Based on ABRs, striped dolphins hear SLs equal to or louder than 120 dB in the range of less than 10 to greater than 100 kHz (Popper, 1980a). The behavioral audiogram developed by Kastelein and Hagedoorn (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 and Hagedoorn, 2003). They have relatively less hearing sensitivity below 32 kHz and above 120 kHz. There is no direct measurement of auditory threshold for the hearing sensitivity of the remaining *Stenella* dolphins (Ketten, 2000; Thewissen, 2002).

Dolphins of the genus *Stenella* produce sounds as low as 0.1 kHz and as high as 160 kHz with tri-modal dominant frequencies at 5 to 60 kHz, 40 to 50 kHz, and 130 to 140 kHz (Caldwell and Caldwell, 1971c; Popper, 1980a; Steiner, 1981; Norris et al., 1994; Richardson et al., 1995; Au et al., 1998; Croll et al., 1999; Oswald et al., 2003). The amount and variety of signal types generally increases with increasing social activity, particularly in Hawaiian spinner dolphins (Frankel, 2002). 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).

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 is 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).

The 6 species in the genus ***Lagenorhynchus*** (Peale's, dusky, Atlantic white-sided, white-beaked, hourglass, and Pacific white-sided dolphins) are currently classified with Peale's and dusky dolphins as data deficient species status. Atlantic white-sided, white-beaked, hourglass, and Pacific white-sided dolphins are classified as lower risk status. The worldwide population sizes for all species of *Lagenorhynchus* spp. are unknown. Between 30,000 and 50,000 Pacific white-sided dolphins have been estimated around Japan (Nishiwaki and Oguro, 1972), and ship surveys report an estimate of 39,800 Pacific white-sided dolphins in eastern North Pacific waters (Carretta et al., 2005). Estimates of the Atlantic white-sided dolphins were approximate 77,000 along the North American seaboard (Croll et al., 1999). A total of 3,486 white-beaked dolphins were reported in the shelf water along the coast of Labrador (Alling and Whitehead, 1987), and 6,000 white-beaked dolphins were estimated in the western North Atlantic (Waring et al., 2004). 144,300 hourglass dolphins have been estimated south of the Antarctic Convergence in January (Kasamatsu and Joyce, 1995).

Peale's dolphins inhabit the inshore waters of southern South America and the Falkland Islands, from 60° to 35°S. They live in coastal bays, inlets and the shelf waters. Occasional sightings have occurred around the Palmerston Atoll in the south Pacific (Goodall, 2002c; Reeves and Leatherwood, 1994 *in* Croll et al., 1999). In the Strait of Magellan and near Isla Chiloe, resident Peale's dolphins have been noted throughout the year, with more animals present during the summer. The dolphins move inshore during the summer in Tierra del Fuego. They are found in open coasts over continental shelves to the north and deep, protected bays and channels to the south and west. They often swim in kelp beds. Prey include octopus in the kelp beds and demersal and bottom fish. Peale's dolphins dive sequences are usually three short dives followed by one longer dive. Their dive durations last between 3 and 157 seconds, averaging 28 seconds (Croll et al., 1999).

Dusky dolphins occur off the coastal waters of New Zealand, South America, southwestern Africa and several islands in the South Atlantic and southern Indian Oceans from 60° to 9°S (Croll et al., 1999). They are distributed from northern Peru south to Cape Horn and from southern Patagonia north to approximately 36°S. They can also be found off of southwest Africa from False Bay to Lobito Bay, Angola, and off of New Zealand including Chatham and Campbell Islands. No well-defined seasonal migrations are apparent, but they are known to have a range of 780 km (484.7 mi) (Van Waerebeek and Wursig, 2002). However, 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 Patagonia, they are known to forage during the day on fish. Off of New Zealand, they feed at night on prey in the deep scattering layer. Prey spercies include hake, anchovies, and squid (Van Waerebeek and Wursig, 2002). Off Argentina, the mean dive time for dusky dolphins was 21 seconds, with shorter dives during the day and longer dives at night (Wursig, 1982). Dusky dolphins in New Zealand swim at mean routine speeds between 4.5 and 12.2 km/hr (2.4 and 6.6 knots) (Cipriano, 1992).

Atlantic white-sided dolphins are found in the cold-temperate waters of the North Atlantic from 35°N to 80°N. They generally range over the continental shelf and slope, extending into deeper oceanic waters and occasionally into coastal areas. Cape Cod is the southern limit to the Atlantic white-sided dolphin, with an eastern limit of Georges Band and Brittany. In the north, they extend at least to Greenland, southern Iceland, and the south coast of Svalbard Island. Atlantic white-sided dolphins apparently undergo seasonal movements on both sides of the Atlantic. Calving occurs during the summer months (Croll et al., 1999; Kinze, 2002). They prey on herring, mackerel, gadid fish, smelts and hakes, sand lances, and squids. Atlantic white-sided dolphins are probably not deep divers. A tagged dolphin dove for an average of 38.8 seconds with 76 percent of dives lasting less than 1 minute (Mate et al., 1994). This dolphin also swam at an average speed of 5.7 km/h (3.1 knots).

White beaked dolphins share a similar habitat to that of the Atlantic white-sided dolphin, but within a more northern range, which includes the western Mediterranean Sea (Evans, 1987; Jefferson et al., 1993; Reeves and Leatherwood, 1994; Cipriano, 2002; Kinze, 2002). White-beaked dolphins are distributed in the temperate and subarctic North Atlantic Ocean. They are often in shelf waters and sometimes in shallow coastal waters. They can be found as far north as the White Sea in the northeast Atlantic and are abundant along the Norwegian coasts and in the northern parts of the North Sea along the United Kingdom, Belgium, the Netherlands, Germany, and Denmark. White-beaked dolphins are less abundant in the northwest Atlantic compared to the northeast, and the largest concentrations are found off the Labrador coast and in southwest Greenland. Some individuals have been seen as far south as Cape Cod. Calving occurs during the summer months (Croll et al., 1999; Kinze, 2002). They feed mostly on mesopelagic fish such as cod, whiting, other gadids, and squids (Kinze, 2002).

Hourglass dolphins are pelagic animals that occur in the high latitudes of the Southern Hemisphere from 68 to 33 deg S latitude (Croll et al., 1999; Goodall, 2002b). It has been suggested that this species may undergo a southward migration to the Antarctic during the summer season (Kasamatsu and Joyce, 1995 *in* Goodall, 2002b). They are found on both sides of the Antarctic Convergence and northward in cool currents associated with the West Wind Drift. Water temperatures range from - 0.3 to 13.4 deg C (31.5 to 56.1 deg F). Most sightings are near islands and banks, often in the Drake Passage. Hourglass dolphins feed on small fish and squid, seabirds and in plankton slicks (Goodall, 2002b). Hourglass dolphins have swim speeds between 7 and 29 km/h (3.8 and 15.7 knots) (Croll et al., 1999; Goodall, 2002b).

Pacific white-sided dolphins are mostly pelagic and have a primarily temperate distribution across the North Pacific, 20 to 60 deg N latitude (Jefferson et al., 1993 *in* Croll et al., 1999; Croll et al., 1999). They have been recorded with a seasonal north-south migration pattern and calve during the late winter and spring off California and in the North Pacific (Croll et al., 1999) from Taiwan to the Kurile and Commander Islands in the west. They are more common on the coasts in the fall and winter and move offshore in the spring and summer, following their prey. It is assumed based on feeding habits that Pacific white-sided dolphins dive to at least 120 m (393.7 ft), with most of their foraging dives lasting 15 to 20 seconds (Croll et al., 1999). Captive Pacific white-sided dolphins have been recorded as swimming up to 27.7 km/hr (15.0 knots) during 2-second intervals (Croll et al., 1999). Ferrero et al. (2002) examined the indications of habitat use patterns in the central North Pacific for Pacific white-sided dolphin, along with Dall's porpoise and northern right whale dolphins. They are the three most common cetacean species in the central North Pacific (from 37 to 46 deg N latitude and 170 deg E to 150 deg W longitude) . Similar to that reported in Croll et al. (1999), Ferrero et al. (2002) reported that the Pacific white-sided dolphin occurs across temperate Pacific waters to latitudes as low as or lower than 38 deg N, and northward to the Bering Sea and coastal areas southeast of Alaska. The primary habitat feature of the studied area is the Polar Front Region which is at 45 deg N latitude at 170 deg E longitude, curving southward to 42 deg N latitude at 150 deg W longitude. North of the front, the surface waters have relatively low salinity and waters to the south of the Front generally have a higher salinity. The sea surface temperature, however, was the most pronounced environmental feature in the studied species' habitat. Pacific white-sided dolphins showed the broadest preference for sea surface temperature in the study area (Ferrero et al., 2002).

No breeding grounds are known for *Lagenorhynchus* spp.

Pacific white-sided dolphins hear frequencies in the range of about 0.5 to 135 kHz when the sounds are equal to or softer than 120 dB RL. At a frequency of 1 kHz, they can listen to pure tones that are at least 106 dB RL. At an intensity less than 90 dB RL, they can hear a frequency range of 2 to 128 kHz (Tremel et al., 1998 *in* Croll et al., 1999). There is no direct measurement of auditory threshold for the hearing sensitivity of the remaining *Lagenorhynchus* dolphins (Ketten, 2000; Thewissen, 2002).

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, 1980a; Richardson et al., 1995).

Peale's dolphin vocalizations were recorded in the Chilean channel. The recordings showed that Peale's dolphins make broadband clicks at 5 to 12 kHz and narrowband clocks at 1- to 2-kHz bandwidths (Goodall, 2002c). Peale's dolphin SLs were recorded at low levels of 80 dB 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).

The average estimated SL for an Atlantic white-sided dolphin is approximately 154 dB with a maximum at 164 dB (Croll et al., 1999).

Clicks produced by white-beaked dolphins resemble those by bottlenose dolphins. They make short, broadband clicks with peak frequencies of about 120 kHz. They are approximately 10 to 30 microsec in duration. Some clicks have a secondary peak of 250 kHz. The maximum sound level from one study was recorded at 219 dB and was measured at a range of 22 m (72.2 ft). The minimum recorded sound level was 189 dB at a distance of 1.5 m (4.9 ft) from the dolphin (Rassmussen et al., 2002).

Pacific white-sided dolphins produce broad-band clicks which have a SL at 180 dB (Richardson et al 1995; Rasmussen et al., 2002).

There are no available data regarding seasonal or geographical variation in the sound production of *Lagenorhynchus* dolphins.

Subfamily Steninae

The subfamily Steninae includes one species of interest: the rough-toothed dolphin (*Steno bredenansis*).

Rough-toothed dolphins (*Steno bredenansis*) are currently classified with a data deficient species status under IUCN. The worldwide population size for this species is unknown. Estimates of 145,900 have been documented in the eastern tropical Pacific (Wade and Gerrodette, 1993). Estimates of 2,223 have been documented in the Gulf of Mexico (Waring et al., 2004)

Rough-toothed dolphins occur between 45 deg S to 55 deg N in deep, oceanic tropical, subtropical, and warm-temperate waters around the world and appear to be relatively abundant in certain areas (Croll et al.; 1999; Jefferson, 2002c). In the Atlantic Ocean, they are found between the southeastern United States and southern Brazil, across to the Iberian Peninsula and West Africa. Some animals have been seen in the English Channel and North Sea. Their range also includes the Gulf of Mexico, Caribbean Sea, and the Mediterranean Sea (Jefferson, 2002c). 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. Their range includes the southern Gulf of California and the South China Sea. They have an extensive distribution north of 20 deg S with scattered sighting records in New Zealand, the Indian Ocean, and along the western United States. Rough-toothed dolphins feed on fish and cephalopods (Jefferson, 2002c). Breeding areas and seasonal movements of 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 and have a distinctive splash (Jefferson, 2002c). Swim speeds of this species vary from greater than 5.5 to 16 km/h (3.0 to 8.6 knots). Rough-toothed dolphins can dive down between 30 and 70 m (98 and 230 ft)(Croll et al., 1999). The dive duration ranges from 0.5 to 3.5 min (Ritter, 2002). The maximum dive recorded was 70 m (230 ft). Although, due to their morphology, it is believed that they are capable of diving much deeper. Dives up to 15 min have been recorded for groups of dolphins (Croll et al., 1999).

There is no direct measurement of auditory threshold for the hearing sensitivity of rough-toothed dolphins (Ketten, 2000; Thewissen, 2002).

Rough-toothed dolphins produce sounds ranging from 0.1 kHz up to 200 kHz (Popper, 1980a; 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 and at 4 to 7 kHz (Norris and Evans, 1967; Norris, 1969; Popper, 1980a). There is no available data regarding seasonal or geographical variation in the sound production of this species.

Subfamily Lissodelphinae

The subfamily Lissodelphinae consists of two species, the northern right whale dolphin (*Lissodelphis borealis)* and the southern right whale dolphin (*Lissodelphis peronii).*

The finless **northern right whale dolphin (*Lissodelphis borealis)*** is currently classified as lower risk status and the **southern right whale dolphin (*Lissodelphis peronii)*** is listed as data deficient under IUCN. The worldwide population size for these species is unknown. Although, ship surveys have produced population estimates of 16,417 northern right whale dolphins in the eastern Pacific (Carretta et al., 2005).

Right whale dolphins inhabit cool-temperate and sub-Arctic waters in the North Pacific, circumpolar sub-Antarctic, and cool-temperate waters in the Southern Ocean. They are found in oceanic, deep waters, on highly productive continental shelves, or where deep waters approach the coast (Lipsky, 2002).

Northern right whale dolphins inhabit deep, offshore waters in the North Pacific. They range from 29 to 59 deg N latitude (Croll et al., 1999), but are commonly found from 34 to 55 deg N latitude and 145 deg W to 118 deg E longitude. They range from the Kuril Islands, Russia, south to Sanriku, Honshu, Japan, and eastward to the Gulf of Alaska and south to Southern California (Lipsky, 2002). They prefer cold, deep, offshore waters, most often between 8 and 19 deg C (Croll et al., 1999). This species migrates southward and inshore during the winter and northward and offshore during the summer months (Kasuya, 1971 *in* Croll et al., 1999; Leatherwood and Walker, 1979; Lipsky, 2002). They feed mostly on squid and lanternfish, but also prey on Pacific hake, saury, and mesopelagic fish (Lipsky, 2002).

Ferrero et al. (2002) examined the indications of habitat use patterns in the central North Pacific for northern right whale dolphins, along with Dall’s porpoise and Pacific white-sided dolphins. They are the three most common cetacean species in the central North Pacific (from 37 N to 46 deg N latitude and 170 deg E to 150 deg W longitude). Similar to that reported in Croll et al. (1999), Ferrero et al. (2002) reports that northern right whale dolphins range from 30 to 50 deg N latitude in the eastern Pacific Ocean and from 35 to 51 deg N latitude in the western Pacific Ocean. The primary habitat feature of the studied area is the Polar Front Region which is at 45 deg N latitude at 170 deg E longitude, curving southward to 42 deg N latitude at 150 deg W longitude. North of the front, the surface waters have relatively low salinity and to the south generally have higher salinity. The sea surface temperature, however, was the most pronounced environmental feature in the studied species’ habitat. The northern right whale dolphins were found to occupy the warmer waters. However, this could also have been related to their reproductive activity (Ferrero et al., 2002).

Southern right whale dolphins inhabit the area between the Subtropical and Antarctic Convergence zones most commonly between 25 and 55 deg S latitude but range from 25 to 65 deg S latitude. Their range extends northwards along cold-water boundaries (Lipsky, 2002). They are commonly found in northern Chile (Lipsky, 2002). It has been suggested that southern right whale dolphins may migrate, although this species seems to inhabit waters off Namibia, Africa year round. Breeding grounds are unknown for both species. They feed on a variety of squids and fish (Lipsky, 2002).

Swim speeds for northern right whale dolphins can reach 34 to 40 km/hr (18.3 to 21.6 knots) (Croll et al., 1999; Lipsky, 2002). Southern right whale dolphins can swim up to 22 km/h (12 knots) (Cruickshank and Brown, 1981). The maximum dive times recorded are 6.25 min for northern right whale dolphins and 6.5 min for southern right whale dolphins (Croll et al., 1999). They appear to make dives to more than 200 m (656 ft) while foraging (Jefferson et al., 1994; Fitch and Brownell, 1968; Croll et al., 1999).

There is no direct measurement of auditory threshold for the hearing sensitivity of *Lissodelphis* dolphins (Ketten, 2000; Thewissen, 2002).

Northern right whale dolphins 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 *in* Croll et al., 1999; Leatherwood and Walker, 1979 *in* Croll et al., 1999). The maximum known peak to peak SL of northern right whale dolphins is 170 dB (Fish and Turl, 1976 *in* Croll et al., 1999).

There are no data available on southern right whale dolphin sound production or on seasonal or geographical variation in the sound production of right whale dolphins.

Subfamily Cephalorhynchinae

The subfamily **Cephalorhynchinae** includes four species of the *Cephalorhynchus* genus: **Commerson's dolphin (*Cephalorhynchus commersonii)***, **black or Chilean dolphin (*Cephalorhynchus eutropia)***, **Heaviside's dolphin (*Cephalorhynchus heavisidii)*** and **Hector's dolphin (*Cephalorhynchus hectori)***.

The four species are currently classified with Commerson's, black, and Heaviside's dolphins as data deficient species status and Hector's dolphins as endangered status under IUCN. The worldwide population size for all species of *Cephalorhynchus* spp. is unknown. Total population of Hector's dolphins is estimated at 3,408 (Croll et al., 1999). In the northeastern Strait of Magellan, abundance estimates were recorded at 718 for Commerson's dolphins (Croll et al, 1999).

Cephalorhynchus dolphins are found in temperate coastal waters in the Southern Hemisphere, (Goodall et al., 1988; Goodall, 1994a and 1994b; Sekiguchi et al., 1998; Dawson, 2002). They occur in waters less than 200 m (656 ft) deep and are commonly seen in the surf zone (Dawson, 2002). *Cephalorhynchus* dolphins feed on demersal and pelagic fish, squid, and crustaceans (Slooten and Dawson, 1994; Croll et al., 1999). Heaviside's dolphin particularly preys on octopus (Dawson, 2002).

Commerson's dolphins inhabit coastal waters of the southwestern Atlantic off South America and the Kerguelen Islands in the southern Indian Ocean (Croll et al., 1999; Goodall, 1994a). They are mainly found in the coastal waters of Argentina and in the Strait of Magellan, but are sometimes seen in the Falkland Islands. They range from Rio Negro at 40°S and Cape Horn at

55°S down to the Drake Passage at 61°S to the Falkland Islands. At Kerguelen, they are frequently seen on the eastern side in the Golfe du Morbihan (Dawson, 2002). There is evidence of seasonal movement for this species (Goodall, 1994a). Calving season ranges between October and March (Goodall et al., 1988 *in* Croll et al., 1999).

The black or Chilean dolphin is restricted to the shallow, coastal waters, estuaries, and rivers of Chile, the Straits of Magellan, the channels of Tierra del Fuego, and along the west coast of Chile. Chilean dolphins have been noted as a year-round resident throughout their range. Chilean dolphins have a large latitudinal range, from Valparaiso at 33°S to near Cape Horn at 55°S on both open and sheltered coasts (Dawson, 2002). Calving appears to occur between October and March (Goodall et al., 1988 *in* Croll et al., 1999).

Heaviside's dolphins are only found along the west coast of southern Africa and Namibia from 17 deg S on the Namibian coast to Cape Town at 34 deg S and typically occur in shallow water no deeper than 100 m (328 ft) (Croll et al., 1999; Dawson, 2002). Most sightings are around Cape Town and Walvis Bay. There is no evidence of large-scale seasonal movement for Heaviside's dolphins (Dawson, 2002). They appear to calve in the austral summer (Croll et al., 1999).

Hector's dolphins inhabit shallow waters and occur off of New Zealand (Slooten and Dawson, 1994; Croll et al., 1999). They are most common on the east and west coasts of South Island between 41 and 44 deg S, particularly around Banks Peninsula and between Karamea and Moakawhio Point. A small population exists on the west coast of North Island between 36 and 38 deg S. An isolated population also exists in Te Wae Bay on the Southland coast. They are rarely seen more than 8 km (5 mi) from shore or in waters greater than 75 m (246 ft) deep. They range over about 30 km (18.6 mi) of coastline (Dawson, 2002). Calving season for Hector's dolphins ranges from early November to mid-February. There is no evidence of seasonal movement for Hector's dolphins (Croll et al., 1999).

No breeding areas are known for *Cephalorhynchus* dolphins.

No swim speeds are described for *Cephalorhynchus* dolphins. Heaviside's dolphins make relatively shallow and short dives typically less than 20 m (66 ft). Most dives lasted less than two min, and the maximum recorded dive from this species was 104 m (340 ft) by a male and 92 m (301.8 ft) by a female (Sekiguchi et al., 1998). The average long dive of Hector's dolphins lasts 89 seconds (Slooten and Dawson, 1994, Croll et al., 1999).

There is no direct measurement of auditory threshold for the hearing sensitivity of *Cephalorhynchus* dolphins (Ketten, 2000; Thewissen, 2002; Croll et al., 1999).

Dolphins of this genus produce sounds as low as 320 Hz and higher than 150 kHz, with dominant frequencies at 0.8 to 1 kHz, 1 to 2 kHz, 4 to 4.5 kHz, and 116 to 134 kHz (Croll et al., 1999; Watkins et al., 1977; Watkins and Schevill, 1980; Kamminga and Wiersma, 1981; Sho-Chi et al., 1982; Evans and Awbrey, 1984; Dawson, 1988; Evans et al., 1988; Dziedzic and De Buffrenil, 1989; Dawson and Thorpe, 1990; Au, 1993). The maximum peak to peak SL ranges from 160 dB for Commerson's dolphin to 163.2 dB for Hector's dolphin (Croll et al., 1999). The high click rates produced by this genus of dolphins are termed "cries" or "squeals" (Watkins et al., 1977; Dziedzic and DeBuffrenil, 1989; Dawson, 1988; Dawson and Thorpe, 1990). Hector's dolphin is the only *Cephalorhynchus* species that has been recorded comprehensively in the wild. Almost all of their sounds are short (140 microsec) with a high, narrow-band frequency of 125 kHz. Trains consist of several thousand ultra-sonic clicks. The maximum click rate calculated was 1149 clicks/second. Both Heaviside's and Chilean dolphins make this sound, but they have not been recorded. Commerson's and Hector's dolphins produce HF narrow band clicks (3-dB bandwidth = 10 to 22 kHz) with most energy focused around 120 to 130 kHz and little to no energy below 100 kHz (Croll et al., 1999). Clicks appear to have a role in both communication and echolocation (Dawson, 2002). Dziedzic and DeBuffrenil (1989) recorded sounds from Commerson's dolphins. Their "cry" sounds had a frequency up to 10 kHz with the most powerful part of the spectrum between 200 Hz and 5 kHz with a dominant component at about 1 kHz. Low-frequency clicks at 6 kHz had a duration of approximately 6 μs and had two dominant components at 1 and 2.4 kHz. Frequencies recorded from Heaviside's dolphin had a restricted bandwidth to less than 5 kHz and often less than 2 kHz with the major emphasis around 800 Hz. A secondary emphasis was sometimes around 2 to 5 kHz (Watkins et al., 1977).

Phocoenidae

The family Phocoenidae includes three species that have ranges that could overlap potential LFA operating areas. These are the harbor porpoise *(Phocoena phocoena)*, Dall's porpoise *(Phocoenoides dalli)*, and spectacles porpoise (*Phocoena dioptrica*).

The **harbor porpoise** ***(Phocoena phocoena)*** is considered a candidate species for the Gulf of Maine stock under the ESA and classified as vulnerable under IUCN. The North Atlantic population is estimated at 456,717 (IWC, 1996). The overall estimate from a survey in the North Sea in 1994 was 341,000 (Evans and Raga, 2001). Based on ship surveys off California and Oregon/Washington, estimates for harbor porpoises are 52,743 and 39,586, respectively (Barlow, 1995; Carretta et al., 2005). An estimate of 89,700 was reported for the Gulf of Maine (Waring et al., 2004).

Harbor porpoise are found in cold temperate and sub-arctic coastal waters of the Northern Hemisphere, from 15 to 70^{o} N (Gaskin, 1992; Jefferson et al., 1993; Bjorge and Tolley, 2002). 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 0 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, over deep water (Croll et al., 1999; Gaskin, 1992). For example, they are not found in California waters deeper than 125 m (410 ft) (Barlow, 1988). They show seasonal movement in northwestern Europe, which may be related to oceanographic changes throughout certain times of the year (Heimlich-Boran et al., 1998; Gaskin, 1992; Read and Westgate, 1997). Although migration patterns have been inferred in harbor porpoise (Gaskin, 1992), data suggests that seasonal movements of individuals are discrete and not temporally coordinated migrations (Read and Westgate, 1997). In certain areas harbor porpoise seem to be resident (Berrow et al., 1998). Three major isolated populations exist: 1) the North Pacific, 2) North Atlantic, and 3) the Black Sea of Azov (Yurick and Gaskin, 1987). However, there is morphological and genetic data that suggest that different populations may exist within these three regions (Croll et al., 1999).

Swim speeds for harbor porpoises range between 16.6 and 22.2 km/h (9.0 to 12.0 knots) (Kanwisher and Sundnes, 1965; Gaskin et al., 1974). Dive times range between 0.7 and 1.71 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). Descent rates are not constant. The deeper the dives, the faster mean decent and initial descent rates are (Croll et al., 1999).

The diet of this species is primarily small, pelagic schooling fish, but may include cephalopods (Read and Gaskin, 1988; Gannon et al., 1998; Bjorge and Tolley, 2002). Harbor porpoises have been known to dive for two to six min during foraging activity.

Harbor porpoise can hear frequencies in the range of 100 Hz to 140 kHz (Andersen, 1970; Kastelein et al., 2002). Kastelein et al. (2002) determined the best range of hearing for a two-year old male to be from 16 to 140 kHz. This harbor porpoise also demonstrated the highest upper frequency hearing of all odontocetes presently known (Kastelein et al., 2002).

Harbor porpoise are known to produce sounds ranging from 40 Hz to at least 150 kHz (Frankel, 2002), with dominant frequencies at 2 kHz and at 110 to 150 kHz (Popper, 1980a; Richardson et al., 1995). Variations of click trains have different functions based on the different frequency ranges associated with each activity. For example, long range detection has been associated with low frequency calls ranging from 1.4 to 2.5 kHz, while higher frequency, narrow band click trains ranging from 110 to 150 kHz may be used for object detection. Whistles are also part of the harbor porpoise repertoire, ranging from 40 to 600 Hz (Frankel, 2002). Estimated SLs can reach 177 dB (Richardson et al., 1995).

Dall's porpoise *(Phocoenoides dalli)* is considered lower risk (conservation dependent) under the IUCN. The total population of Dall's porpoise is estimated to be 1.4 to 2.8 million (Jones et al., 1987). Estimates of 75,900 are reported for the eastern Pacific (Carretta et al., 2005).

Dall's porpoise is found exclusively in the North Pacific Ocean and adjacent seas (Bering Sea, Okhotsk Sea, and Sea of Japan) between 28 and 63^{o} N including southern California and southern Japan (Jefferson, 2002b). This oceanic species is primarily found in deep offshore waters, but is also found in deeper nearshore waters along the North American west coast (Jefferson, 2002b). This species is a resident year-round in the eastern North Pacific with seasonal inshore-offshore and north-south movements (Croll et al., 1999), but in most areas are very poorly defined (Jefferson, 2002b).

Ferrero et al. (2002) examined the indications of habitat use patterns in the central North Pacific for Dall's porpoise, along with northern right whale dolphins and Pacific white-sided dolphins. They are the three most common cetacean species in the central North Pacific (from 37 to 46 deg N and 170 deg E to 150 deg W) . Ferrero et al. (2002) reports that Dall's porpoise are principally a cold temperate and sub-arctic species, ranging from the Bering Sea south to 41 deg N in pelagic waters, which is within the range described by Jefferson (2002b). The primary habitat feature of the studied area is the Polar Front Region which is at 45 deg N at 170 deg E, curving southward to 42 deg N at 150 deg W. North of the Front, the surface waters have relatively low salinity and waters to the south of the Front generally have a higher salinity. The sea surface temperature, however, was the most pronounced environmental feature in the studied species' habitat. Dall's porpoise were only present in low numbers in the southern latitudes of this study, but it is believed that this may have been the southern fringe of their habitat (Ferrero et al., 2002).

Dall's porpoises are thought to be one of the fastest small cetaceans (Croll et al., 1999; Jefferson, 2002b). Dall's porpoise average swim speeds are between 2.4 and 21.6 km/h (1.3 and 11.7 knots), and are dependent on the type of swimming behavior (slow rolling, fast rolling, or rooster-tailing) (Croll et al., 1999). They may reach speeds of 55 km/h (29.7 knots) for quick bursts (Leatherwood and Reeves, 1986). They are relatively deep divers, diving to 275 m (900 ft) and for as long as 8 min (Ridgway, 1986; Hanson et al., 1998).

Dall's porpoises feed on cephalopods, schooling fish and occasionally on crustaceans (Mizue and Yoshida, 1965; Crawford, 1981; Walker, 1996; Jefferson, 2002b).

There is no direct measurement of auditory threshold for 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 20-100 kHz is about 116-130 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.

Spectacled porpoise (*Phocoena dioptrica*) are circumpolar found in the Southern Hemisphere in cool temperate, sub-Antarctic waters from about 32 to 59^{o} S (Croll et al., 1999; Goodall, 2002a). 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 Kergulen in the southern Indian Ocean (Croll et al., 1999, Goodall, 2002a).

What little is known about the spectacled porpoise is from skeletal remains and rare. However, sightings at sea have been widely distributed. There are no world-wide population estimates. There is no data on diving, swim speeds, hearing, or vocalizations.

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Sperm whale (*Physter macrocephalus*)	ESA endangered CITES protected IUCN Vulnerable	- All oceans tropical and temperate waters; -Deep waters -Commonly found near Equator and in the North Pacific	Global estimates: 500,000 –up to almost 2 million North Pacific: 250,000 Eastern tropical Pacific: 39,200 Eastern Pacific: 1,400 North Atlantic: 4,700 Gulf of Mexico: 1,350	Dive duration: 18.2-65.3 min Average dive depth: 400 m Maximum dive depth: 3,000 m Foraging Dives: 300-1245 m for 30-40 min Travel speed: 1.25-4 km/h	Hearing Hearing range: 2.5 -60 kHz Dominant Frequencies Hear: 5-20 kHz Sound Production frequency range: <0.1- 30 kHz signal type: -click trains -codas source level: 202 an 236 dB re: 1µPa at 1 m for clicks
Pygmy and dwarf sperm whale *(Kogia* species)	IUCN-lower risk, least concern species	-Deep ocean temperate, subtropical, and tropical waters -40° to 60° N	Derived abundance of 11,200 for the Eastern Tropical Pacific and 247 in California, Oregon, and Washington, with a minimum of 120	Dive duration: 8.6 min Average dive depth: No direct data available Max dive duration: 43 min Travel speed: <11 km/h	Hearing Hearing range: 90 -150 kHz Sound Production frequency range: 60 - 200 kHz Peak frequencies: 120-130 kHz signal type: Echolocation pulses: peak 125-130 kHz LF sweep: 1300-1500 Hz source levels: No direct data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Baird's and Arnoux's beaked whales (*Berardius* species)	IUCN-lower risk	-All oceans temperate, subtropical deep waters -Most abundant around shelf breaks and seamounts Baird's: -Continental Shelf off the Bering and Othotsk Seas to southern Japan in the west and northern Baja California in the east Arnoux's: -Antarctic waters -Northern New Zealand, South Africa, and southeast Australia	Global estimates: No direct data available - Baird's population in NW Pacific: Baird's 7,000 California: 38 in 1991 North Pacific: minimum estimate 228	Dive duration: - Baird's – 15-20 min - Arnoux's – 10-65 min Dive depth: No direct data available Dive duration max: -Baird's – 67 min -Arnoux's – 70 min Travel speed: 5 km/h	Hearing No direct data available Sound Production frequency range: Baird's: 12 - 134 kHz Dominant frequency produced: 23-24.6 kHz, and 35-45 kHz Arnoux's: 1-8.7 kHz signal type: burst pulse clicks FM whistles click trains source levels: No direct data available
Shepherd's beaked whale (*Tasmacetus shepherdi*)	IUCN-data deficient species	-Cold temperate seas of S. Hemisphere -temperate Antarctic waters -Brazil, the Galapagos Islands, New Zealand, Argentina, Australia, and the south Sandwich Islands	No direct data available	No direct data available Travel speed: 5 km/h	Hearing No direct data available Sound Production No direct data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Cuvier's beaked whale (*Ziphius cavirostris*)	IUCN-data deficient species	- Offshore waters of all oceans -Most common in the subtropical and temperate regions -Common in offshore deep waters of Mediterranean, British Isles, Caribbean seas, the Sea of Japan, western North America, and off of Hawaii -60°N to 60°S	Global estimate: No direct data available E. tropical Pacific: 90,725 Eastern North Pacific: 1,900	Dive duration: 20-87 min Average dive duration: 30 min Dive depth: No direct data available Travel speed: 5-6 km/h	Hearing No direct data available Sound Production frequency range: 13-17 kHz signal type: HF clicks source levels: No direct data available
N. and S. bottlenose whales (*Hyperoodon* species)	IUCN-lower risk/conservation dependent species	Northern Bottlenose: -Cold temperate and subarctic latitude of the North Atlantic -Deep waters, >1000 m -35º to 85 ºN -Seaward of the Continental Shelf -Common in The Gully off Nova Scotia Southern Bottlenose: -South of 20°S with circumpolar distribution -Near South Africa in February and southward towards the Antarctic in October	Global estimate: No direct data available The Gully-SE Sable Island: N. bottlenose 230 S. Antarctic Convergence: S. bottlenose 600,000	Dive duration: N. bottlenose: up to 70 min S. bottlenose: 11-46 min Average: 25.3 min Dive depth: N. bottlenose: 120-800 m Maximum dive depth: N. bottlenose: 1453 m S. bottlenose: no direct data available Travel speeds: 5 km/h	Hearing No direct data available Sound Production frequency range: N. bottlenose: 2 kHz - 20 kHz Signal type: click series while diving: peak frequencies at 6-8 kHz and 16-20 kHz click trains while socializing: peak frequencies at 2-4 kHz and 10-12 kHz source levels: No direct data available S. bottlenose: no direct data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Longman's beaked whale (*Indopacetus pacificus*)	IUCN-data deficient	- Indo-Pacific region - Possibly around Equatorial Indian and Pacific oceans	No direct data available	No direct data available Travel speeds: 5 km/hr	Hearing No direct data available Sound Production No direct data available
Beaked whale (*Mesoplodon* species)	IUCN-data deficient species	- All oceans; tropical to temperate offshore waters - 72°N to 60°S -North Atlantic: Sowerby's, Blainville's, Gervais, and True's beaked whales -Northwestern Pacific: Ginkgo-toothed beaked whales - North Pacific: Blainville's beaked whale Aleutian Islands: Stejneger's beaked whale	Global estimate: No direct data available E. tropical Pacific: 25,300 California: 250 Minimum population estimates for western North Atlantic: 3200 Minimum population estimate for eastern North Pacific: 1250	Blainville's Dive duration: 7.47 min Maximum dive duration: 45 min Dive depth: No direct data available for most species Blainville: Max to near 900 m for >20 min Travel speeds: 5 km/h	Hearing No direct data available Sound Production frequency range: Blainville's: chirps and whistles at <1 kHz - 6 kHz Hubb's: Whistles 2.6-10.7 kHz Pulses: 300 Hz -80kHz Dominant frequencies: 300 Hz-2 kHz Stejneger's: 500 Hz - >26 kHz source levels: 200-220 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Beluga *Delphinapterus leucas)*	ESA -Cook Inlet stock proposed Candidate Species N - vulnerable ies	-Circumpolar ranging into subarctic coastal waters -Both shallow and deep water -East and west coasts of Greenland -Extend from Alaska across the Canadian western arctic to the Hudson Bay -Occasional sightings as far south as the Bay of Fundy in the Atlantic -In the Pacific, migratory Belugas summer in the Okshotsk, Chukchi, Bering, and Beaufort seas, the Anadyr Gulf, and off Alaska -Residents in Cook Inlet	Global estimate: ~100,000; Western Greenland 12,000-14,000	Dive depth: 647 m for 15 min Maximum dive depth: >1000m for up to 25 min Shallow surface dives: <1min Deep dives: 300-600 m for 9-18 min Max travel speed: 22 km/h Ave travel speeds: 2.5 – 3.3 km/h	Hearing Hearing range: 40 Hz -150 kHz Threshold of 42 dB re: 1µPa at 1 m at < 11-100 kHz Sound Production frequency range: 100 Hz – 120 kHz signal type: Tonal calls: 100 Hz-16 kHz Echolocation clicks: 120 kHz clicks: bimodal 40-60 kHz and 100-120 kHz whistles: 260 Hz – 20 kHz source levels: 206-225 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Killer whale (*Orcinus orca*)	IUCN-lower risk/conservation dependent	-All oceans; temperate to subpolar waters -80°N to 77°S -Most common within 800 km of major continents	Global estimate: 100,000; E. tropical Pacific: 8,500 NE Pacific: 2000 Antarctic: 70,000 Norwegian waters: 440 Gulf of Mexico: 133	Dive duration: 1 – 10 min Dive depth: 100 m Maximum dive depth: 265 m Foraging dive: <180 m Travel speed max: 37 km/h Travel speed average: 6-10 km/h	Hearing hearing range: <500 Hz - 120 kHz Dominant frequencies: 15-42 kHz with a threshold of 34-36 dB re: 1µPa at 1 m Sound Production frequency range: 80 Hz – 85 kHz Dominant frequencies: 1-20 kHz signal type: dialects: 500 Hz – 10 kHz source levels: 105-124 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
False killer whale (*Pseudorca crassidens*)	IUCN-Lower risk/least concern	-W. Atlantic; tropical to warm temperate deep waters -60°S to 60°N	Global estimate: No direct data available E. tropical Pacific: 39,800 NW Pacific: 17,000	No direct data available Travel speed max: 28.8 km/h Travel speed average: 3 km/h	Hearing hearing range: <1 -115 kHz Dominant frequencies: 17 kHz at 39-49 dB re: 1µPa at 1 m; 140 dB re: 1µPa at 1 m at 75 Hz; 108 dB re: 1µPa at 1 m at 1 kHz; and 70 dB re: 1µPa at 1 m at 5 kHz Sound Production frequency range: 4 – 130 kHz Dominant frequencies: 25-30 kHz and 95-130 kHz signal type whistles: 4.7-6.1 kHz clicks: 20-60 kHz and 100-130 kHz source level clicks: 228 dB re: 1µPa at 1 m
Pygmy killer whale (*Feresa attenuata*)	IUCN-data deficient species	-All oceans; oceanic tropical to subtropical waters -40°S to 40°N -Frequently sighting in the E. tropical Pacific, the Hawaiian Archipelago, and off of Japan	Global estimate: No direct data available E. tropical Pacific: 39,800 Gulf of Mexico: 408	Dive duration: 25 sec Travel speeds: Unknown	Hearing No direct data available Sound Production -LF growls -little data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Melon-headed whale (*Peponocephala electra*)	IUCN-lower risk/least concern species	-Tropical to subtropical pelagic waters -20°S to 20°N	Global estimate: No direct data available E. tropical Pacific: 45,400 Gulf of Mexico: 3,451	No direct data available Possibly forages at depths of 1500 m Travel speeds: unknown	Hearing No direct data available Sound Production frequency range: 8 – 40 kHz signal type click bursts: 20-40 kHz whistles: 8-12 kHz source levels: 155-165 dB re: 1µPa at 1 m
Long-finned pilot whale (*Globicephala melas*)	IUCN: lower risk/least concern	-All oceans; outside tropical waters, temperate and subpolar waters -20°N to 75°N -5°S to 70°S, excluding North Pacific -Occur along shelf edges in deep pelagic waters -High abundance in Mediterranean Sea	Global estimate: No direct data available N/E Atlantic: 778,000 Antarctic Convergence: 200,000 W. North Atlantic: 14,524	Dive duration: 2 – 13 min Dive depth: 16m day ; 648 m night Travel speeds: 2-12 km/h Travel speed average: 3.3 /h	Hearing No direct data available Sound Production frequency range: 500 Hz – 18 kHz Dominant frequencies: 1-11 kHz signal type double clicks whistles: 4.48 kHz source levels: no direct data available
Short-finned pilot whale (*Globicephala macrorhynchus*)	IUCN-lower risk/conservation dependent	-Tropical, subtropical, and temperate waters -50°N to 40°S -Residents around the California Channel Islands	Global estimate: No direct data available E. tropical Pacific: 160,000 N/W Pacific: 54,000 Gulf of Mexico: 2,388 W. North Atlantic: 14,524	Dive duration: no direct data available Dive depth: 610 m Travel speeds: 2-12 km/h Travel speeds average: 7-9 km/h	Hearing No direct data available Sound Production frequency range: 280 – 100 kHz Dominant frequencies: 2-14 kHz and 30-60 kHz signal type calls: 7.87 kHz source level clicks: 180 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Risso's dolphin (*Grampus griseus*)	IUCN-data deficient species	-Temperate to tropical oceanic waters -55°S to 60°N -Continental slope waters -Shelf-edge habitats between 400 and 1000 m deep -Water temperature 15-20 ºC and rarely below 10 ºC -Common in the north-central Gulf of Mexico and in northwestern Atlantic -Seasonal migrations for Japan and North Atlantic populations	Global estimate: No direct data available E. tropical Pacific: 175,800 N/W Atlantic: 3,500 in summer; 350+ in winter California: 8,500 E. North Pacific: 12,748 W. North Atlantic: 29,110	Diving behavior: no direct data available Possibly forage at 400 m deep Travel speeds: 2-12 km/h	Hearing hearing range: 1.5 -100 kHz at 120 dB re: 1µPa at 1 m Dominant frequency: 4-80 kHz at 63.6-74.3 dB re: 1µPa at 1 m Sound Production frequency range: 100 Hz – 65 kHz Dominant frequencies: 2-5 kHz and 65 kHz Max peak-peak source level: 120 dB re: 1µPa at 1 m at -5 kHz signal type whistles: 4- 22 kHz clicks: 6-22 kHz burst pulses: 2-20 kHz grunts: 400-800 Hz barks: 2-20 kHz buzzes: 2.1-22 kHz chirps: 2-4 kHz source level: 216 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Short-beaked common dolphin (*Delphinus delphis*)	IUCN-lower risk/least concern species	-All oceans; temperate, subtropical, and tropical waters -60°N to 50°S -Along continental shelf and bank regions -Most common 40 ºN-40 ºS in coastal waters of the Pacific Ocean, beyond 200 m isobath and north of 50 ºN in the Atlantic Ocean -Occur southern Norway to West Africa in eastern Atlantic Ocean -From Newfoundland to Florida in the western Atlantic, from Canada to Chile along the coast and pelagically in the eastern Pacific, and in central North Pacific from central Japan to Taiwan -Found around New Caledonia, New Zealand and Tasmania in the western Pacific -Possibly in the South Atlantic and Indian Oceans	Global estimate: No direct data available E. Pacific: 365,617 California: 225,821 N/W Atlantic: 31,000	Maximum dive duration: 5 min Dive depth: 9-200 m Avg dive depth: 9-50 m Maximum dive depth: 260 m Max foraging dive: 200 m Travel speeds: 5.8-16.2 km/h Travel speed max: 37.1 km/h	Hearing hearing range: <5 kHz - 150 kHz at a source level less than or equal to 120 dB re: 1µPa at 1 m Dominant threshold: 65 kHz at 53 dB re: 1µPa at 1 m Sound Production frequency range: 200 Hz – 150 kHz Dominant frequencies: 0.5-18 kHz and 30-60 kHz signal type whistles: 7.4 – 13.6 kHz clicks: 15-100 kHz source level: 180 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Long-beaked common dolphin (*Delphinus capensis*)	IUCN-lower risk/least concern species	-All oceans; temperate, subtropical, and tropical waters -60°N-50°S -Along continental shelf and bank regions -Most common 40 ºN-40 ºS in coastal waters of the Pacific Ocean, beyond 200 m isobath and north of 50 ºN in the -Prefer shallower, warmer waters than short-beaked common dolphins -Occur around West Africa, 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, South Africa. -Possibly around Oman in the Indian Ocean	Global estimate: No direct data available California: 25,163	Maximum dive duration: 5 min Dive depth: 9-200 m Avg dive depth: 9-50 m Maximum dive depth: 260 m Max foraging dive: 200 m Travel speeds: 5.8-16.2 km/h Travel speed max: 37.1 km/h	Hearing hearing range: <5 kHz - 150 kHz at a source level less than or equal to 120 dB re: 1µPa at 1 m Dominant threshold: 65 kHz at 53 dB re: 1µPa at 1 m Sound Production frequency range: 200 Hz – 150 kHz Dominant frequencies: 0.5-18 kHz and 30-60 kHz signal type whistles: 7.7-15.5kHz echolocation clicks: 15-100 kHz source level: 180 dB re: 1µPa at 1 m In the North Atlantic: Mean source level of 143 dB re: 1µPa at 1 m with a max frequency of 154 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Very long-beaked common dolphin (*Delphinus* tropicalis)	IUCN-lower risk/least concern species	-Temperate, subtropical, and tropical waters -60°N-50°S -Found only in the northern Indian Ocean and Southeast Asia	No estimate	Maximum dive duration: 5 min Dive depth: 9-200 m Avg dive depth: 9-50 m Maximum dive depth: 260 m Max foraging dive: 200 m Travel speeds: 5.8-16.2 km/h Travel speed max: 37.1 km/h	Hearing hearing range: <5 kHz - 150 kHz Source Level of less than or equal to 120 dB re: 1µPa at 1 m Dominant threshold: 65 kHz at 53 dB re: 1µPa at 1 m Sound Production frequency range: 200 Hz – 150 kHz Dominant frequencies: 0.5-18 kHz and 30-60 kHz signal type

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Fraser's dolphin (*Lagenodelphis hosel*)	IUCN-data deficient species	-All oceans; tropical and subtropical oceanic waters -50°N to 40°S, primarily between 30°N and 30°S -Found near central Visayas, Philippines in nearshore waters, along the outer continental shelf, and in deep oceanic waters -Also in Indonesia and the Lesser Antilles 100 m from shore -15 km and 45-110 km from shore in the E. Tropical Pacific at depths 1500-2000 m -In Sulu Sea, reach depths of 5000 m -Most common in Gulf of Mexico -Occasionally in the Atlantic Ocean	Global estimate: No direct data available E. tropical Pacific: 289,300 Gulf of Mexico: 726	Dive duration: No direct data available Dive depth: 600-700 m Eastern Tropical Pacific depths: <250 m and <500m Sulu Sea depths: <600m South Africa and the Caribbean: feed near surface Travel speeds: 4-7 km/h Travel speed max: 28 km/h	Hearing No direct data available Sound Production frequency range: 4.3 – <40 kHz signal type Clicks: below 40 kH whistles: 4.3 – 24 kHz source levels: no direct data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Bottlenose dolphin (*Tursiops truncatus*)	IUCN-data deficient species	-All oceans; temperate, tropical, and subtropical waters -45°N to 50°S and up to 60°N around the United Kingdom and northern Europe -Water temps of 10°-32°C -Primarily coastal but have diverse habitats of rivers and bays, oceanic islands and open ocean, over the continental shelf, and along the shelf break -Common in southern Okhosk Sea, the Kuril Islands, and along central California in the North Pacific -In Atlantic, found inshore during summer months in New England north to Nova Scotia and have been sighted off Norway and Lofoten Islands -Southern range extends as far south as Teirra del Fuego, South Africa, Australia, and New Zealand	Global estimate: No direct data available E. tropical Pacific: 243,500 N/W Pacific: 169,000 Black Sea: 6,900 Shark Bay, Australia: minimum of 3,000 Western N Atlantic and Gulf of Mexico: 30,000-35,000	Dive duration: 38 sec-1.2 min Dive depth: 98 m Maximum dive depth: 535 m Maximum dive duration: 10 min Travel speeds: 4-20 km/h Travel speed average: 6.4-11.5 km/h Travel speed max: 29.9 km/h	Hearing hearing range: 150 Hz - 135 kHz Best hearing frequency: 15 kHz with threshold of 42-52 dB re: 1µPa at 1 m Sound Production frequency range: 50 Hz – 150 kHz Dominant frequency: 0.3-14.5 kHz, 25-30 kHz, and 95-130 kHz signal type Whistles: 4-20 kHz, source level of 125-140 dB re: 1µPa at 1 m burst-pulse clicks: 40-130 kHz In Hawaii: 100-130 kHz source level: 228 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Dolphins (*Stenella* species)	IUCN-data deficient species -clymene and Atlantic spotted dolphins IUCN-lower risk/ conservation dependent species -striped, pantropical spotted, and spinner dolphins	-All oceans; tropical, subtropical, and temperate waters 40°S-40°N -Atlantic Spotted: 50°N-25°S in tropical and warm-temperate waters of the Atlantic Ocean; Commonly found around southeastern United States, in the Caribbean, and off of West Africa; around continental shelf and shelf-break -Striped: tropical and warm-temperate waters below 43°N and associated with convergence zones -Striped dolphins most abundant in the Mediterranean Sea but also in the eastern North Atlantic and south of the United Kingdom. -Pantropical Spotted: tropical and subtropical Indo-West Pacific; 30°N to 40°N and 20°S to 40°S	Global estimate: No direct data available E. tropical Pacific: Pantropical- 2,059,100 Spinner- 1,651,1000 Striped- 1,918,000 Gulf of Mexico: Pantropical- 91,300 Spinner- 12,000 Clymene- 17,300 Atlantic spotted- 31,000 Striped- 6,500	Pantropical dolphins: Dive duration: 1.95 min Dive depth: 100 m Maximum dive depth: 122 m during day; 213 m during night Travel speed max: 39.7 km/h Atlantic spotted dolphins: Maximum dive duration: 3.5 min Striped: Dive depth: 200-700 m foraging Travel speed: 11 km/h Spinner: Dive depth: 600 m foraging Hawaiian spinner dolphins: Travel speed: 2.6-6 km	Hearing hearing range: Striped dolphin: 500 Hz -160 kHz Source level: 120 dB re: 1µPa at 1 m at frequencies less than 10 kHz to greater than 100 kHz Less sensitivity below 32 kHz and above 120 kHz No direct measurement of auditory threshold for the remaining *Stenella* dolphins Sound Production frequency range: 100 Hz – 160 kHz Dominant frequency range: 5-60 kHz, 40-50 kHz, and 130-140 kHz signal type whistles burst-pulse calls clicks: 40-50 kHz and 110-130 kHz source level: 210 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
		-Range from South Africa to the Red Sea and the Persian Gulf, east to Australia, the Indo-Malayan Archipelago, and the Philippines, and north to southern Japan -Spinner: pantropical; 30°N to 40°N and 20°S to 30°S; common in the high seas, but coastal populations exist in the eastern Pacific, Indian Ocean, and Southeast Asia -Pantropical, spinner, and striped dolphins most abundant cetaceans in the E. tropical Pacific -Clymene: tropical to warm-temperate waters of the south and mid-Atlantic Ocean			Atlantic spotted dolphin: Clicks: 60 kHz-120 kHz with low frequency peak 40-50 kHz an high frequency peak 110 kHz-130 kHz Sounds: Whistle-squawks, buzzes, burst-pulses, synch pulses, barks, screams, squawks, tail slaps echolocation clicks: 40-50 kHz and a high frequency peak between 110 and 130 dB re: 1µPa at 1 m Whistles: <20 kHz BroadB re: 1µPa at 1 mand clicks: 60-120 kHz Harmonics: >50 kHz Source level: 223 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Dolphins (*Lagenorhynchus* species)	IUCN - data deficient species: Peale's and dusky dolphins IUCN - lower risk/least concern species: Atlantic white-sided, white-beaked, hourglass and Pacific white-sided dolphins	-Temperate and subpolar areas -Peale's: 60°S to 35°S in southern South America and the Falkland Islands in coastal bays, inlets, and shelf water; occasionally around the Palmerston Atoll -Dusky: N. Peru to Cape Horn and S. Patagonia to 36°S; occur off coastal waters of New Zealand, South America, southwestern Africa, and several islands in the South Atlantic and southern Indian Oceans; from 60° to 9°S -Atlantic white-sided: cold temperate N. Atlantic; 35°N to 80°N; extend over continental slope and deeper waters; Cape Cod is the southern limit; eastern limit is Georges Band and Brittany; extend north to Greendland, southern Iceland, and the south coast of Svalbard Island	Global estimate: No direct data available Pacific White-Sided Dolphins: 30,000-50,000 in Japan 39,800 in eastern North Pacific Hourglass Dolphins: 144,300 hourglass dolphins in the Antarctic Convergence Atlantic White-Sided Dolphins: 77,000 along the North American seaboard White-Beaked Dolphins: 3,486 in the shelf waters along the coast of Labrador 6,000 in the western North Atlantic	Atlantic white-sided dolphin: Dive duration: <1min Dive duration max: 4 min Travel speeds: 2-12 km/h Dusky: Dive duration: 21 seconds Shorter dives during the day, longer dives at night Travel speeds: 4.5-12.2 km/h in New Zealand; 7.7 km/hr in Argentina Peale's: Dive duration: 3-157 seconds Average dive duration: 28 seconds Dive depths: No direct data available Pacific white-sided: Dive depth: 120 Dive duration: 15-20 sec Travel speeds: Up to 27.7 km/h Hourglass: Travel speeds: 7-29 km/h	Hearing hearing range: Pacific white-sided: -500 Hz -135 kHz with source level 120 dB re: 1µPa at 1 m -1 kHz pure tone with source level of 106 dB re: 1µPa at 1 m -2-128 kHz with source level of 90 dB re: 1µPa at 1 m There is no direct measurement of auditory threshold for the rest of the *Lanenorhynchus* dolphins Sound Production frequency range: 60 Hz – 325 kHz Dominant frequencies: 0.3-5 kHz, 4-15 kHz, 6.9-19.2 kHz, and 60-80 kHz signal type clicks source levels: 80 - 211 dB re: 1µPa at 1 m Peale's: broadB re: 1µPa at 1 mand clicks 1-5 kHz at 80 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
		-White-beaked: temperate and subarctic N. Atlantic; in the Western Mediterranean Sea; often in shelf and coastal waters; as far north as White Sea in the northeast Atlantic and abundant along the Norwegian coasts and in the northern parts of the North Sea along the United Kingdom, Belgium, the Netherlands, Germany, and Denmark -Hourglass: High latitudes of the southern hemisphere; 68°-33°S; on both sides of the Atnarctic Convergence and northward in cool currents with the West Wind Drift; Water temperatures from -0.3° - 13.4°C -Pacific white-sided: Temperate; mostly pelagic; 20°N to 61°N on the east and across the North Pacific			White-beaked: Click: Peak frequency: 120 kHz Secondary peak freq: 250 kHz Max source level: 219 dB re: 1µPa at 1 m Min source level: 189 dB re: 1µPa at 1 m Atlantic White-Sided: Maximum source level 164 dB re: 1µPa at 1 m Average source level 154 dB re: 1µPa at 1 m Pacific White-Sided: BroadB re: 1µPa at 1 mand clicks with a source level of 180 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Rough-toothed dolphin (*Steno bredanensis*)	IUCN-data deficient species	-All oceans; deep oceanic tropical, subtropical, and warm-temperate waters -45°-55°N -In the Atlantic, found between the southeastern United States and southern Brazil, across to the Iberian Peninsula and West Africa -Range also includes Gulf of Mexico, Caribbean Sea, and Mediterranean Sea -In the Pacific, range from central Japan to northern Australia, and from Baja, California, Mexico south to Peru	Global estimate: No direct data available E. tropical Pacific: 145,900 Gulf of Mexico: 2,233	Dive duration: 0.5 – 3.5 min Dive depth: 30-70 m Max depth: 70 m Max duration: 15 min Travel speeds: 5.5-16 km/h	Hearing hearing range: Unknown Sound Production frequency range: 100 Hz – 200 kHz signal type clicks: peak of 25 kHz whistles: peaks at 2-14 kHz and 4-7 kHz source levels: No direct data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Northern right whale dolphin (*Lissodelphis borealis*)	IUCN-lower risk/least concern species	-Deep, offshore waters in the North Pacific -Cold temperate and Subantarctic -29° to 59°N, most common between 34° to 55°N and 145°w to 18°E -Range from Kuril Islands, Russial, south to Sanriku, Honshu, Japan, and eastward to the Gulf of Alaska and south to Southern California -Prefer cold, deep, offshore waters 8° to 19°C	Global estimate: No direct data available Eastern Pacific: 16,417	Dive duration: <6 min Dive depth: <200 m Max dive duration: 6.25 min Travel speed: 34-40 km/h	Hearing No direct data available Sound Production frequency range: 1– <40 kHz Dominant frequencies: 1.8-3 kHz signal type clicks source level: 170 dB re: 1µPa at 1 m
Southern right whale dolphin (*Lissodelphis peronii*)	IUCN- data deficient species	-Subtropical and Antarctic Convergence Zones -25°S to 65°S -Common in northern Chile	Global estimate: No direct data available	Dive duration: <6 min Dive depth: <200 m Max dive duration: 6.5 min Travel speed: 22 km/h	Hearing No direct data available Sound Production No direct data available

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Dolphins (*Cephalorhynchus* species)	IUCN data deficient species- Commerson's, black, and Heaviside's dolphins IUCN endangered - Hector's dolphin	-Coastal temperate waters of the Southern Hemisphere -Occur in <200 m water; common in surf zone -Commerson's: 40°S to 61°S in the Atlantic; off South America and the Kerguelen Islands in the southern Indian Ocean; mainly in the coastal waters ofArgentina and the Strait of Magellan -Black: 33°S to 55°S; shallow, coastal waters and estuaries and rivers of Chile, the Straits of Magellan, the channels of Tierra del Fuego, and along the west coast of Chile -Hector's: 41°S to 44°S and 36° to 38°S; shallow waters off New Zealand	Global estimate: No available data Hector's dolphins: 3,408 Commerson's dolphins: 718 in Straits of Magellan	Heaviside's dolphins: Dive duration: > 2 min Dive depth: > 20 m Maximum dive depth: 104 m by male; 92 m by female Hector's dolphins: Dive duration: 89 seconds Travel speeds: No available data	Hearing No direct data available Sound Production frequency range: 320 Hz – 150 kHz Dominant frequency range: 0.8-1 kHz, 1-2 Khz, 4-4.5 kHz, 116-134 kHz signal type clicks: 120-130 kHz source levels: 160 - 163 dB re: 1µPa at 1 m Commerson's: Cry: <10 kHz Dominant frequencies: 200 Hz, 1 kHz, and 5 kHz LF clicks: 6 kHz Dominant frequencies: 1-2.4 kHz Max source level: 160 dB re: 1µPa at 1 m Heaviside's: Frequency range: <2kHz and 5 kHz Dominant frequency: 800 Hz
		-Heaviside's: found along the west coast of southern Africa and Nambia from 17°S on Namibian coast to Cape Town at 34°S and near shallow waters no deeper than 100 m			Hector's: Frequency range: 125 kHz Max source level: 163.2 dB re: 1µPa at 1 m Commerson's and Hector's produce HF narrow band clicks with most energy focused around 120-130 kHz and little to no energy below 100 kHz

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Harbor porpoise (*Phocoena phocoena*)	ESA: Gulf of Maine stock candidate species IUCN- vulnerable	-Cold temperate to subarctic coastal waters of Northern Hemisphere -15°N to 70°N -Most in waters 5°-16°C and some in 0°-4°C -Mostly coastal	Global estimate: No direct data available N. Atlantic: 456,717 California: 52,743 North Sea: 341,000 in 1994 Gulf of Maine: 89,700	Dive duration: 0.7-1.71 min Maximum dive duration: 9 min Dive depth: 20 - 130 m Maximum dive depth: 226 m Travel speeds: 16.6 to 22.2 km/h	Hearing hearing range: 100 Hz - 140 kHz Source level: 120 dB re: 1µPa at 1 m Dominant frequencies: 16-140 kHz in juveniles Sound Production frequency range: 40 Hz – 150 kHz Dominant frequencies: 2 kHz and 110-150 kHz signal type clicks: 110 - 150 kHz LF calls: 1.4 – 2.5 kHz whistles: 40 – 600 Hz source level: 177 dB re: 1µPa at 1 m
Dall's porpoise (*Phocoenoides dalli*)	IUCN-lower risk/conservation dependant	-N. Pacific, Bering Sea, Okhotsk Sea, and Sea of Japan -28°N to 63°N -Including southern California and southern Japan -Deep offshore waters and deep nearshore waters	Global estimate: 1.4 to 2.8 million Eastern Pacific: 75,900	Dive duration: 8 min Dive depth: 275 m Travel speeds: 2.4-21.6 km/h Max travel speed: 55 km/h	Hearing Estimated reaction threshold 20-100 kHz at 116-130 dB re: 1µPa at 1 m Sound Production frequency range: 40 Hz – 160 kHz signal type LF clicks: 40 Hz - 12 kHz Narrow band clicks: 120-130 kHz source level: 175 dB re: 1µPa at 1 m

Table 3.2-4. Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior And Travel Speeds	Underwater Hearing/Sound Production
Spectacled porpoise (*Phocoena dioptrica*)	IUCN: Data Deficient	-Circumpolar in the southern hemisphere -Cool temperate, sub- and low-Antarctic waters -32°S to 59°S -Brazil to Argentina in offshore waters and around offshore islands including Tierra del Fuego, the Falklands, and South Georgia in the southwestern South Atlantic; Aukland and Macquarie in the southwestern Pacific; and Heard and Kergulen in the southern Indian Ocean	Unknown	Unknown	Unknown

3.2.5 Pinnipeds

Pinnipeds (sea lions, seals, and walruses) are globally distributed amphibious mammals with varying degrees of aquatic specialization (Gentry, 1998). There are up to 37 living species in the suborder, which includes eared seals (family Otariidae), true or earless seals (family Phocidae), and walruses (family Odobenidae) (Berta, 2002). Walruses are not found near SURTASS LFA sonar operation areas and will not be discussed in this document.

Compared to phocids, 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. The ears of otariids have ear flaps and are similar to carnivore ears, while phocid ears have no external features and are more water-adapted. Otariids have also retained their fur coats (Berta, 2002), while 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. Due to the otariid's need to hunt, they 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 3200 kg (99 to 7,055 lb) and from approximately one meter (3 ft) to 5 m (16 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., 2002). Pinnipeds were hunted for their furs, blubber, hides, and organs. Some stocks have begun to recover. However, species such as the northern fur seal and the Steller sea lions are still declining (Gentry, 2002). 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 feed on a variety of prey items, mainly fish and cephalopods, but also eat krill and crustaceans. Some pinnipeds are also known to eat other pinnipeds. For example, Steller sea lions are known to eat harbor, bearded, ringed, northern fur, and spotted seals. Pinnipeds usually feed underwater, 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 while adult harbor seals eat benthic animals. The amount of benthic prey in the diet of the bearded seal also increases with age (Berta, 2002; Bowen et al., 2002). 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 millions 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 (Bowen et al., 2002). Phocids are circumpolar but are most abundant in the North Atlantic and Antarctic Ocean, found in both temperate and polar waters (Bowen et al., 2002). The northern fur seal, Cape fur seal, and Antarctic 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., 2002).

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., 2002). 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 both tropical and polar waters. Some species have even adapted to live in fresh and estuarine waters (Berta, 2002).

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 (Berta, 2002). Pinnipeds are generally long-lived with estimates of longevity up to 40 years or more (Berta, 2002). Age of sexual maturity ranges from 2 to 6 years (Boyd, 2002). 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. Smaller species dive on average for 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, 2002).

Hearing capabilities and sound production is 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, 2002; Frankel, 2002; Van Parijs and Kovacs, 2002). 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. Underwater, pinnipeds can vocalize using whistles, trills, clicks, bleats, chirps, and buzzes as well as lyrical calls (Schusterman, 1978; Berta, 2002; Frankel, 2002). 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. Studies that have examined the hearing capabilities of some pinniped species, particularly ringed seals, harp seals, harbor seals, California sea lions, and northern fur seals (Mohl, 1968; Terhune and Ronald, 1972; 1975a; 1975b; Kastak and Schusterman, 1996, 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 man-made 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 underwater with a threshold of 89.9 dB RL at 100 Hz. Kastak and Schusterman (1996; 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, 1968; Terhune and Ronald, 1972, 1975a, 1975b; Terhune 1991). In a recent study, Kastak and Schusterman (1996) 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.

California sea lions are one of the few otariid species whose underwater sounds have been well studied. Other otariid species with documented vocalizations are the South American sea lions and northern fur seals (Fern’ndez-Juricic et al., 1999; Insley, 2000). Otariid hearing abilities are thought to be intermediate between Hawaiian monk seal 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: both in Richardson et al., 1995).

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 Shusterman, 1998; Van Parijs and Kovacs, 2002).

3.2.5.1 Otariidae

The family Otariidae is divided into two groups containing nine species of fur seals (*Arctocephalinae)* and seven species of sea lions (*Otariinae)*. Table 3.2.5 summarizes information on the status, distribution, abundance, diving behavior, sound production and hearing of Otariidae species being evaluated for potential impacts.

Fur Seals (*Arctocephalinae)*

The genus *Arctocephaus*, or southern fur seals, consists of eight species: Southern American fur seal (*A. australis*), New Zealand fur seal *(A. forsteri)*, Antarctic fur seal *(A. gazelle)*, Galapagos fur seal *(A. galapagoenisi)*, Juan Fernandez fur seal *(A. philippii)*, South African and Australian fur seals (*A. pusillus)*(consisting of two subspecies—South African fur seal (*A. p. pusillus)* and

Australian fur seal (*A. p. doriferus)),* Guadalupe fur seal (*A. townsendi),* and sub-Antarctic fur seals (*Arctocephalus tropicalis*) (Berta, 2002). The genus *Callorhinus* has a single species, the northern fur seal *(C. ursinus).* Antarctic fur seal (*Arctocephalus gazelle)* can be excluded from further analysis because it is a polar species.

South American fur seal (Arctocephalus australis), also known as the southern fur seal, are not listed under the IUCN. Their abundance is not well known. In 1976, there were approximately 40,000 seals in southern Chile. In 1982, there were 228 seals counted along the northern Chilean coast (22 to 23N). The Falkland Islands had a population estimated to be between 14,000 and 16,000 individuals in 1973. There were approximately 2,700 along the Argentinean coast in 1954. Two newer breeding colonies have been established on Staten Island and numbers have increased on a small island near Ushuaia. In 1979, almost 20,000 fur seals inhabited the Peruvian coast, primarily at Point San Fernando, San Fernando Islet, and Point San Juan. The majority of the population is in Uruguayan waters, with an estimated 280,000 fur seals (Reeves et al., 1992). More recently, Gentry (2002) estimated a total of 285,000 fur seals, with numbers continuing to increase.

South American fur seals occur at the Falkland Islands, including Volunteer Rocks, Elephant Jason Island, and New Island, and along the coasts of South America. They range as far north as southern Brazil in the Atlantic and near Paracas, Peru in the Pacific (Reeves et al., 1992). In the Atlantic, they can be found along the coast of Argentina to Uruguay. They prefer to haul out and breed on rocky beaches (Reeves et al., 2002). Females usually remain close to the rookery year-round. Males are sometimes seen seasonally up to 200 km (124 mi) offshore (Reeves et al., 1992).

In the Uruguayan islands, pupping occurs from November through December, with the majority of pups born in late November and early December. Along the Peruvian coast, pupping and breeding occurs from mid-October through mid-December, with the majority of pups born in November (Reeves et al., 1992).

Postpartum females alternate days foraging and nursing their pups. They will spend an average of 4.6 days at sea feeding and 1.3 days ashore nursing. The females dive and feed mostly at night, reaching depths of 40 m (131 ft) for close to 3 min. They have been recorded diving for up to 7 min and to maximum depths of 170 m (558 ft) (Reeves et al., 1992). South American fur seals eat sardines, southern anchovy, and jack mackerel (Bowen, 2002).

New Zealand fur seals (*Arctocephalus forsteri*) are a temperate species having two main breeding populations. One population is on the South Island of New Zealand and the second is along southeastern Australia. Their principal breeding colonies occur at South Island and Stewart Island along the coast of western and southern Australia and off Tasmania at Maatsuyker Island. Breeding colonies also exist at the sub-Antarctic Chatham, Campbell, Antipodes, Bounty, Aukland, and Macquarie Islands, and at Kangaroo Island off southern Australia. During the non-breeding season, they can be found as far west as Perth and as far northeast as Queensland, Australia and New Caledonia (Reeves et al., 2002). Newer colonies have been established at Kaikoura, Banks Peninsula, and Otago along the Nelson coast of New Zealand (Reeves et al., 1992). Their eastern boundaries lay at Bounty, Antipodes, and Chatham Islands and Snares, Aukland, and Campbell Islands to the south (Arnould, 2002).

In Australia, their abundance was estimated to total 35,000 in 1991. In the late 1980's, the population on Macquarie Island for non-breeding seals in April and May was estimated to be 2,000 individuals (Reeves et al., 2002). Gentry (2002) estimates the total population to be 135,000 individuals.

New Zealand fur seals eat mostly cephalopods and bony fish, but sometimes replace fish with rock lobster (Gentry, 2002). Males may also eat seabirds and penguins. Seals forage at night, diving between 10 and 15 m (35 and 50 ft). Their dives are usually deepest closer to dawn and dusk, with their longest dive bouts at night. Their dives are shallowest and shortest during the summer and deeper and longer during the autumn and winter (Reeves et al., 2002). Lactating females have been recorded as diving as deep as 274 m (898 ft). The average depths of their dive bouts are 5 to 10 m (16.4 to 32.8 ft). The longest measured dive was for 11 min (Stewart, 2002).

In-air vocalizations of the New Zealand fur seal haVE been described as a full-threat call. These individually distinctive vocalizations are emitted by males during the breeding season (Stirling, 1971). The hearing capabilities of this species are unknown.

Galapagos fur seals (*Arctocephalus galapagoensis*) are the smallest of the otariids and are the only fur seals that breed in a tropical climate (Reeves et al., 2002). They are also the only southern fur seal to extend their range into the northern hemisphere (Arnould, 2002). Their population size is unknown, although believed to be around 40,000 individuals and are therefore the rarest of the southern fur seals (Arnould, 2002; Gentry, 2002). Galapagos fur seals are listed as vulnerable under the IUCN. The Ecuadorian government prohibits the hunting of Galapagos fur seals, and this law has become well-enforced since the islands became a national park (Reeves et al., 2002).

Galapagos fur seals are non-migratory. Their range is centered around 1 deg S latitude and approximately 1,100 km (684 mi) west of Ecuador (Reeves et al., 1992). They only breed in the Galapagos Islands at 15 islands in the archipelago. The largest colonies are found at Isabela Island, which boasts one-third of their population, and at Fernandina Island. When they haul out, they typically seek shelter behind large boulders and in caves to avoid the heat. Males also stake their territories in the splash zone on the beach. Most of their breeding sites are on west-facing beaches because they are closer to the cool upwelling waters which circulate around the islands and create a higher productivity for prey species (Reeves et al., 2002).

The Galapagos fur seals feed mostly on lanternfish and squid. The seals forage most during new moons. This is believed to be because their prey migrates vertically and they come closer to the surface during the new moon (Reeves et al., 2002). 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 seconds. Yearlings dive to 47 m (150 ft) for 2.5 mi, and eighteen-month old juveniles dive up to 61 m (200 ft) for 3 min (Reeves et al., 2002; Stewart, 2002). The longest and deepest dive recorded by a Galapagos fur seal was for 6.5 min at a depth of 169 m (555 ft) (Reeves et al., 2002).

There is no information available on the hearing abilities or sound production of this species.

Juan Fernandez fur seals (*Arctocephalus philippi)* are classified as a vulnerable species under the IUCN. They were believed to be extinct until 1965 when a scientist discovered about 200 fur seals in the islands. The population was estimated to be around 12,000 in the late 1990's (Reeves et al., 2002) and was estimated to be around 18,000 in 2002 (Gentry, 2002).

Juan Fernandez fur seals are restricted to the Juan Fernandez island group, including Mas a Tierra or Robinson Crusoe, Santa Clara, and Mas Afuera or Alejandro Selkirk, and the San Feliz island group, including San Ambrosio and San Felix, off the coast of north central Chile. Breeding occurs on Mas a Tierra, Mas Afuera, and Santa Clara Islands. They haul out but do not breed on San Ambrosio Island (Reeves et al., 1992). In autumn and winter, vagrant fur seals have been recorded as far south as Punta San Juan, Chile, and as far north as Peru. They prefer to haul out in caves and on beaches with rocky, volcanic substrates, particularly on bluffs (Reeves et al., 2002).

Breeding occurs from mid-November to January (Reeves et al., 1992, 2002). Most pups are born in late November and December (Reeves et al., 1992). After mating, females have long foraging trips, lasting an average of 12 days with the longest lasting up to 25 days (Reeves et al. 2002).

Lactating females eat lanternfish and squid. They will forage at depths between 10 and 90 m (35 and 300 ft), reaching as far as 500 km (300 mi) offshore. They mainly feed and dive at night when their prey are migrating in the water column (Reeves et al., 2002). Their dives typically last 1.7 to 2 min (Stewart, 2002). Nothing is known about the diving habits of males, non-lactating females, or juveniles (Reeves et al., 2002).

South African/Australian fur seals (*Arctocephalus pusillus)* consists of two subspecies—**South African fur seal (*A. p. pusillus)*** and **Australian fur seal (*A. p. doriferus)***. The subspecies status is based on their slight cranial differences and on their location. The South African fur seal is believed to be the parent stock of the Australian fur seal (Reeves et al., 1992). The Australian fur seals, also known as Tasmanian fur seals, are closely related to the South African fur seal. However, their temperate distribution has made them a separate subspecies.

South African fur seals (A. *p. pusillus*) occur along the coast of South Africa and Namibia (Reeves et al., 1992). Their population numbers are unknown, but they are estimated to number several hundred thousand or more. Gentry (2002) estimated that the abundance of South African fur seals was around 1,700,000 individuals.

They have breeding colonies and haul-out sites from Cape Cross, Namibia around the Cape of Good Hope to Black Rocks, Cape Province and reaching west to Angola and south to Marion Island (Reeves et al., 2002). They may reach as far south as 11S, following the coastal Benguela Current (Reeves et al., 1992).

South African fur seals often breed and pup on small rocky islands. However, there are also several colonies on the mainland. Bulls arrive to the rookeries before the females, usually in mid-

October to early November (Reeves et al., 1992). Pupping typically occurs from late October through late December (Reeves et al., 1992; 2002). The females leave the rookeries for approximately seven days in the winter and four days in the summer for a postpartum feeding trip (Reeves et al., 2002).

Fur seals feed on fish and cephalopods, particularly mackerel, pilchard, Cape hakes, and anchovies. They feed within approximately 5 km (3.1 mi) of land and are believed to be non-migratory. Lactating females dive an average depth of 40 to 50 m (131.2 to 164 ft) for 1.5 to 2.5 min. The maximum recorded depth and durations for two females were 204 m (669 ft) and 7.5 min. However, dives deeper than 150 m (492 ft) were not common. Daytime dives are typically shallower than nighttime dives (Reeves et al., 1992) and they typically travel alone at sea but forage in groups (Reeves et al., 2002).

Australian fur seals (*Arctocephalus pusillus doriferus*) are the largest species of fur seals. Most of their breeding and haul out sites are protected by Australian federal, state, and territorial laws. In 1991, their abundance was estimated at 47,000 to 60,000 off southeast Australia and 15,000 to 20,000 off Tasmania (Reeves et al., 2002). Gentry (2002) estimated that there was a total of 60,000 Australia fur seals and stated that their populations are stable.

Australian fur seals are believed to be non-migratory. They breed in the Bass Strait on four islands off Victoria in southeast Australia and at five islands off Tasmania. The largest colonies are found at Lady Julia Percy Island, Seal Rocks, and Reid and Judgement Rocks off Tasmania. Vagrants have been seen as far north as Port Stephens in New South Wales (Reeves et al., 1992; Reeves et al., 2002). Maatsuyker Island is also an important haulout for fur seals (Arnould, 2002).

Bass Strait waters are nutrient-poor (Arnould, 2002). Fur seals must forage over the continental shelf and at the sea bottom, searching under rocks for squid and octopus (Gentry, 2002; Reeves et al., 2002).

Females dive to the seabed of the continental shelf, a depth of 65 to 85 m (213 to 279 ft). The average dive depth for males is 14 m (46 ft) for an average duration of 2.5 min, with deepest dives recorded at 102 m (338 ft) for 6.8 min (Reeves et al., 2002). Australian fur seals spend approximately one-third of their time at sea (Stewart, 2002).

There is no information available on the hearing abilities or sound production of this species.

Guadalupe fur seals *(Arctocephalus townsendi)* are currently classified as threatened under ESA, CITES protected and considered a vulnerable species under IUCN. The worldwide population size for this species is unknown. Estimates of 7,400 have been documented on Guadalupe Island, Mexico (Gallo-Reynoso, 1994).

Guadalupe fur seals are found in temperate waters off the eastern coast of Guadalupe Island, Mexico and along the coast of southern California. They prefer either a rocky habitat or volcanic caves. Currently the species only breeds on the eastern coast of Guadalupe Island. The stock of Guadalupe fur seals returns to Guadalupe Island to breed during the summer and again in the fall-winter to molt. Female Guadalupe fur seals give birth in June. It appears that the individuals are faithful to the same breeding site from year to year (Reeves et al., 1992).

Swim speeds of this species range from 1.8 to 2.0 m/s (3.4 to 3.9 knots) (Croll et al., 1999). Guadalupe fur seals are shallow divers, foraging within the upper 30 m (100 ft) of the water column. The average dive duration is near 2.6 min at depths near 61 m (200 ft) (Gallo-Reynoso, 1994; Reeves et al. 2002). Their diet consists of squid and lanternfish (Reeves et al., 2002).

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 is that males produce airborne territorial calls during the breeding season (Pierson, 1987).

Sub-Antarctic fur seals (*Arctocephalus tropicalis*) occur in the sub-Antarctic islands north of the Antarctic Convergence. The population of fur seals is believed to be between 280,000 and 350,000 individuals, with numbers continuing to increase. In 1995, the population at Macquarie Island was estimated to be around 110. In the early 1990s, there were approximately 50,000 sub-Antarctic fur seals at Amsterdam Island. In 1978, the population at Gough Island was estimated to be around 200,000 and was increasing (Reeves et al., 2002). Gentry (2002) estimated that there were more than 310,000 sub-Antarctic fur seals.

Sub-Antarctic fur seals haul out and breed 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. Occasionally, adult males have been seen near Brazil, Cape of Good Hope, and Australia. Males begin arriving at the islands in November and begin leaving in January. At Gough Island, most rookeries are on the western side of the island, on the windward coasts where the ocean spray and the wind have a cooling effect and help to reduce heat stress (Reeves et al., 1992). They prefer to breed in rocky coastal habitats while non-breeding animals haul out on tussock slopes above the beaches (Reeves et al., 2002).

Pupping occurs from late November to December (Reeves et al., 2002). Lactating females alternate their foraging days at sea and days on land. Their trips in the winter typically are longer and may last up to 28 days (Reeves et al., 2002). Their diet includes fish, cephalopods, and occasionally rockhopper penguins (Reeves et al., 1992). They commonly dive to depths of around 15 to 20 m (50 to 65 ft) in the summer and to 30 m (100 ft) in the winter. Each dive typically lasts 1 to 1.5 min. The deepest recorded dive was to 208 m (682 ft) and the longest dive lasted 6.5 min. Nocturnal diving is common at some sites (Reeves et al., 2002; Stewart, 2002).

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. The primary call of the female is a loud, tonal honk to call their pups (Reeves et al., 2002).

Northern fur seals (*Callorhinus ursinus*) are currently classified as a vulnerable species under IUCN and depleted under the MMPA. The worldwide population size for this species is estimated near 1.2 million (Gentry, 2002). Fur seals were harvested for their pelts beginning in 1771-1772 when they were discovered (Reeves et al., 1992).

Northern fur seals are subpolar animals widely distributed across the North Pacific in November and December, and are generally associated with the continental shelf break in the North Pacific. Males arrive at breeding grounds in the Bering Sea during May and June, while females arrive in July and early August (Gentry, 1998). Breeding locations are predictable due to site fidelity. Thirty-one breeding sites exist on Bering Island in the Commander Islands of Russia, which have been occupied since at least 1742. Other sites include the Pribilof Islands, Robben Island in the Sea of Okhotsk, the Kuril Islands, Bogoslof Island, and San Miguel Island for California (Gentry, 2002; Reeves et al., 2002). 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. They are typically solitary when observed at sea (Reeves et al., 2002). Some pups have also been seen along the Washington, British Columbia, and Japan coasts (Gentry, 2002).

Routine swim speeds of this species are reported between 1.5 and 1.9 m/s (2.9 and 3.7 knots) (Williams, 2002). 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 (Reeves et al., 1992). They forage primarily on small surface-schooling fish (e.g. Pollack, mackerel, capelin, herring, and eulachon) and squid in the upper 100 m (345 ft) of the water column. Northern fur seals do not feed on top of the continental shelf; instead, they forage along the shelf break. Diving behavior changes based on the behavior of prey (Gentry, 2002).

The northern fur seal can hear sounds in the range of 500 Hz to 40 kHz (Moore and Schusterman, 1987; Babushina et al., 1991). Their hearing is most sensitive between 4 and 28 kHz.

Northern fur seals are known to produce clicks and high frequency sounds underwater (Frankel, 2002). Estimated source levels and frequency ranges are unknown. There are no available data regarding seasonal or geographical variation in the sound production of this species. There is evidence of long-term, on-land vocal recognition between mother and pup (Insley, 2000).

Sea Lions (*Otariinae)*

The genus *Otariinae*, or sea lions, consist of five living genera and seven species including Northern sea lions *(Eumetopias jubatus*) (also known as the Steller sea lion), California sea lions (*Zalophus californianus*), Australian sea lions (*Neophoca cinerea*), New Zealand sea lions (*Phocartos hookeri*) (also known as Hooker’s sea lions), Galapagos sea lions (*Zalophus californianus wollebaeki*), Japanese sea lions (*Zalophus californianus japonicus*), and southern sea lion (*Otaria flavescens).*

Northern sea lions *(Eumetopias jubatus*) are also known as Steller sea lions. The stock west of 144W longitude was recently reclassified as endangered, and the threatened listing is being maintained for the remaining stock (FR Vol. 62 No. 86). They are classified as an endangered species under IUCN. The worldwide population size for this species was estimated near 100,000 in 1994 (Loughlin, 2002).

Northern sea lions are found in temperate or sub-polar waters and are widely distributed throughout the North Pacific and southern Bering Sea from Japan to California. 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 in Alaska and the southernmost rookery is found at Ano Nuevo Island in California (Loughlin, 2002). Smaller rookeries exist on Southeast Farallon Island, Cape St. George in California, along the Oxford and Rogue reefs in Oregon, and along the British Columbia coast at Cape St. James and North Danger Rocks (Reeves et al., 1992). They may haul out on sea ice in the Bering Sea and the Sea of Okhotsk, which is unusual for otariids (Reeves et al., 2002).

When females forage with pups during the summer, the trip may last an average of 18 to 25 hours; and they may travel up to17 km (10.6 mi). They dive an average of 4.75 hours per day. During the winter, females may travel for 200 hours with a trip length of approximately 130 km (81 mi) and dive for approximately 5.3 hours per day. The estimated home range in the summer for adult females is approximately 320 sq km (199 sq mi). In the winter the estimated home range is 47,600 sq km (29,577 sq mi) for adult females and 9,200 sq km (5717 sq mi) for yearlings (Loughlin, 2002).

Swim speeds of this species are not known. The maximum recorded dive depth is 328 m (1,076 ft). Average dive depths are 21 m (69 ft) and generally last for less than 1 min. Deeper dives are usually less than 250 m (820 ft). They forage primarily on small surface-schooling fish. Northern sea lions eat a variety of species, including pollock, cod, mackerel, herring, flatfish, sculpins, octopus, and squid. Females with pups usually feed at night during the breeding season but feeding occurs at all times when breeding season ends (Laughlin, 2002).

Northern sea lion underwater sounds have been described as clicks and growls (Poulter, 1968; Frankel, 2002). 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 (Laughlin, 2002). There is no available data regarding seasonal or geographical variation in the sound production of this species.

Kastelein et al. (2005) studied the differences between male and female northern seal lion hearing and vocalizations. They described male in-air vocalizations as belches, growls, snorts, scolds, and hisses, and are believed to be mainly related to the breeding season. The female and pup in-air vocalizations are described as bellows and bleats. The underwater vocalizations are belches, barks, and clicks. Their study was conducted because northern sea lion hearing may not resemble that of other tested *Otariids* and because there are large size differences between male and females which mean there could be differences in the size structure of hearing organs and therefore differences in hearing sensitivities. The background noise levels used in this study were given in equivalent sound-pressure spectrum levels, or time-averaged levels of fluctuating noise. The underwater audiogram of the male showed his maximum hearing sensitivity at 77 dB RL at 1 kHz. The range of his best hearing, at 10 dB from the maximum sensitivity, was between 1 and 16 kHz. His average pre-stimulus responses occurred at low frequency signals. The female’s maximum hearing sensitivity, at 73 dB RL, occurred at 25 kHz. This study showed a difference of hearing threshold between the male and female due to frequency. 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 northern 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 northern sea lions in this study. This study also showed that low frequency sounds are audible (Kastelein et al., 2005).

California sea lions (*Zalophus californianus*) are common along the Pacific coast of the United States and Mexico. They are common as far north as Vancouver Island but may reach as far north as Prince William Sound, Alaska and are found as far south as Chiapas, Mexico (Heath, 2002). California sea lions breed mostly on the Channel Islands and the Pacific islands along Baja, California, Mexico in the Gulf of California (Reeves et al., 2002). Pups are rarely born as far north as the Farralon Islands off central California (Heath, 2002). Females and juveniles do not migrate extensively. However, males migrate north after the breeding season (Reeves et al., 2002). The largest California sea lion colony is on San Miguel Island (Reeves et al., 1992).
California sea lions haul out and travel in large numbers, preferably on sandy beaches. They breed in areas of high productivity due to foraging requirements during lactation (Heath, 2002). They feed mostly in cool upwelling waters along the continental shelf and seamounts and occasionally on the ocean bottom. They feed mostly on anchovy, squid, sardines, mackerel, rockfish, whiting, and blacksmith (Reeves et al., 2002).

In the summer, females may dive up to 75 m (245 ft), remaining submerged for 4 min at a time. For the rest of the year, the females typically dive deeper and longer. The maximum depth recorded was 536 m (1,760 ft). The maximum duration of a dive recorded was for 12 min. California sea lions spend several days at a time at sea, diving for most of that time (Reeves et al., 2002).

The most recent population estimates in the United States is a minimum of 139,000 individuals, with 49,000 pups born in 2001. The population in Mexico was estimated to be between 13,000 and 22,000. The total population is estimated to be 211,000 to 241,000 (Heath, 2002).

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).

Southall et al. (2005) examined the reliability of underwater hearing thresholds in pinnipeds. They found that underwater, low frequency behavioral hearing thresholds from the study years 2000 and 2001 for California sea lions were not statistically different compared to studies conducted four to seven years earlier. There were no measurable reductions in hearing sensitivity for the frequencies tested despite that the research conducted in 1996 and 2000 involved several hundred controlled noise exposures at similar frequencies resulting in auditory masking and a lesser number of exposures known to induce temporary hearing losses of 6 dB or greater (18 occurrences in California sea lions). The results from these tests suggest that hearing abilities in some mammals, including those regularly exposed to moderate levels of noise, may remain relatively unchanged over multiple years prior to senescence (aging) (Southall et al., 2005).

Underwater sounds produced by California sea lions include barks, clicks, buzzing, and winnies. Barks are less than 8 kHz with the dominant frequencies below 3.5 kHz. The winny call is typically between 1 to 3 kHz, and the clicks have dominant frequencies between 500 Hz to 4 kHz. Buzzing sounds are generally from less than 1 kHz to 4 kHz, with the dominant frequencies occurring below 1 kHz (Schusterman, 1967).

Australian sea lions (*Neophoca cinerea*) are a temperate species found between 28 and 38S (Ling, 2002). Their range is limited to Australia. The largest colony is found in eastern South Australia with 28 other colonies in Western Australia and 38 colonies in South Australia (Reeves et al., 2002). Australian sea lions have an estimated total population ranging between 9,300 and 12,000 (Gentry, 2002). The Seal Bay area has been designated as a conservation park for the sea lions (Ling, 2002).

Australian sea lions have a breeding range from Houtman Abrolhos in western Australia east to the Pages Islands near Kangaroo Island. The largest breeding colonies are found on Purdie Island, Dangerous Reef, Seal Bay on Kangaroo Island, and the Island of the Pages. Mainland breeding colonies exist at Point Labatt in southern Australia and near Twilight Cove (Thundula) in Western Australia. Australian sea lions prefer to haul out on sandy beaches and on rocky reefs but have been known to wander inland several kilometers. They are typically found in smaller breeding colonies of several hundred or less. They are primarily asocial except during breeding season (Reeves et al., 2002).

Females and juveniles do not typically migrate. During the non-breeding season, males migrate widely along the western coast. Vagrants are found as far north as Shark Bay and as far east as Portland, Victoria (Reeves et al., 2002).

Female Australian sea lions forage locally. Their diet is poorly known, but it is assumed that they eat mostly fish, small sharks, octopus, squid, and occasionally penguins. They feed mostly on the sea floor within 30 km (20 mi) of the shore at a depth of 150 m (492 ft) (Reeves et al., 2002).

There is no information available on the hearing abilities or sound production of this species.

New Zealand sea lions, also known as **Hooker's sea lions (*Phocartos hookeri*),** range along the Auckland Islands. They are listed under the IUCN as vulnerable with an estimated abundance of 12,500 to 13,000 individuals (Gentry, 2002; Gales, 2002).

New Zealand sea lions are found in a range of temperate habitats including sandy beaches, reef flats, grass and herb fields, dense bush and forests, and bedrock. They may also wander several kilometers inland (Gales, 2002). Their range centers around the Auckland Islands, approximately 400 km (249 mi) south of Stewart Island (Reeves et al., 1992). Approximately 95 percent of pups are born at Enderby, Dundas, and the Figure Eight Islands. Smaller colonies exist on Campbell Island and the Snares Islands. They typically spend more time at sea in the fall and the winter

(Reeves et al., 2002). Males haul out in the fall and winter at Port Pegasus on Stewart Island. Males also occur year-round at Otago Peninsula at Papanui Beach on the mainland of South Island, New Zealand. Males can migrate 600 km (375 mi) south of the Aucklands to Macquarie Island. Vagrants have also been identified in Maori middens on North Island, Cape Kidnappers, and Coromandel Peninsula.

The diet of New Zealand sea lions includes flounder, octopus, opalfish, munida, hoki, rattail, salps, squid, and crustaceans. Males may also eat seabirds, penguins, and seal pups (Gales, 2002; Reeves et al., 2002). Lactating females typically forage in benthic habitats. They may dive up to 120 m (400 ft) for 4 min at a time, diving continuously to the sea floor (Reeves et al., 2002). New Zealand sea lions are the deepest and longest divers of the otariids. On average, they make 7.5 dives an hour, spending 45 percent of that time submerged. Their average dive is 123 m (404 ft) in depth. The maximum recorded depth for a dive was approximately 500 m (1,640 ft). The average time that sea lions spend submerged at depths is less than 6 m (19.7 ft) is 3.9 min. The maximum time recorded on a dive was 11.3 min (Gales, 2002). Swim speed is typically about 1 m/s (1.9 knots) (Williams, 2002).

Hooker sea lions all bark and produce clicks underwater (Poulter, 1968). There is no information available on the hearing abilities of this species.

Galapagos sea lions (*Zalophus californianus wollebaeki*) are an equatorial subspecies related to California sea lions. They are classified as a vulnerable species under IUCN. Their range is restricted to the Galapagos Islands with a small colony on La Plata Island off Ecuador. Occasionally, vagrants can be seen along the Ecuador and Columbia coasts, particularly around Isla del Coco, Costa Rica, and Isla del Gorgona (Heath, 2002). They typically haul out and travel in large numbers (Reeves et al., 2002).

The Galapagos sea lions' diet is associated with the isolated areas of high productivity found around the nutrient-rich upwelling areas of the Galapagos Archipelago. Sardines are a staple in their diet (Heath, 2002). They also eat anchovy, squid, mackerel, and rockfish. Galapagos sea lions forage along the continental shelf and seamounts and occasionally on the ocean bottom (Reeves et al., 2002). They forage within a few kilometers of the coast, feeding only at daytime. Their dives average 37 m (121 ft) but have been known to reach as deep as 186 m (610 ft) (Heath, 2002). Average dive duration is less than 2 min, and maximum recorded dive duration is 6.0 min (Kooyman and Trillmich, 1986). Swim speed is typically about 2 m/s (3.9 knots) (Williams, 2002).

There is no information available on the hearing abilities or sound production of this species.

Japanese sea lions (*Zalophus californianus japonicus*) are also a subspecies related to California sea lions. This temperate subspecies is believed to be extinct; there have been no reliable sightings since the 1950's. The subspecies is classified as extinct under IUCN. They are believed to have ranged along the southern coast of Kamchatka into the southern Sea of Japan (Reeves et al., 2002). Their range centered along the coasts of Honshu, off Shikoku and Kyoshu in Seto Inland Sea and in the islands of the Sea of Japan and the Izu region (Heath, 2002).

Rookeries existed at Takeshima, Ullung-do, the northwest and central-eastern coasts of Honshu, and four islands in the Izu region. Vagrants were seen in the southwestern Sea of Okhotsk, the Kuril Islands, southern Kamchatka, and the east coast of South Korea. There is no foraging information on Japanese sea lions (Heath, 2002).

South American sea lions (*Ottaria byronia*) are also known as the southern sea lion. In the early 1980's, the world population was estimated to be around 300,000. There are approximately 34,000 in Peru, 9,000 in Chile, more than 170,000 in Argentina, and at least 30,000 in Uruguay (Reeves et al., 1992). Cappozzo (2002) estimates 110,000 live on the southwestern Atlantic coast, concentrated mainly around Patagonia and the southern islands but there is no reliable information to estimate the population size on the Pacific coast.

South American sea lions are distributed along the coast of South America from southern Brazil to northern Peru, including the Falkland Islands, Tierra del Fuego, and Staten Island. They are not known to inhabit the Juan Fernandez Islands off Chile. They range as far north as the east coast of Rio de Janeiro or Sao Paulo along the west coast of Zorritos, Peru. The northernmost breeding sites are at Recife das Torres, Uruguay in the east and Lobos de Tierra Island, Peru in the west. They are also found on some islands south of Cape Horn, including the Diego Ramirez Islands of Chile and the San Martin de Tours of Argentina. They are occasionally seen as far west as Tahiti in the South Pacific (Reeves et al., 1992).

Male South American sea lions in particular are known to wander great distances. Groups have been observed more than 200 km (124 mi) north of the Falklands in late December when breeding season has already begun. They also enter estuaries and freshwater systems (Reeves et al., 1992).

There are no breeding colonies on the mainland of Brazil and Uruguay. Uruguayan breeding colonies exist on the Coronilla, Castillos, and Torres island groups and on Lobos Island. Breeding habitat varies with the location. In Chile, South American sea lions breed and pup in rocky areas and sometimes in caves that are inaccessible by land. In Argentina, they come ashore on open sandy or pebbly beaches. At Punta Norte, males and females both arrive during the first half of December for breeding (Reeves et al., 1992). Pupping begins in September and ends in March, depending on location (Reeves et al., 2002).

Postpartum females typically forage for three days at a time (Reeves et al., 1992). They often dive at night (Reeves et al., 2002). South American sea lions feed on Argentine hake, anchovy, red octopus squid, lobster krill, and sometimes jellyfish (Reeves et al., 1992; Reeves et al., 2002). They also occasionally eat fur seals, ducks, and penguins. They forage mainly in shallow waters, less than 300 m (984.2 ft), near coasts or productive fishing banks (Reeves et al. 1992). They eat fish that live on the seafloor because they are typically slow-swimming. Lactating females usually dive to depths of 250 m (820 ft) (Reeves et al., 2002).

Males often bark when establishing and maintaining territories and herding females. They make airborne high-pitched, directional calls during encounters with other males.

Table 3.2-5. Information Summary for Otariidae: Fur Seal and Sea Lions

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
South American fur seal (*Arctocephalus australis*)		-South American coast in both Atlantic and Pacific oceans -Falkland Islands -As far north as southern Brazil in Atlantic and near Paracas, Peru in Pacific -In the Atlantic, found along the coast of Argentina to Uruguay	Total population estimates: 285,000 Chile: 40,000 in 1976 Northern Chile: 228 in 1982 Falkland Islands: 14,000 to 16,000 in 1973 Argentinean coast: 2,700 in 1954 Peruvian coast: 20,000 in 1979 Uruguay: 280,000 in 1992	Female forage dive duration: 3 min Female forage dive depth: 40 m Female forage max dive depth: 170 m Max dive duration: 7 min	Hearing No direct data available Sound Production Males produce airborne vocalizations during breeding season and threat calls
New Zealand fur seal (*Arctocephalus forsteri*)		-Breeding populations on South Island, NZ, and southeastern Australia -Western limit is Perth -Northeast limit is Queensland, Australia, and New Caledonia -Eastern limit is Bounty, Antipodes, and Chatham Islands -Southern limit is Snakes, Aukland, and Campbell Islands	Estimate: 135,000 Australia: 35,000 in 1991 Macquarie Island: 2,000 non-breeding individuals in April and May in the late 1980's	-Forage at night Dive depth: 10-15 m Max duration: 11 min Max depth: 274 m for lactating female Average swim speed: Unknown	Hearing No direct data available Sound Production Males produce airborne vocalizations during breeding season

Table 3.2-5. Information Summary for Otariidae: Fur Seal and Sea Lions

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Galapagos fur seal (*Arctocephalus galapagoensis*)	IUCN-Vulnerable species	-Galapagos Islands, particularly Isabela Island and Fernandina Island	Estimate: 40,000	Age-Dependent 6 mo old: 6 m, 50 sec 12 mo old: 47 m, 2.5 min 18 mo old: 61 m, 3 min Max depth: 169 m for 6.5 min Average swim speed: Unknown	Hearing No direct data available Sound Production No direct data available
Juan Fernandez fur seal (*Arctocephalus philippi)*	IUCN-Vulnerable species	-Juan Fernandez island group, including Mas a Tierra or Robinson Crusoe, Santa Clara, and Mas Afuera or Alejandro Selkirk - San Feliz island group, including San Ambrosio and San Felix - As far south as Punta San Juan, Chile - As far north as Peru	Estimate: 12,000 in late 1990's Estimate: 18,000 in 2002	Diving behavior based on information on lactating females: Dive depths: 10-90 m Dive duration: 1.7-2 min Dive at night Reach as far as 500 km offshore	Hearing No direct data available Sound Production No direct data available
South African fur seal (*Arctocephalus pusillus pusillus*)		- Along the coast of South Africa and Namibia - Breeding colonies from Cape Cross, Namibia around the Cape of Good Hope to Black Rocks, Cape Province, reaching west to Angola and south to Maron Island - May reach as far south as 11ºS	Estimate: 1,700,000 in 2002	Diving behavior based on information on lactating females: Dive depths: 40-50 m Max depth: 204 m Dive duration: 1.5-2.5 min Max duration: 7.5 min Dive 5 km offshore Nighttime dives typically deeper than daytime dives	Hearing No direct data available Sound Production No direct data available
Australia fur seal (*Arctocephalus pusillus doriferus*)		-Found in Victoria, Australia, Lady Julia Percy Island, Seal Rocks, Reid and Judgement Rocks off Tasmania -Seen as far north as Port Stephens in New South Wales	Global estimate: 60,000 Southeast Australia: 46,000 to 60,000 in 1991 Tasmania: 15,000 to 20,000 in 1991	Dive to seabed of continental shelf Depth: 65-85 m females Depth: 14 m males Dive duration: 2.5 min male Max depth: 102 m for 6.8 min Average swim speed: Unknown	Hearing No direct data available Sound Production No direct data available

Table 3.2-5. Information Summary for Otariidae: Fur Seal and Sea Lions

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Guadalupe fur seal (*Arctocephalus townsendi*)	ESA - threatened IUCN - vulnerable species CITES protected	-E. coast of Guadalupe Island, Mexico; southern California	Guadalupe Island: 7,400	Dive duration: 2.6 min Dive depth: 30 m Average swim speed: 1.8-2.0 m/s	Hearing No direct data available Sound Production Males produce airborne vocalizations during breeding season
Sub-Antarctic fur seal (*Arctocephalus tropicalis)*		-Found in the Subantarctic islands north of the Antarctic Convergence - Haul out and breed in the South Atlantic and Indian oceans, mostly on the islands of Amsterdam, Saint Paul, Crozet, Gough, Marion, Prince Edward, and Macquarie -Males occasionally seen around Brazil, Cape of Good Hope, and Australia	Global estimate: 310,000 in 2002 Macquarie Island: 110 in 1995 Amsterdam Island: 50,000 in early 1990's Gough Island: 200,000 in 1978	Diving behavior based on information on lactating females: Dive depth: 15-20 m in the summer; to 30 m in the winter Dive duration: 1-1.5 min Max depth: 208 m Max duration: 6.5 min Nocturnal diving common	Hearing No direct data available Sound Production Males produce three types of airborne vocalizations: -Barks for territorial status -Guttural growls or puffs to state territorial boundaries -High-intensity calls to warn or challenge other males Females make a loud, tonal honk to call their pups
Northern fur seal *(Callorhinus ursinus)*	IUCN - vulnerable species MMPA - depleted	-North Pacific; Bering Sea	Global estimates: 1.2 million	Dive duration: 2.6 min Dive depth: 100 m Max depths: 207 - 230 m Average swim speed: 1.5-1.9 m/s	Hearing Frequency range: 500 Hz- 40 kHz Dominant range: 4 kHz and 28 kHz Sound Production Underwater clicks and high frequency vocalizations

Table 3.2-5. Information Summary for Otariidae: Fur Seal and Sea Lions

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Northern sea lion *(Eumetopias jubatus)*	ESA – endangered - Stock west of 144°W; threatened-remaining population	-Temperate to sub-polar waters in North Pacific -Southern Bering Sea from Japan to California	Global estimates: 100,000 in 1994	Dive duration: <1 min Dive depth: 21 m Max depth: 328 m Average swim speed: Unknown	Hearing No direct data available Sound Production Underwater clicks and growls Airborne: Males produce a low frequency roar when courting or signaling threats Pups make a bleating cry and their voices deepen with age
California sea lion (*Zalophus californianus*)		-Prince William Sound, Alaska south to Chiapas, Mexico -Common as far north as Vancouver Island -Reach as far north as Prince William Sound -Reach as far south as Chiapas, Mexico	Global estimate: 211,000-241,000 U.S.: 167.000-188,000 Mexico: 13,000-22,000	Dive depth in the summer: 75 m Dive duration: 4 min Max depth: 536 m Max duration: 12 min Average swim speed: Unknown Diving depth and durations increases after summer months	Hearing Frequency range: 75 Hz-64kHz Sound Production Barks: <8kHz with dominant frequencies below 3.5 kHz Whinny: 1-3 kHz Clicks: 500 Hz-4 kHz Buzz: <1-4 kHz with dominant frequencies below 1 kHz
Australian sea lion (*Neophoca cinerea*)	IUCN-Near-threatened	-Temperate waters of Australia, 28-38° S -Vagrants found as far north as Shark Bay and as far east as Portland, Victoria	Global estimate: 9,300-11,700	Depth: 150 m Feed mostly on the seafloor within 30 km of shore Average swim speed: Unknown	Hearing No direct data available Sound Production No direct data available
New Zealand sea lion (*Phocartos hookeri*)	IUCN-Threatened	-Auckland Islands - Males migrate south to Macquarie Island -Vagrants in Maori middens on North Island, Cape Kidnappers, and Coromandel Peninsula	Global estimate: 12,500-13,000	Depth: 123 m Duration: 3.9 min for dives less than 6 m depth Max Depth: 500 m Max Duration: 11.3 min Average swim speed: 1 m/s	Hearing No direct data available Sound Production Airborne barks and underwater clicks

Table 3.2-5. Information Summary for Otariidae: Fur Seal and Sea Lions

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Galapagos sea lion (*Zalophus californianus wollebaeki*)		-Galapagos Islands -Occasionally seen along Ecuador and Columbia coasts -La Plata Island off Ecuador	Global estimate: unknown	Depth: 37 m Dive duration: <2 min Max depth: 186 m Max dive duration: 6 min Forage only in the daytime Average swim speed: 2 m/s	Hearing No direct data available Sound Production No direct data available
Japanese sea lion (*Zaophus californianus japonicus*)	IUCN-Extinct	-Southern coast of Kamchatka into the southern Sea of Japan	Possibly extinct	Unknown	Hearing No direct data available Sound Production No direct data available
South American sea lion (*Ottaria byronia*)		- Along the coast of South America from southern Brazil to northern Peru, including Falkland Islands, Tierra del Fuego, and Staten Island - Range as far north as the east coast of Rio de Janeiro or Sao Paulo along the west coast of Zorritos, Peru - Northernmost breeding site at Recife das Torres, Uruguay in the east and Lobos de Tierra Island, Peru in the west - Also found on some islands south of Cape Horn, including Diego Ramirez Island of Chile and the San Martin de Tours of Argentina -Occasionally seen as far west as Tahiti in South Pacific	Estimate: 110,000 in 2002 in southwestern Atlantic coast Early 1980's: 300,000 Peru: 34,000 Chile: 9,000 Argentina: 170,000 Uruguay: 30,000	Diving behavior based on information on lactating females: Dive depths: 250 m Forage in shallow waters, less than 300 m, near coasts and fishing banks Dive at night	Hearing No direct data available Sound Production In air, males often bark when establishing and maintaining territories and herding females Make airborne high-pitched directional calls during encounters with other males
Source: See individual species descriptions for literature references.					

3.2.5.2 Phocidae

The family Phocidae is divided into two subfamilies (Monachinae and Phocinae) containing 18 species of true seals. Phocids are generally restricted to polar and subpolar climate. Phocids are also known for their adaptability to live in estuarine or freshwater habitats, such as the Caspian and Baikal seals inhabiting lakes (Berta, 2002). In total, nine of the species are eliminated from consideration because they are found outside of SURTASS LFA sonar operational areas. There is little information on the responses of phocids to low frequency sound. One report by Richardson et al. (1995) indicates 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, 1968; Terhune and Ronald, 1972, 1975a, 1975b; Terhune, 1989, 1991; Terhune and Turnbull, 1995). Of the species that have been studied, 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). Phocids probably hear sounds underwater at frequencies up to about 60 kHz. Above 60 kHz, their hearing is poor. Table 3.2-6 summarizes information on the status, distribution, abundance, diving behavior, sound production and hearing of Phocidae species being evaluated for potential impacts.

Mediterranean monk seals (*Monachus monachus)* 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 at less than 500 (Croll et al., 1999). The largest colony at the Cape Blanc Peninsula on the coast of the Western Sahara, Africa was estimated at 100 in 1997 (Reeves et al., 2002).

Historically, Mediterranean monk seals had a large range from 20N, along northwestern Africa, into the Mediterranean Sea, and into the southern Black Sea. The range of these seals has significantly decreased. They have disappeared from the Canary Islands, the French, Italian, and Spanish Mediterranean mainlands, Cyprus, Egypt, Malta, and Israel. Cape Blanc is the southern limit of their range with groups on the tip of the Cape and along the Las Cuevecillas coast. Some seals have been seen further south around Dakar, Senegal, and Gambia. The Desertas Islands once had a large population of seals, but the numbers have declined to only a dozen individuals. Monk seals are present north of Cape Blanc between Cape Barbas and Guerguerat. They are distributed throughout the archipelago of the Mediterranean, particularly in the Aegean and northern Ionian seas. Small groups of seals occur in the Greek archipelago and some small groups occur along the Turkish and Bulgarian coasts of the Black Sea and Sea of Marmara. A few individuals live off the coast of Yugoslavia, Algeria (particularly the Oran coast), Morocco, the La Galite archipelago off northern Tunisia, the Cyrenaican coast of Libya, and around remote parts of Albania and Lebanon (Riedman, 1990; Reeves et al., 1992). Vagrant seals have also been seen off northwestern Corsica, the northeastern and southwestern islands of Sardinia, the southeastern coast and islands of Sicily, and the southeastern coast of Puglia (Reeves et al., 2002). There is no evidence of seasonal movement for Mediterranean monk seals. Mediterranean monk seals breed from the spring through the fall with a peak in births occurring between September and October (Sergeant et al., 1978; Kenyon 1981). Much like other phocids, Mediterranean monk seals are a solitary species. They usually haul out and give birth in caves or grottos.

No direct data are available on swim speed. Mediterranean monk seals tend to forage in coastal waters for fish, octopus, squid, and crustaceans. They do not forage at depths greater than approximately 70 m (230 ft) and most dives do not last longer than 10 min. Most of the monk seal observations have been within 5 to 6 km (3.1 to 3.7 mi) of the shore. However, they have also been observed as far as 37 km (23 mi) from shore. The home range for individuals in the Aegean Sea has been estimated to be within 20 to 40 km (12.4 to 24.9 mi) of the coastline. Mediterranean monk seals have been observed along 600 km (373 mi) of the shoreline of the Aegean Sea (Reeves et al., 1992).

There is no direct measurement of auditory threshold for the hearing sensitivity of Mediterranean monk seals (Thewissen, 2002), and there are no available data on the sound production of this species.

Hawaiian monk seals ***(Monachus schauinslandi)*** are listed as endangered under the ESA, classified as endangered under IUCN, and protected under CITES. The worldwide population size for this species was estimated at nearly 1,400 in 2000 (Reeves et al., 2002).

Hawaiian monk seals are found almost exclusively on the northwest Hawaiian Islands where they occasionally move among islands and atolls. Their rookeries are primarily located on the Leeward Islands of French Frigate Shoals, Pearl and Hermes Reef, Kure Atoll, and Laysan and Lisianski Islands (Croll et al., 1999; Reeves et al., 2002). Smaller colonies also live on Nihoa and Necker Islands. After two males were translocated to Johnston Atoll in 1997, a few seals have been seen there each year. Hawaiian monk seals have also been seen in the main islands of Hawaii and since the 1980s, pups have been born on the islands of Maui, Kauai, Oahu, and Molokai. Hawaiian monk seals do not seem to be tolerant of human presence. When the U.S. military inhabited Sand Island and the Midway Islands and Kure Atoll, the monk seals disappeared until after the military left. Monk seals prefer to be solitary animals (Reeves et al., 2002).

No swim speed data are available. Foraging dive durations last up to 4 min. Some dives have been recorded to last longer than 30 min; however, it is unclear if these are foraging dives. Hawaiian monk seals forage on benthic or reef fish, cephalopods, and crustaceans (particularly lobster). Seals may dive to depths from 60 m (200 ft) to greater than 250 m (820 ft). They have been recorded as diving up to 490 m (1,608 ft) (Reeves et al., 1992).

The Hawaiian monk seal can hear underwater sounds in the range of 2 to 40 kHz. Their most sensitive hearing is at 12 to 28 kHz, which is a narrower range compared to other phocids. Above 30 kHz, their hearing sensitivity drops markedly (Thomas et al., 1990a). No underwater sound production has been reported. In air sounds include a soft liquid bubble (100 to 400 Hz), a guttural expiration (<800 Hz), a roar (<800 Hz), and a belch cough (Miller and Job, 1992).

Northern elephant seals (***Mirounga angustirostris)*** were estimated in 2000 at over 150,000 (Reeves et al., 2002). **Southern elephant seals** ***(M. leonina)*** were estimated at 750,000 (Reeves et al., 2002). 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 Pacific. They occur during the breeding season from central Baja, Mexico to central California in about 15 colonies (Le Boeuf and Laws, 1994; Stewart and DeLong, 1994; Hindell, 2002). Most of the colonies are located on offshore islands. They make long, seasonal migrations between foraging and breeding areas twice a year, returning to their southern breeding grounds to molt (Hindell, 2002). 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 14 colonies around the Antarctic Convergence, between 40 and 62S (King and Bryden, 1981; Laws, 1994). They are commonly found along the southern coast of Argentina (Reeves et al. 2002). 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 north of the Antarctic Polar Front to the Antarctic pack ice. During non-breeding seasons, both the southern and the northern elephant seals are widely dispersed (Hindell, 2002).

Studies on California rookeries have shown three seasonal changes in the age and sex composition. There are three seasonal peaks in abundance: the first in January during the peak of breeding season, the second in late April or early May when juveniles and females are molting, and the third in October when the females, the pups of the year, and juveniles haul out (Reeves et al., 1992).

Foraging for both northern and southern elephant seals differs between males and females. Male northern elephant seals forage on the continental shelf in the northern parts of their range while the females feed in the middle of their range in deeper oceanic waters (Le Boeuf, 1994). Male southern elephant seals feed in southern waters along the Antarctic continental shelf. They feed on deep-water fish and squid (Hindell, 2002).

Elephant seals spend more than 80 percent of the year at sea, mostly feeding to build up blubber required for breeding and molting. On average, adult females dive for 20 min to depths of 400 to 800 m (1312 to 2325 ft). Adult males make dives on average for 30 min at shallower depths. One recorded dive reached in excess of 1,500 m (4,921 ft) for approximately 120 min (Hindell, 2002). Le Boeuf et al. (1989 *in* Kastak and Schusterman, 1999) reported that northern elephant seals dive to average depths of 500 to 700 m (1,640 to 2297 ft) and may spend as much as 90 percent of their time at sea under water hunting for food, traveling, and resting (Hindell, 2002). Swim speeds were recorded near 1.1 m/s (2.1 knots) for northern elephant seals (Fletcher et al., 1996). Swim speeds were not available for southern elephant seals.

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). The reduction of the external meatus and the presence of cavernous tissue in the ear are likely to be adaptations that minimize water penetration into the ear canal and the size of the middle-ear space. This reduction in the volume of the outer and middle ear air space could enhance underwater sound detection by matching the acoustic impedance of the ear with that of the water (Repenning, 1972 *in* 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). In 1998, Kastak and Schusterman 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 is no direct 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, 2002). In the air, mean frequencies for adult male northern elephant seal vocalizations range from 147 to 334 Hz (Le Boeuf and Petrinovich, 1974; Le Boeuf and Peterson, 1969). 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, 2002). There are no available data regarding seasonal or geographical variation in the sound production of either species.

Ribbon seals *(Phoca fasciata*) occur near the Bering Sea, Okhotsk Sea along eastern Russia, and the southern part of the Chukchi Sea, Japan, and Korea. There are three main populations of ribbon seals, one in the Bering Sea and two in the Okhotsk Sea. Parts of the Okhotsk Sea populations may migrate in the spring and summer with the receding ice to the southern Chuckchi Sea (Fedoseev, 2002). Some also migrate to the Beaufort Sea, the Aleutian Islands, northern Hokkaido, and the central North Pacific Ocean (Reeves et al., 2002). Ribbon seal individuals have also been observed along the California coast in Morro Bay. However, the range of the migration is poorly understood. Pack-ice breeding takes place throughout this range from March to April (Fedoseev, 2002).

Ribbon seals are strongly connected to the ice. However, if the ice is thicker than 10 to 15 cm (3.9 to 5.9 in), ribbon seals have a difficult time making holes. They often inhabit areas with large chunks of stable white ice, which is commonly found along the continental shelf where there is high water circulation (Fedoseev, 2002).

Due to sealing (the hunting of seals) in the Bering Sea in the 1960s, the ribbon seal population severely declined from 115,000-120,000 seals in 1961 to 60,000-70,000 in 1969. Sealing was then limited and in 1987, the population rose to 120,000-140,000 seals. In the Okhotsk Sea, the population fluctuated between 200,000 and 630,000 from 1968 to 1990 (Fedoseev, 2002).

Swim speeds and dive data for this species are not known. Ribbon seals forage primarily on fish, crustaceans, krill, and cephalopods (Riedman, 1990). Pups mostly feed on euphausiids, juveniles feed mostly on shrimp, and adults feed on cephalopods and fish. Adults in the Okhotsk Sea mostly eat Alaskan Pollack and adults in the Bering Sea eat mostly squid and octopus (Fedoseev, 2002).

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 (Watkins and Ray, 1977). According to Reeves et al. (1992), two types of underwater vocalizations produced by ribbon seals have been recorded: 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. Sweeps are diverse and range from 100 Hz to 7.1 kHz. 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 seals (*Phoca largha)*, also called larga seals, occur in temperate to polar regions, spending their time either in open ocean or in pack-ice habitats (Reeves et al., 2002). Populations are found in the Bering, Chukchi, and Beaufort Seas in the summer, and the Sea of Okhotsk, Tartar Strait, the Sea of Japan, the northern Yellow Sea/Bo Hai, and adjacent waters around Korea and China. The southernmost breeding population occurs at 38N and is in the Sea of Japan and the Yellow Sea. They inhabit sea ice throughout the year including the ice over continental shelves during the winter and spring. When the ice cover recedes in the Bering Sea, spotted seals migrate northward into the Chukchi and Beaufort seas. They spend the summer and fall near Point Barrow in Alaska and the northern shores of Chukotka, Russia. Off-shore and near-shore migration patterns are restricted within this range. They migrate southward through the Chukchi and Bering Sea region to maintain association with drifting ice. They rarely haul out during the winter. Their peak haul-out time is during molting and pupping from February to May (Burns, 2002).

Three breeding populations are known in or adjacent to the Okhotsk Sea: in the Shelikhoba Gulf, east of Sakhalin Island, and in Tartar Strait. Other breeding populations exist in Peter the Great Bay in the Sea of Japan and in the Bo Hai Sea of the Yellow Sea (Reeves et al., 1992).

Current population estimates are unavailable. An estimated population of 4,500 in the Bohai Sea was determined during a 1990 survey. The Bering Sea population was estimated at 200,000 to 250,000 in the 1980s. In 1982, the population was estimated to be 130,000 in the Okhotsk Sea (Burns, 2002). However, particularly high densities have been observed in April in outer Bristol Bay, central Bering Sea, and the Karaginskii Gulf. The western stock winters in Karaginskii Gulf and toward the coasts of Koryak and Kamchatka off Russia. The central stock is distributed around the south of Cape Navarin to St. Matthew Island and the Anadyr Gulf in the winter and spring. The eastern stock is distributed around Bristol Bay northward through the Bering Strait and along the Chukchi Sea (Reeves et al., 1992).

Swim speeds and dive times of this species are not known. Dive depths have been recorded to at least 300 m (984 ft) (Reeves et al., 1992). Spotted seals forage primarily on fish, crustaceans, and cephalopods (i.e., pollock, herring, cod, sand lance, capelin, eelpout, flounder, shrimp, and crabs). Spotted seal pups will usually begin eating small amphipods or euphausiids (Bigg, 1981; Reeves et al., 1992; Burns, 2002).

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 seals *(Phoca vitulina)* are also known as common seals. They have an estimated population of 500,000 worldwide (Croll et al., 1999). Of this, 300,000 harbor seals are found in the North Pacific and 40,000 to 100,000 were reported in 1993 in Canadian waters. It is estimated that approximately 98,000 harbor seals existed in the eastern Atlantic in the mid-1980s. In 1990, the largest populations occurred in the North Sea and Iceland. The abundance in Great Britain was up to 47,000 harbor seals. Other large populations include Iceland with 28,000, Wadden Sea with 10,000, and Kettega/Skagerrak with 6,000. The smallest populations occur in the Baltic Sea with around 200 individuals and around Svalbald with 500 to 600 individuals. The abundance in the western Atlantic Ocean is unknown. In 1993, an estimated 40,000 to 100,000 harbor seals were reported. Of that, approximately 30,000 to 40,000 lived in Canadian waters. The population in the United States was around 4,700. Harbor seals are abundant in the eastern Pacific Ocean. In the mid-1990s, estimates along the U.S. coast were 34,500 in California, 39,900 in Oregon and Washington, 13,800 in inland waters of Washington, 100,000 in British Columbia, and 35,000 in eastern Alaska. Population numbers are declining in parts of Alaska. 20,000 animals are estimated in the Gulf of Alaska region, including Prince William Sound. In southwestern Alaska, not including the Aleutian Islands, there is a population with an estimated 15,000 individuals. In 1994, the estimated population of harbor seals living on the Aleutian Islands was 3,400. Other abundance estimates include the Commander Islands (1,500), Kamchatka Peninsula (200), Kuril Island (1,900), and northern Japan (300) (Burns, 2002).

Harbor seals are widely distributed in subarctic and temperate waters along the margins of the North Atlantic Ocean between 30N and 80S latitudes and North Pacific Ocean between 28N and 62S latitudes (Burns, 2002; Riedman, 1990). 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. The Atlantic populations are mainly influenced by warm oceanographic features such as the North Water in Baffin Bay and the water carried by the Gulf Stream and gyres (Burns, 2002).

Harbor seals have a very large range with five subspecies. One subspecies occurs from the French coast on the English Channel throughout the North Sea and north to Finmark on the Barents Sea. This also includes the southern Baltic Sea and the waters of Ireland and Great Britain. Individuals have also been seen around Portugal and the eastern Barents Sea. The northernmost breeding point for this population is in western Svalbard. The western Atlantic subspecies ranges from about 40N around New Jersey to about 73N in northern Baffin Island, Canada. This includes the Hudson Bay and southern Foxe Basin. Individuals have been observed as far south as Florida. A freshwater population also exists around the Ungava Peninsula in eastern Canada and in the eastern Hudson Bay.

In the North Pacific, one subspecies of harbor seals inhabits the eastern North Pacific while another inhabits the western North Pacific. Their boundary is thought to be the western Alaskan Peninsula, and the eastern Aleutian Islands. These two population ranges extend from Cedros Island near Baja, California, Mexico (28N) to the Gulf of Alaska and the southeastern Bering Sea and across the Aleutian Ridge to the Kamchatka Peninsula of Russia and south to the Kuril Islands. They are also found beyond Hokkaido Island in northern Japan. In the Pacific region, the northernmost pupping colonies occur in Prince William Sound in Alaska (Burns, 2002).

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. They haul out along lakes, rivers, estuaries, bays, and ocean shorelines (Burns, 2002). Breeding grounds are generally associated with isolated places such as pack ice, offshore rocks, and vacant beaches (Riedman, 1990).

Harbor seals are capable of foraging in deep waters, up to 150 m (500 ft), depending on their location. Their diet varies by season and the region. The harbor seal feeds on pelagic and benthic fish, cephalopods and crustaceans (Bigg, 1981; Reeves et al., 1992; Burns, 2002). They prey on cod, hake, mackerel, herring, sardines, smelts, shad, capelin, sand lance, sculpins, flatfish, salmon, squid, octopus, crab, and shrimp. Shrimp may be particularly important in the diet of pups (Burns, 2002).

Maximum swim speeds have been recorded over 13 km/hr (7 knots) (Bigg, 1981). Harbor seals dive to up to 150 m (500 ft), depending on their location. Seals in southern California have been recorded diving up to 450 m (1,500 ft). Their dives generally last a few min, but the longest dive recorded was 31 min (Reeves et al., 2002).

Underwater, some low-frequency pulse sounds were recorded to threaten other males (Reeves et al., 2002). Hangii 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. (1999) studied male vocalizations as a tool for comparing the distribution of displaying males in two topographically different areas in northern Scotland, estuarine haul out areas in the Moray Firth and Orkney, which are rocky islands. They aimed to compare the spatial and temporal patterns of male vocalizations in two areas to assess how male display activity varies in relation to geographical differences in female distribution. Harbor seal low-frequency vocalizations were heard for a 40-day period starting in early July through mid-August in the Moray Firth. This was coincidental to the onset of weaning of pups in this population. In Orkney, male harbor seals began vocalizing seven days earlier than in the Moray Firth. This is possibly due to the variation of the timing and duration of the pupping season in the two latitudes, and therefore, different timing of the female estrus. Peak numbers of pups are seen slightly later in the Moray Firth. Throughout the Moray Firth, there was a temporal pattern in relation to the tidal cycle in the number of male vocalizations. There was an increase in vocalization around high tide. In Orkney, male vocalizations were related to both the tides and the time of day. Diel cycles seem to be more closely related in rocky shore areas where site availability is less influenced by the tidal cycle. Similarly, in Sable Island, Canada, temporal patterns of male behavior during the mating season also varied. Males showed a diurnal relationship in their diving patterns. In the Moray Firth, vocalizing males were found throughout the range known to be used by females at that time of year. The highest densities of males were found in the narrow channels along female transit routes between their haul out sites and feeding grounds. Lower densities were found on female feeding grounds. In Orkney, male harbor seals were found in two areas, around Eynhallow and the channels between Egilsay, Wyre, and Rousay. No males were heard vocalizing at any other sampling stations (Van Parijs et al., 1999).

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 subadult 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, 1968; Terhune, 1991; Kastak and Schusterman, 1998). Richardson et al. (1995) reported that phocinid seals have a mostly flat audiogram from 1 kHz up to approximately 50 kHz with hearing thresholds between 60 and 85 dB RL. One harbor seal showed a threshold of 96 dB RL at 100 Hz. Although harbor seals can hear up to 180 kHz, this is extreme and most phocids have an upper frequency closer to 60 kHz (Richardson et al., 1995).

Southall et al. (2005) examined the reliability of underwater hearing thresholds in pinnipeds. They found that underwater, low frequency behavioral hearing thresholds from the study years 2000 and 2001 for harbor seals were slightly statistically different compared to studies conducted four to seven years earlier. There was a slight measurable increase in hearing sensitivity (lower hearing threshold) for the frequencies tested despite that the research conducted in 1996 and 2000 involved several hundred controlled noise exposures at similar frequencies resulting in auditory masking and a lesser number of exposures known to induce temporary hearing losses of 6 dB or greater (20 occurrences in harbor seals). The results from these tests suggest that hearing abilities in some mammals, including those regularly exposed to moderate levels of noise, may remain relatively unchanged over multiple years prior to senescence (aging) (Southall et al., 2005).

Gray seals (*Halichoerus grypus)* have an estimated population of 110,000 in British waters, 69,000 in the western North Atlantic, and 85,000 around Sable island. Other large populations are in the Gulf of St. Lawrence (69,000), Iceland (11,600 in 1987), Norway (3,000), Ireland (2,000), and in the White Sea (between 1,000 and 2,000). The Baltic Sea has approximately 5,000 resident seals (Hall, 2002). Other colonies include the Faroe Island, the Hebrides, North Rona Island, the Orkney Shetland, and Farne Islands (Reeves et al., 2002). Gray seals breed on remote islands that are typically uninhabited or on fast ice. The biggest island breeding colony is on Sable Island (Hall, 2002).

Gray seals occur in temperate and sub-polar regions mostly in the Baltic Sea and the eastern and western North Atlantic. 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 knots). Gray seals dive between 4 and 10 min with a maximum dive duration recorded at 30 min (Hall, 2002). A maximum dive depth of 400 m (1,300 ft) has been recorded for this species. Gray seals are demersal or benthic feeders and forage on a variety of fish species and cephalopods, mostly sand eels and sand lance (Hammond et al., 1994). Other prey species include herring, whiting, cod, haddock, saithe, flatfish, and the occasional bird. Gray seals typically forage for one to five days, focusing on discrete areas that are within 40 km (25 mi) of their haul-out site (Hall, 2002).

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 seals (*Cystophora cristata*) have an estimated population of 250,000 near Jan Mayen Island and nearly 300,000 off Newfoundland (Reeves et al., 2002).

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, and Newfoundland (Wynne and Schwartz, 1999). They are also present in the Norwegian and Barents seas. 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. They are also found in the Davis and Denmark straits, Norwegian, and Barents seas (Reeves et al., 2002). Breeding takes place in this range from late March to the beginning of April for a 2 to 3-week period. They are associated with the outer edge of pack ice and drifting ice throughout much of the year (Reeves et al., 2002). They congregate on ice floes for both mating and pupping. Females in the Gulf of St. Lawrence halt out on ice floes in large congregations. In the summer, hooded seals are found along the Greenland coast and as far north as Cape York. They sometimes occur in the Thule district of northwestern Greenland, as well as in Lancaster and Jones sounds. Hooded seals are a migratory species and are often seen far from their haul-outs and foraging sites. They have been observed as far south as Portugal in Europe and as far south as Florida in the Atlantic and California in the Pacific Ocean. Some individuals swim up the St. Lawrence River as far as Montreal (Reeves et al., 1992).

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 more than 52 min. This species typically feeds on squid and fish species of halibut, redfish and cod (Reeves et al., 2002).

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, 2002). The dominant frequencies of the sounds produced by hooded seals are below 1000 Hz (Schevill et al., 1966; Terhune and Ronald, 1973; Ray and Watkins, 1975). There are at least three types of LF, pulsed sounds, described as grung, snort, and buzz that are made by the male underwater. The grung 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. This vocalization was typically paired with a defensive posture. Pups are generally silent. The sounds produced by hooded seals have a variety of functions ranging from female-pup interactions to fighting behavior and visual displays among males (Frankel, 2002; Terhune and Ronald, 1973). 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.

Table 3.2-6. Information Summary for Phocidae: True Seals

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Mediterranean monk seal (*Monachus monachus)*	ESA-endangered; CITES-protected IUCN-critically endangered	-Mediterranean and Black Seas, Atlantic coast, and offshore islands of N. Africa -Southern limit is Cape Blanc	Global estimates: less than 500 Cabo Blanco Peninsula: 100 in 1997	Foraging depth: <70 m Average duration: <10 min Average swim speed: Unknown	Hearing No direct data available Sound Production No direct data available
Hawaiian monk seal *(Monachus schauinslandi*)	ESA-endangered; CITES-protected IUCN-endangered	Leeward Chain of the Hawaiian Islands; Nihoa, Necker, French Frigate Shoals, Pearl and Hermes Reef, Kure Atoll, Laysan, and Lisianski islands	Global estimates: 1,400 in 2000	Dive duration: up to 4 minutes Average depth: 60-250 m Max depth: 490 m Max duration: >30 min Average swim speed: Unknown	Hearing Frequency range: 2 kHz- 40 kHz Greatest sensitivity from 12-28 kHz Hearing drops >30 Hz Sound Production Airborne sounds Soft liquid bubble: 100-400 Hz Guttural expiration: <800 Hz Roar: <800 Hz Belch cough

Table 3.2-6. Information Summary for Phocidae: True Seals

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Northern elephant seal (*Mirounga angustirostris*)	No status	-NE Pacific around Oregon, Washington, British Columbia, the Gulf of Alaska, and the Aleutian Islands	Global estimates: 150,000 in 2000	Dive duration female: 20 min Dive duration male: 30 min Dive depth: 400 – 800 m Max depths: 1,500 m Max duration: 120 min Swim Speed: 1.1 m/s	Hearing Frequency range: Underwater 75 Hz- 6.3 kHz Increases for frequencies below 64 kHz More sensitive to anthropogenic LF sound Sound Production No known underwater vocalizations In Air: Frequency range males: 147-334 Hz Male LF Sound: 175 Hz Signal type: Snorting- 200-600 Hz Clap- up to 2.5 kHz Pulse from female- 220-420 Hz Frequency range females: 500-1000 Hz Frequency range pups: up to 1.4 kHz Source level: No direct data available

Table 3.2-6. Information Summary for Phocidae: True Seals

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Southern elephant seal (*Mirounga leonina*)	CITES - protected	-Antarctic Polar Front to Antarctic pack ice- circumpolar between 40° and 62° South; southern coast of Argentina	Global estimates: 750,000	Dive duration: 20-30 min Dive depth: 400 – 800 m Max depths: 1,500 m Average swim speed: Unknown	Hearing No direct data available Most sensitive to anthropogenic LF sound source Sound Production No known underwater vocalizations In air: Frequency range: 175 Hz Signal type: Pulse level: No direct data available
Ribbon seal (*Phoca fasciata*)	No status	-Bering Sea; Okhotsk Sea and Chukchi Sea in Russia, Japan, and Korea	Global estimates: Up to 630,000 in 1990	No direct data available	Hearing No direct data available Sound Production Frequency range: 100 Hz – 7.1 kHz Source level: 160 dB Underwater sound production Short, broadband puffs- <5 kHz Downward-frequency sweeps with harmonics- 100 Hz- 7.1 kHz

Table 3.2-6. Information Summary for Phocidae: True Seals

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Spotted seal (*Phoca largha*)	No status	- Temperate to polar waters - Bering Sea, Sea of Okhotsk, Beaufort Sea, Chukchi Sea, Tartar Strait, northern Yellow Sea/ Bo Hai, Sea of Japan, and adjacent waters are Korea and China	Global estimates: No direct data available Bohai Sea: 4,500 in 1990 Bering Sea: 20,000-250,000 in 1980's Sea of Okhotsk: 130,000 in 1982	Dive duration: No direct data available Dive depth: <300 m Average swim speed: Unknown	Hearing No direct data available Sound Production Frequency range: 500 Hz – 3.5 kHz Growls, drums, snorts, chirps, and barks
Harbor seal (*Phoca vitulina*)	No status	- Subarctic and temperate waters - North Pacific Ocean, Eastern Atlantic Ocean, Wadden Sea, Baltic Sea, Western Atlantic Ocean - Northern and Southern boarders of 30° N and 80° S in the Atlantic -28° N and 68° S in the Pacific	Global estimates: 500,000 N. Pacific: 300,000 Canadian Waters: 30,000-100,000 in 1993 W. Atlantic: 40,000-100,000 in 1993 Great Britain: 47,000 Iceland: 28,000 Wadden Sea: 10,000 Kettega/Skagerrak: 6,000 Baltic Sea: 200 Svalbald: 500-600 U.S. 4,700 in 1993	Dive duration: 3-7 min Dive depth: 17-87 m Max depths: 450 m in CA Max duration: 31 min Swim speed: <13 km/hr	Hearing Frequency range: 75 Hz-180 kHz Dominant hearing range: 100 Hz – 2 kHz and 12-40 Khz Sound Production Frequency range: 100 Hz – 150 kHz Dominant frequencies: 100 Hz-2 kHz and 12-40 kHz Signal type: LF pulses, clicks, grunts, groans, creaks Source level: 169 dB

Table 3.2-6. Information Summary for Phocidae: True Seals

Species	Protected Status	Distribution	Abundance	Diving Behavior And Swim Speeds	Hearing/Sound Production
Gray seal (*Halichoerus grypus*)	No status	- Temperate to polar waters in Baltic Sea; E. and W. North Atlantic - Gulf of St. Lawrence, Iceland, Norway, Ireland, White Sea	Global estimates: No direct data available British waters: 110,000 NW Atlantic: 69,000 Sable Island: 85,000 Gulf of St. Lawrence: 69,000 Iceland: 11,600 in 1987 Norway: 3,000 Ireland: 2,000 White Sea: 1,000-2,000 Baltic Sea: 5,000	Dive duration: 4-10 min Max depth: 400 m Max duration: 30 min Swim Speed: 4.5 km/hr	Hearing Frequency range: 2- 90 kHz Dominant hearing range: 20 kHz and 50-60 kHz Sound Production Frequency range: 100 Hz – 16 kHz Dominant frequency: 100 Hz, 4 kHz, and 10 kHz Max frequency: 40 kHz Source level: No direct data available
Hooded seal (*Cystophora cristata*)	No status	-North Atlantic; Canada, Gulf of St. Lawrence and Newfoundland - Norwegian and Barents Sea - As far south as Portugal in Europe and as far south a Florida in the Atlantic and California in the Pacific	Global estimates: No direct data available Jan Mayen Island: 250,000 Newfoundland: 300,000	Dive duration: < 15 min Dive depth: 100 - 600 m Max depth: 1,000 m Max duration: >52 min Average swim speed: Unknown	Hearing No direct data available Sound Production Frequency range: 500 Hz – 6 kHz Dominant frequency: <1kHz Signal type: Pulse Buzz: 1.2 kHz with harmonics of 6 kHz Grung: 0.2-0.4 kHz Snort: 0.1-1 kHz with harmonics as 3 kHz Source level: No direct data available
Source: See individual species descriptions for literature references.					

3.3 Socioeconomics

3.3.1 Commercial and Recreational Fisheries

Pelagic and demersal fish species have the potential to be affected by SURTASS LFA sonar because some have demonstrated response to and have the potential to be physically affected by LF sound (Subchapter 3.2.2). In addition, the geographic sphere of SURTASS LFA sonar's acoustic influence overlaps the distribution of some fish species. If SURTASS LFA Sonar has the potential to affect fish species, then it follows that this could potentially affect commercial and recreational 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.

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.

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 Data

The general composition of 2002 global marine fisheries catches is presented in Table 3.3-1. As indicated, marine fish, crustaceans, and mollusks represent the majority of the total 84 million mt of nominal catches. Table 3.3-2 shows the capture production by principal species for the top fifteen. Of marine fish, the Peruvian anchovy is by far the largest with over 9 million mt caught in 2002. Other significant catch volumes include pollack, tuna, capelin, herring, mackerel, whiting, sardine, and cod (FAO, 2002a).

Table 3.3-1. Catches in Marine Fishing Areas by type, 2002.

ISSCAAP Division [1]	Catches (mt)	Percent of World Catch
Freshwater Fish	28,132	<0.1
Diadromous Fish	1,141,310	1
Marine Fish	70,177,288	83
Crustaceans	5,781,432	7
Mollusks	6,793,067	8
Whales, Seals, Other Aquatic Mammals[2]	NA	***
Miscellaneous Aquatic Animals	531,258	<1
Miscellaneous Aquatic Products	NA	***
Aquatic Plants[2]	NA	***
Total	84,452,487	100

Notes:

1. ISSCAAP = International Standard Statistical Classification of Aquatic Animals and Plants.

2. Data on aquatic mammals and plants are excluded from all national, regional, and global totals.

NA = Not Available or unobtainable.

Source: FAO (2002a)

Regional Trends

Global production from capture fisheries has remained basically stable since 1996 when the total capture production was 86 million mt and the latest FAO statistics for 2002 were 84 million mt (FAO, 2002a). This followed the oceanic water mass oscillations of the 1994-1998 El Niño events on the Peruvian anchovies (FAO, 2002b).

Nominal catches for each marine fishing zone in 1996 and 2002 are presented in Table 3.3-3. The Northwest Pacific marine fishing area was by far the greatest single contributor to global marine fisheries production, recording over 21 million metric tons of the global totals. This zone, including the marine waters of China and the Russian Federation, has been the world's most productive fishing zone since 1971 (Grainger, 1997).

Table 3.3-2. Marine capture production by principal species, 2002 (Top 15).

Species Name	Scientific Name	Capture Production (mt)
Peruvian anchovy	*Engraulis ringens*	9,702,614
Alaska Pollock (Walleye)	*Theragra chalcogramma*	2,654,854
Skipjack tuna	*Katsuwonus pelamis*	2,030,648
Capelin	*Mallotus villosus*	1,961,724
Atlantic herring	*Clupea harengus*	1,872,013
Japanese anchovy	*Engraulis japonicus*	1,853,936
Chilean jack mackerel	*Trachurus murphyi*	1,750,078
Blue whiting	*Micromesistius poutassou*	1,603,263
Chub mackerel	*Scomber japonicus*	1,470,673
Largehead hairtail	*Trichiurus lepturus*	1,452,209
Yellowfin tuna	*Thunnus albacares*	1,341,319
European pilchard (Sardine)	*Sardina pilchardus*	1,089 836
Atlantic cod	*Gadus morhua*	890,358
Atlantic mackerel	*Scomber scombus*	769,068
California pilchard	*Sardinops caeruleus*	722,071
Reference: FAO (2002a)		

The southeast Pacific zone also was a major contributor to global marine fisheries catches in 2002, providing catches of over 13 million mt. This has historically been the most dynamic zone and is dominated by small pelagic species (Grainger, 1997). In 2002, the combined zones of the Pacific Ocean yielded the majority of all marine catches, with over 51 million mt, or 61 percent of the world's catches in marine waters.

Table 3.3-3. Nominal catches in Marine Fishing Areas.

Marine Fishing Area	FAO Area	1996 Catches (mt)	2002 Catches (mt)
Arctic Sea	18	0	0
Atlantic, Northwest	21	2,069,186	2,245,008
Atlantic, Northeast	27	11,066,088	11,048,962
Atlantic, Western Central	31	1,720,699	1,764,352
Atlantic, Eastern Central	34	3,572,444	3,373,623
Mediterranean and Black Sea	37	1,531,975	1,550,099
Atlantic, Southwest	41	2,479,862	2,089,660
Atlantic, Southeast	47	1,325,437	1,701,440
Atlantic, Antarctic	48	95,088	134,595
Indian Ocean, Western	51	3,897,309	4,243,330
Indian Ocean, Eastern	57	4,190,529	5,100,261
Indian Ocean, Antarctic	58	5,689	8,004
Pacific, Northwest	61	23,542,610	21,436,229
Pacific, Northeast	67	2,833,342	2,702,885
Pacific, Western Central	71	8,730,620	10,510,202
Pacific, Eastern Central	77	1,619,642	2,037,267
Pacific, Southwest	81	663,750	739,868
Pacific, Southeast	87	17,068,356	13,765,143
Pacific, Antarctic	88	NA	1,559
Reference: FAO (2002a)			

Fishery Trends by Country

Table 3.3-4 shows the total capture of marine fisheries for the top ten fishing nations for 1996 and 2002 (FAO, 2002a). Brief descriptions of the fishing industries of these nations are discussed below. Information on other world fisheries is provided by the FAO on their Fisheries Country Profile website at http://www.fao.org/fi/fcp.asp.

Table 3.3-4. Top 10 fishing nations.

Country	Total 1996 Capture (mt)	Total 2002 Capture (mt)
China	14,182,107	16,553,144
Peru	9,515,048	8,766,991
USA	5,001,191	4,937,305
Indonesia	3,604,795	4,505,474
Japan	5,931,872	4,443,000
Chile	6,690,665	4,271,475
India	3,447,954	3,770,912
Russian Federation	4,675,738	3,232,295
Thailand	3,013,961	2,921,216
Norway	2,648,457	2,743,184
Reference: FAO (2002a)		

China

China has seen a rapid increase in the fishing industry. The total capture production for 1993 was 9.4 million mt compared to the 2002 output of 16.6 million mt (FAO, 2002a). However, there are indications that capture fishery production and aquaculture statistics have been misreported since the early 1990s and thus the values may be too high (Watson and Pauly, 2001; FAO, 2002b). In 1999, an estimated 6.05 million people were employed in either the primary or secondary sector with approximately 470,700 fishing vessels. China consumes 36,493 tons of fish and marine products per year and exports an additional $2.96 billion worth of goods. Their main-targeted species include hairtail, chub, mackerel, mackerel scad, Chinese herring, sea eel, yellow croaker, porgy, silvery pomfret, mullet, flukes, cuttlefish, squid, octopus, abalone, Chinese shrimp, northern maoxia, shrimp, rough shrimp, swimming crab, mud crab, sea cucumber, and jellyfish. While total catch output has been increasing, the numbers of highly valued species have been decreasing. More attention is being paid to sustainable fishing and environmental protection.

Peru

Peru is considered a major-scale industrial fleet, being composed of 677 purse seine vessels, 70 trawl fleet vessels, and 30 multipurpose vessels. The purse seine fleet primary catches are anchovy, sardine, Inca scad, and Atlantic mackerel. The trawl fleet primary captures are mainly hake, Inca scad, and Atlantic mackerel. The multipurpose vessel catches include common dolphinfish and shark. In 2002 Peru was second in total capture (Table 3.3-4), and her major exports are fishmeal and oil. Their fishing industry is one of the most adaptable in the world, having to withstand the effects of climatic variations, such as El Niño, that affect coastal upwelling, and fluctuations of the market conditions for fishmeal and oil.

United States

Commercial fishing in the U.S. is a multibillion-dollar industry closely connected to the world economy. More than a fifth of the world's most productive marine fisheries lie within the U.S. EEZ (NMFS, 2002b). Based on total capture as reported by the FAO (Table 3.3-4), the U.S. is the third ranked fishing nation in the world. In 2001, there were over 170,000 people and 123,000 commercial fishing vessels employed by the commercial fishing industry (NMFS, 2002b). In addition, 82,582 people were employed by wholesalers and processors in 2000 (FAO, 2003). Another 20,108,000 people fish recreationally. In 2001, the contribution of the domestic commercial seafood industry to the U.S. Gross National Product (GNP) was $28.6 billion, with recreational fisheries contributing an additional $25 billion to the GNP (NMFS, 2002b; PEW Oceans Commission, 2003; Panetta, 2003). The U.S. is the fourth largest exporter, with $11.8 billion in fish products sent to countries such as Japan, Canada, South Korea, China, and Germany (FAO, 2003).

Fisheries contribute less than one percent of the U.S. economic activity. However, for many coastal cities, a major contribution to the economy comes from fishing. Major U.S. domestic species landed in 2001 included pollack, menhaden, salmon, cod, hakes, flounders, shrimp, herring (sea), crabs, squid, lobsters, scallops, calms, and halibut (NMFS, 2002c).

U.S. fisheries are divided into regions. The **Northeast** region includes mixed-species groundfish, American lobsters, and Atlantic sea scallops. Recreational fisheries include Atlantic cod, winter flounder, Atlantic mackerel, striped bass, bluefish, and bluefin tuna. The **Southeast** region covers the Gulf of Mexico, U.S. Southeast Atlantic, and the Caribbean Sea. Important resources in this region are Atlantic sharks, Atlantic and Gulf of Mexico reef fish, drum and croaker, menhaden, Southeast Atlantic and Caribbean invertebrates, and highly migratory pelagic fish. Shrimp lead the region's fisheries in value. The **Alaska** region's major resources include Pacific salmon, groundfish, Pacific halibut, shellfish, and herring. This region has the potential to dominate tonnage of fisheries captured in the long term for the U.S because many resources are underutilized. The **Pacific Coast** region's major species are Pacific salmon, coastal pelagic fish, groundfish, and Pacific halibut. Recreational fisheries are important, especially in Southern California, where gamefish include albacore, billfish, rockfish, and salmon. Recreational crabbing, clam digging, and abalone diving activities are also significant. The **Western Pacific** region stretches across the central and western Pacific Ocean including the Hawaiian Islands, American Samoa Islands, Guam, and Northern Marianas. These tropical and subtropical island waters are known for the large diversity of species but low yields due to limited nutrients. Targeted species include tuna, billfish, swordfish, sharks, snapper, jack, grouper, emperors, and spiny and slipper lobsters.

Indonesia

Indonesian fisheries, which are ranked fourth in 2002 for total capture, are very complex and diverse, reflecting the countries extraordinary varied geography and great variations in species and population densities. Over 90 percent of the fisheries production is from small-scale operations, which focus on high-value shrimp and tuna. A large percentage of the vessels in this portion of the industry are non-powered. About half of the fish capture ends up as consumed fresh.

Japan

Japan is one of the top consumers of fisheries products, which play an important role in food security in Japan, accounting for nearly 40 percent of the animal protein in the Japanese diet. Fisheries are an important industry in coastal areas and are vital to the preservation of local traditional culture and regional economics. Japanese fisheries are divided into three categories:

- Distant water fisheries—Operated mainly on the high seas, as well as foreign countries' EEZs;
- Offshore fisheries—operated mainly in the Japanese EEZ, as well as the EEZs of neighboring countries; and
- Coastal fisheries—operated mainly in waters adjacent to fishing villages.

Japanese fisheries are in decline, with reductions in captures from 7.3 mt in 1993 to 4.4 mt in 2002. This is attributed to a combination of factors, including the decline of fisheries resources in coastal, offshore, and distant fisheries. The industry is in depression and there is a decline in the number of fishermen. The major species fished in Japanese waters are silver anchovy, skipjack, tunas (bluefin, albacore, big eye, yellow fin), mackerel, squid, saury, salmon, Japanese horse mackerel, atka mackerel, sand lance, oriental sardine, halibut, cod, red pargo, and flounder.

Chile

Chile is ranked sixth in 2002 for marine fisheries based on total capture. Their fleet consists of approximately 500 vessels. Major pelagic captures include the Chilean jack mackerel, Peruvian anchovy, and Chilean sprat. Main demersal resources are the Chilean hake and New Zealand hake. Their fishing industry is also subject to fluctuations due to the environmental influences of El Niño.

India

India has had a gradual increase in fisheries capture with 3.1 million mt in 1993 and 3.8 million mt in 2002. There are a total of 6 million fishermen in the country with 2.4 million being full-time. Species caught include Indian oil sardine, Indian mackerel, croakers, Bombay duck, anchovies, cephalopods, perches, jacks, and shrimp. India's exported $1.4 billion in fisheries commodities.

Russian Federation

The Russian Federation extends from the Baltic Sea to the Pacific Ocean and from the Arctic Ocean to the Black Sea. As such, its fisheries include the northeastern Atlantic (Barents, White and Baltic seas); Caspian, Black, and Azov seas; and northwestern Pacific (Bering, Okhotsk, and Japanese seas and oceanic waters). The Russian federation is ranked seventh in total capture for marine fisheries in 2002. Catches include Alaska pollock, Arcto-Norwegian and Pacific cods, herring (mostly Pacific herring), Pacific salmon, king and snow crabs, flounder, halibut, and haddock.

Thailand

Marine fisheries have a significant socio-economic role in Thailand. The marine catch is composed of tropical multi-species, including food fish, trash fish, squid and cuttlefish, shrimp, shellfish, and crab. Food fish are composed mainly of sardinellas, anchovies, Indo-Pacific mackerel, scads, threadfin breams, big-eyes, lizard fish, etc.

Norway

Norway is the biggest fishing nation in Europe and fisheries are the major economic activity along its vast coast. The adjacent waters are highly productive, producing herring, sprat, cod, capelin, shrimp, and mackerel. The Norwegian fleet of about 4,000 vessels is classified by function as: large purse seiners fishing for pelagic species; large factory trawlers fishing either for shrimp or demersal species (finfish); smaller wet-fish steel trawlers; smaller purse seiners; smaller shrimp trawlers; and a diverse coastal fleet.

3.3.1.2 Fisheries Trade

In 2000 more than 22 million persons worldwide were estimated to be employed by the marine capture fisheries (FAO, 2002b). In 2002, total exports of fish and fishery products were $58.3 billion in U.S. dollars (FAO, 2002a).

Fish-related import and export values for major regions of the world as expressed in millions of U.S. dollars are presented in Table 3.3-5. As can be seen, fish export values were highest in Europe and Asia at $20.5 billion and $19.6 billion respectively. The Americas followed with $13.2 billion. Africa and Oceania had the lowest fish-related trade.

Table 3.3-5. Total fish imports and exports by region for 2002.

Region	Total Imports (U.S. million dollars)	Total Exports (U.S. million dollars)
Africa	1,070,141	3,153,171
North America	11,923,641	7,999,607
South America	474,498	5,177,442
Asia	23,026,757	19,596,752
Europe	24,270,926	20,469,131
Oceania	679,650	1,815,036
Reference: FAO (2002a)		

Of the almost 200 countries with separate fisheries import/export statistics in the 2002 FAO report, 20 had export volumes above $1 billion including China, Thailand, Norway, U.S., Canada, Denmark, Vietnam, Spain, Chile, Netherlands, Taiwan, Indonesia, Iceland, India, Russian Federation, UK, Germany, France, Peru, and the Korean Republic. China generated the highest export volume in fish-related commodities at $4.5 billion.

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 IWC which, among other things, designates whale sanctuaries, sets limits on the numbers and sizes of whales that may be captured, and provides open and closed 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.

In 1982 the IWC implemented a pause in commercial whaling, which took affect during the 1985-1986 whaling season and is still in effect today. Aboriginal subsistence whaling and collections for scientific research conducted by member nations are still permitted.

Subsistence Whaling

The objectives for subsistence hunting are to ensure that the risk of extinction is not increased, to enable harvests that are appropriate for cultural and nutritional requirements, and to maintain stocks at their highest recruitment level or to ensure that stock numbers are increasing toward this level. The reported takes for aboriginal subsistence hunting can be seen in Table 3.3-6.

Aboriginal subsistence whaling of specific species is allowed in certain countries as follows:

- Denmark and Greenland - fin and minke whales;
- Russian Federation (Siberia) - gray whales;
- St. Vincent and The Grenadines - humpback whales; and
- U.S. (Alaska and Washington) - bowhead and occasionally gray whales.

Table 3.3-6. Aboriginal subsistence hunting as reported by the IWC.

Country	Fin	Humpback	Gray	Minke	Bowhead	Total
2001						
Denmark- West Greenland	8	2	0	139	0	149
Denmark- East Greenland	0	0	0	17	0	17
St. Vincent	0	2	0	0	0	2
Russia	0	0	112	0	1	113
US	0	0	0	0	75	75
2002						
Canada	0	0	0	0	1	1
Denmark- West Greenland	13	0	0	139	0	152
Denmark- East Greenland	0	0	0	10	0	10
St. Vincent	0	0	0	0	0	0
Russia	0	0	131	3	0	134
US	0	0	0	0	50	50
2003						
Denmark- West Greenland	9	1	0	185	0	195
Denmark- East Greenland	0	0	0	14	0	14
St. Vincent	0	1	0	0	0	1
Russia	0	0	128	0	3	131
US	0	0	0	0	48	48
2004						
Denmark- West Greenland	13	1	0	179	0	193
Denmark- East Greenland	0	0	0	11	0	11
St. Vincent	0	0	0	0	0	0
Russia	0	0	111	0	1	112
US	0	0	0	0	43	43
2005						
Denmark- West Greenland	13	0	0	176	0	189
Denmark- East Greenland	0	0	0	4	0	4
St. Vincent	0	1	0	0	0	1
Russia	0	0	124	0	2	126
US	0	0	0	0	68	43

Scientific Research

Scientific research permits are issued for the killing of whales for scientific purposes. In order to obtain a permit, the specific aim, samples, and methodology must be justified including determining that the research is essential for rational management, the methodology and samples are likely to provide answers for the questions asked, the questions cannot be answered non-lethally, the catches will not have an adverse impact on the stock, and scientists from other nations may join the research program.

IWC scientific research permits have been issued as follows:

- Iceland - 292 fin and 70 sei whales;
- Norway - 289 minke whales; and
- Japan - 400± minke whales in the Antarctic and 100 minke whales around Japan.

The data in Table 3.3-7 state the reported whale catches under special permits for scientific research by year from 1999 to 2002.

Table 3.3-7. Japanese Scientific Research Permit whale catches as reported by the IWC.

Country	Fin	Sperm	Sei	Brydes	Minke	Total
1999						
Japan	0	0	0	0	100	100
Japan Pelagic	0	0	0	0	439	439
2000						
Japan	0	5	0	43	40	88
Japan Pelagic	0	0	0	0	440	440
2001						
Japan	0	8	1	50	100	159
Japan Pelagic	0	0	0	0	440	440
2002						
Japan	0	5	39	50	150	244
Japan Pelagic	0	0	0	0	440	440

Norway has objected to the IWC's moratorium on whaling and continues to "take" whales, claiming its right to national catch limits for minke whales as shown in Table 3.3-8. The IWC Commission opposes this right and has called for Norway to stop all whaling activities.

Table 3.3-8. Norway's total minke whale catches from 1993 to 2002.

Year	Total Whales
1993	226
1994	280
1995	218
1996	388
1997	503
1998	625
1998	591
2000	487
2001	552
2002	634

IWC Whale Sanctuaries

The IWC also establishes sanctuaries. The first IWC sanctuary was established in the Antarctic in 1938, south of 40S between longitudes 70W and 160W. The original reason for this was that in this sector commercial whaling had not hitherto been prosecuted and it was thought highly desirable that the immunity that whales in this area had enjoyed should be maintained.

The Indian Ocean Sanctuary was established by the IWC in 1979, extending south to 55S latitude, as an area where commercial whaling is prohibited. This was initially established for 10 years and its duration has since been extended twice.

At the 46th Annual Meeting (1994) the IWC adopted the Southern Ocean Sanctuary as another area in which commercial whaling is prohibited. The northern boundary of this Sanctuary follows the 40S parallel of latitude, except in the Indian Ocean sector where it joins the southern boundary of that sanctuary at 55S, and around South America and into the South Pacific where the boundary is at 60S. This prohibition is reviewed at ten-year intervals. In fact, at the 54th meeting in 2002 the IWC’s Scientific Committee established a Working Group to review existing IWC sanctuaries and sanctuary proposals and carried out a review of the Indian Ocean Sanctuary.

Two additional proposals for the establishment of sanctuaries in the South Atlantic and South Pacific have been under review by the Commission for a number of years. To date, both have failed to achieve the three-quarters majority of votes needed to become designated IWC Sanctuaries.

Fisheries Bycatch

The Pew Oceans Commission reported in America’s Living Oceans: Charting a Course for Sea Change (2003) that fishermen accidentally catch, injure, and kill marine life that they do not intend to capture. They reported that an estimated 2.3 billion pounds of marine wildlife bycatch were discarded, injured or dead, in 2000. This is estimated to be approximately 25 percent of the worldwide catch. Bycatch is not only a concern for commercial marine wildlife; non-commercial wildlife, such as marine mammals, sea birds, sea turtles, blue marlin, smalltooth sawfish, and barndoor skate have also shown signs of decline (Pew Oceans Commission, 2003). Detailed discussion of the bycatch of marine mammals is presented in Subchapter 4.6.2.

The FAO published a technical paper in 1991, which discusses the conflicts between marine mammals and fisheries (Northridge, 1991). This paper, which has not been recently updated, reports that in the northwest Atlantic Ocean, harbor porpoises are the most common marine mammal caught in fishing gear. To a lesser extent larger whales and bottlenose dolphins are also affected in this region. In the northeast Atlantic, harbor porpoises and common dolphins are most affected, although the grey seal is thought to compete with fisheries. Bottlenose dolphins comprise the largest bycatch in the western central Atlantic Ocean. Very little information exists on the eastern central Atlantic. The Atlantic humpbacked dolphin and West African manatee are coastally distributed and could be affected by fisheries. In the Mediterranean and Black Seas, monk seals, striped dolphins, and sperm whales are the most affected by interaction with fisheries. Bottlenose dolphins are also taken in a variety of fishing gears. Commerson's dolphin is reportedly caught in the southwest Atlantic. Few recent studies have been conducted in the southeastern Atlantic.

In the eastern Indian Ocean, the species most heavily impacted by fisheries interactions are the spotted and spinner dolphins, the dwarf and pygmy sperm whale, and the bottlenose and humpbacked dolphins. The finless porpoise and the Irrawaddy dolphins are affected in the western Indian Ocean.

The information from the northwest Pacific came from data on incidental captures by the Japanese, Chinese, and Russian fisheries. The Baiji is the species most severely impacted, but the Kuril seal and Dall's porpoise are also frequently caught. In the northeast Pacific Ocean, the main species affected by the fisheries are the northern right whale dolphin, the Pacific white-sided dolphin, the harbor seal, and the northern fur seal. Bottlenose dolphins are the most heavily affected by fisheries, but Irrawaddy and finless porpoises are affected on a lesser extent in the western central Pacific area. Spotted dolphins, Vaquita, and harbour porpoises are the most affected species in the eastern central Pacific. In the southwest Pacific, Hector's dolphin and Hooker's sea lions are affected by driftnet fisheries and trawl fisheries. Finally, in the southeast Pacific, the dusky dolphin, Burmeister's porpoise, the Chilean dolphin, and possibly southern right whale dolphins, Peale's, and Commerson's dolphins are the most affected by fisheries interactions.

Under Section 118(b) of the MMPA, entitled Zero Mortality Rate Growth (ZMRG), NMFS must review the progress of all commercial fisheries to ensure the reduction of incidental mortality of marine mammals. In August, 2004, NMFS published the "Report to Congress: Review of Commercial Fisheries' Progress Toward Reducing Mortality and Serious Injury of Marine Mammals Incidental to Commercial Fishing Operations" (NMFS, 2004b). The short-term goal is to reduce, within six months of implementation, the incidental mortality and serious injury of marine mammals incidentally taken by commercial fisheries, to levels less than the Potential

Biological Removal (PBR) level. The long-term goal is to reduce incidental mortality and serious injury of marine mammals to insignificant levels, approaching a zero rate of mortality and serious injury within five years of implementation. NMFS concludes that in the 2004 List of Fisheries, 175 of the 216 fisheries are in Category III, which have a remote likelihood of killing or seriously injuring marine mammals. A remote likelihood is defined as having a mortality less than or equal to ten percent of the stock’s PBR. Thirty four fisheries are in Category II, which includes combined fisheries that have occasional mortality and serious injury of marine mammals, causing mortality or serious injury above ten percent of a stock’s PBR. Finally, seven fisheries are in Category I, which includes fisheries that have frequent mortality and serious injury of marine mammals which is quantified as being greater than or equal to 50 percent of the PBR.

3.3.2 Other 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 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, albeit remotely by SURTASS LFA sonar, are further addressed in this subchapter.

3.3.2.1 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 nm) 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).

3.3.2.2 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 the 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 approximately 277,400 diving certifications in 1986 and 854,052 in 2000, reflecting a 32 percent increase during those years (PADI, 2004). In fact, between 1967 and 2000, PADI issued a cumulative total of nearly 10,151,141 diving certifications. The National Association of Underwater Instructors (NAUI) issues approximately 130,000 certifications annually (Davis and Tisdell, 1995).

It is estimated that over 1.2 million dive trips are taken to warm-water destinations each year (Simmons, 1997), including the Caribbean, Gulf of Mexico, south Pacific Ocean, Mediterranean Sea, and Indian Ocean, as well as other locations (see text box below). Surveys of the demographics of diving students and instructors conducted by PADI in 1991 and 1996 revealed that most divers are males between 18 and 29 years old.

Diving Locations			
Anguilla and Antigua	Aruba	Australia	Bahamas
Barbados	Belize	Bermuda	Bonaire
British Virgin Islands	Canada	Cayman Islands	Columbia
Costa Rico	Cuba	Curacao	Cyprus
Dominican Republic	Dutch Antilles	Ecuador	Egypt
England	Fiji	France	Fr. Polynesia
Galapagos Island	Greece	Grenada	Guam
Haiti	Honduras	Indonesia	Israel
Italy	Jamaica	Jordan	Kenya
Madagascar	Malaysia	Malta	Maldives
Marshall Islands	Martinique	Mauritius	Mexico
Micronesia	Mozambique	Netherlands Antilles	New Zealand
Oman	Papua New Guinea	Puerto Rico	Philippines
Reunion	Saudi Arabia	Scotland	Seychelles
Solomon Islands	South Africa	Spain	Sri Lanka
St. Kitt and Nevis	St. Lucia	St. Vincent	Sudan
Thailand	Tonga	Trinidad and Tobago	Tunisia
Turkey	Turks and Caicos	United Kingdom	United States
U.S. Virgin islands	Vanuatu	Venezuela	Yemen
Sources: PADI, 2004; Simmons, 1997; Taylor, 1982			

3.3.2.3 Whale Watching

Whale watching worldwide has been expanding rapidly in recent years and is considered a valuable industry in a commercial, educational, environmental, and scientific sense. In 1994, an estimated 5.4 million people in 65 countries or territories participated in whale-watching excursions, a figure that has been growing at about ten percent per year (WDCS, 1997). Statistics from Iceland also are illustrative of the growth of whale watching. In 1995, the total number of passengers on whale-watching trips in Iceland was 2,200; in 1996 that number had grown to about 9,700. By 1997 Iceland recorded 20,540 passengers, reflecting an increase of 110 percent over 1996 data, and an increase of over 800 percent when compared with 1995 data (CSI, 1998).

According to the International Fund for Animal Welfare (IFAW) (Hoyt, 2001), whale watching has grown to be at least a $1 billion (USD) industry with 87 countries and territories promoting tours and over 9 million people participating in the tours, growing at an average of 12.1 percent per year since 1991.

Due to the seasonal migration of whales, the location of whale-watching activities varies by season, and the employment associated with the industry is temporary; however, it is expanding with the growing industry. Most whale-watching activities focus on humpback whales, gray whales, northern and southern right whales, blue whales, minke whales, sperm whales, short-finned pilot whales, orcas, and bottlenose dolphins (Hoyt, 2001). The IWC and other whale preservation organizations support whale watching as a sustainable use of cetacean resources (IWC, 1998; CSI, 1998; Spalding, 1998). In 1996 the IWC adopted the following general principles for managing this emerging industry in order 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, 1998).

There are, however, costs to whale watching. These costs include pollution due to the use of boats, trash thrown into the water by the observers, trampling coastal areas, the effects of petroleum products on the environment when you drive or fly to the site, effects on the community of marine mammals, and the risk of harassment to marine mammals. Ship strikes are also a risk associated with whale watching. Of the 134 ship strike accounts where the type of vessel is known, there have been 19 reports of ship strikes by whale-watching vessels (Jensen and Silber, 2004).

3.3.3 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.

3.3.3.1 Oceanographic Research

Oceanographic research, much of it sponsored by the world's governments, is conducted in all oceans of the world. This research is geared to refining and expanding our knowledge of marine biology (including the life habits and physiology of marine mammals, fish, and reptiles), and marine geophysics (history, morphology and chemistry of the earth's crust and the potential for natural hazards) (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 (WHOI), the Scripps Institution of Oceanography at the University of California, the Lamont-Doherty Earth Observatory (LDEO) at Columbia University, and several science centers operated by NMFS, conduct research each year over the world's oceans.

Deployment of unmanned diving vessels from research ships constitutes a significant part of ocean research. Unmanned remotely operated vehicles (ROVs) carry television cameras and other equipment such as water samplers. ROVs are 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.

U.S., Canadian, Australian, Japanese, and several European governmental agencies conduct research with ROVs. The Canadian deep-sea vehicle ROPOS (Remotely Operated Platform for Ocean Science), for example, has conducted research at depths as great as 4,960 m (16,270 ft) in the Pacific and North Pacific near Oregon, Washington, and the Aleutians. There are about 16 manufacturers and 30 operator/marine service companies active with ROVs on a year-round basis in the oceans (Ontini, 1998).

Manned submersible vehicles are also used in ocean research. These vehicles communicate with their deployment ship using radios. Of the estimated 160 commercial and scientific submersibles built since 1960, approximately 40 are still operating.

The Autonomous Undersea Systems Institute (AUSI) is an independent research institute that coordinates research for autonomous underwater vehicles (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.

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 HF. The sub-bottom profiler maps the bottom topography while supplying information on sedimentary features (LGL, 2003).

Ocean acoustic tomography (OAT) 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. 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 new program, Scripps is reusing the sound source in Hawaii for its North Pacific Acoustic Laboratory (NPAL). NPAL's objectives combine:

- 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 University-National Oceanographic Laboratory System (UNOLS) is a consortium of 61 academic institutions involved in federally-funded oceanographic research. Twenty of these institutions operate the 28 ships of the UNOLS Fleet. Ship schedules, geographic locations of proposed cruises, and other information are available at http://www.gso.uri.edu/unols/unols.html.

3.3.3.2 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. A drilling record was set in 1998 by Chevron U.S.A. for drilling a well at a depth of 2,352 m (7,718 ft) southeast of New Orleans.

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 collect data up to 300 m (9,845 ft) deep and are used for the initial site evaluation for drill rig emplacement and platform design. Deep seismic surveys obtain data up to several thousands of meters deep and 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 that can be longer than 3 km (1.6 nm) (DOI, 1997). 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 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.

Construction of five to seven percent of wells involves the use of subsea systems to install wellhead and related equipment on the ocean floor. The remaining systems use surface wellhead equipment. Both types 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.

3.3.4 Coastal Zone Management

Since 1972, 33 coastal states and territories have developed and implemented programs to ensure appropriate resource protection and compatibility of uses in their coastal zones. The programs are linked to existing state/territorial laws and authorities, such as tidal wetland statutes, regional agreements, and water quality certification under Section 401 of the Clean Water Act of 1977. The enforcement authority for the program is often a state coastal commission. Federal lands are excluded from the jurisdiction of the state coastal zone management programs, but activities on federal lands are subject to the Coastal Zone Management Act (CZMA) federal consistency requirements if the federal activity will affect land or water or natural resources of the state's coastal zone, including reasonably foreseeable effects.

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;
- 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 addressing 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 three geographic (nautical) miles into the Atlantic or Pacific oceans or three marine leagues (10.35 nm) into the Gulf of Mexico.

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 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.

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4 IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

This chapter supplements the analyses and results on the potential impacts or effects upon 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 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, there are no new data that contradict any of the assumptions or conclusions regarding Chapter 4 in the FOEIS/EIS; hence its contents are incorporated by reference herein.

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 would be deployed in the Pacific-Indian ocean area and in the Atlantic-Mediterranean area.
- The R/V *Cory Chouest* and the USNS IMPECCABLE are presently the only vessels equipped with a SURTASS LFA sonar system. Both vessels are U.S. Coast Guard-certified for operations. In addition, they operate in accordance with all applicable federal and U.S. Navy rules and regulations related to environmental compliance. All future vessels to be equipped with SURTASS LFA sonar systems would also be U.S. Coast Guard-certified and compliant with all applicable federal and U.S. Navy environmental rules and regulations. 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, the SURTASS LFA sonar would be operated in the active mode about 240 days. During these 240 days, active transmissions would occur for a maximum of 432 hours per year per vessel. The FOEIS/EIS analyzed four vessels each with 432 hours of transmission time per year (See FOEIS/EIS Subchapter 2.2). In the ROD, the Navy stated that it would employ only two SURTASS LFA systems because only two systems would be available during the five year period through 2007. In the MMPA Rule, NMFS limited the Navy to two systems, consistent with the ROD, with missions totaling no more than 432 hours of transmissions per vessel per year. Because SURTASS LFA operations were limited to a relatively small area in the northwestern Pacific Ocean by the Court's Permanent Injunction, NMFS restricted the total operating hours to 432 hours for both vessels in the annual LOAs. Because LFA operations are not expected to be geographically restricted (except as noted in the mitigation) in the future, the original planned 432 hours of

active transmissions per vessel per year, as analyzed in the FOEIS/EIS, are also proposed in this SEIS.

- The duty cycle of the SURTASS LFA sonar would be limited (it would generally be on between 7.5 and 20 percent of the time [7.5 percent is based on historical LFA operations since 2003 and the physical maximum limit is 20 percent]). The LFA transmitters would be off the remaining 80-92.5 percent of the time.

References to Underwater Sound Levels

1. 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.
2. References to underwater Sound Exposure Level (SEL) in this SEIS refer to the squared pressure over a duration of the sound referenced to the standard underwater sound reference level (1 µPa) expressed in dB, and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise.

Sources: Urick (1983): ANSI S1.8-1989 (R 2006)

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, all marine animals exposed to $\geq$ 180 dB Received Level (RL) are evaluated as if they are injured.
- **Permanent threshold shift (PTS)**: A severe situation occurs when sound intensity is very high or of such long duration that the result is PTS or permanent hearing loss on the part of the listener. This constitutes Level A "harassment" under the MMPA, as does any other injury to a marine mammal. The intensity and duration of a sound that will cause PTS varies across species and even between 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).
- **Temporary threshold shift (TTS)**: Sounds of sufficient loudness can cause a temporary condition in which an animal's hearing is impaired for a period of time—TTS. 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 intense 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 to be an injury (Richardson et al., 1995), although during a period of TTS, animals may be at some disadvantage in terms of detecting predators or prey and thus potentially harmed.
- **Behavioral change**: Various vertebrate species are affected by the presence of intense sounds in their environment (Salvi et al., 1986; Richardson et al., 1995). For military readiness activities, like 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 harassment definitions, like marine mammals, it is possible that loud sounds could disturb the behavior of fish and sea turtles in the same way, resulting in the same kinds of consequences as for marine mammals.

- **Masking**: The presence of intense sounds in the environment can potentially interfere with an animal's ability to hear sounds of relevance to it. 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.

4.1 Potential Impacts on Fish

Since the SURTASS LFA sonar FOEIS/EIS was completed in 2001, there have been a small number of useful studies on the potential effects of underwater sound on fish, including sharks. However, one of these studies (funded by the Navy to provide data for this SEIS) is directly relevant to effects of SURTASS LFA sonar on fish, while the other examined the effects of seismic air guns[1] on fish. Thus, while earlier studies examined the effects of sounds using pure tones for much longer duration than the SURTASS LFA sonar signals, these 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. This section 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 and sea turtles would spend less time in the LFA mitigation zone (180-dB sound field); therefore, with a ship speed of less than 9.3 kph (5 knots), the potential for animals being in the sonar transmit beam during the estimated 7.5 to 10 percent of the time the sonar is actually transmitting is very low; and

[1] Seismic air guns differ from SURTASS LFA sonar in that they generally transmit in the 5-20 Hz frequency band and their typical air gun array firing rate is once every 9-14 seconds, but for very deep water surveys could be as high as 42 seconds. Air gun 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 248-255 dB are typical for a full-scale array, but can be as high as 259 dB SL.

- Small size of the LFA mitigation zone (180-dB 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 a sound transmission.

4.1.1 Potential Impacts on Fish (Class Osteichthyes) Stocks

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 from the cellular level to gross damage to the swim bladder and circulatory system (reviewed in Hastings and Popper, 2005). However, the bulk of the data suggesting such injuries come from studies that tested the effects of explosives on fish (e.g., Yelverton et al., 1975; and see review in Hastings and Popper, 2005). 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 looking at the effects of sound on terrestrial mammals suggest that lungs and other organs are potentially damaged by sound (e.g., Fletcher et al., 1976; Yang et al., 1996; Dodd et al., 1997). 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 (e.g., 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 (e.g., Abbott and Bing-Sawyer, 2002; Caltrans, 2004).

The only studies that examined the effects of sound on non-auditory tissues have been recent work using SURTASS LFA sonar (undertaken by the Navy) and seismic air guns, both of which are reviewed below. The significant point from these studies, however, is that neither source, despite being very intense, had any effect on non-auditory tissues. In all fish, the swim bladder was fully 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. These studies provide the first direct evidence that sounds including seismic air guns and SURTASS LFA sonar may be of concern, but that does not necessarily mean that they kill or damage fish. However, both groups of investigators were careful to note that their studies were done with only a limited number of species, and that extrapolation between 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.

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 (e.g., 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, as discussed below, indicating some damage to sensory hair cells in fish resulting from exposure to very intense and relatively long signals, there has yet to be any study that has examined fish hearing before and after such damage. Thus, while it may be speculated that fish with damaged and destroyed sensory hair cells would also have hearing loss, to date this is only conjecture.

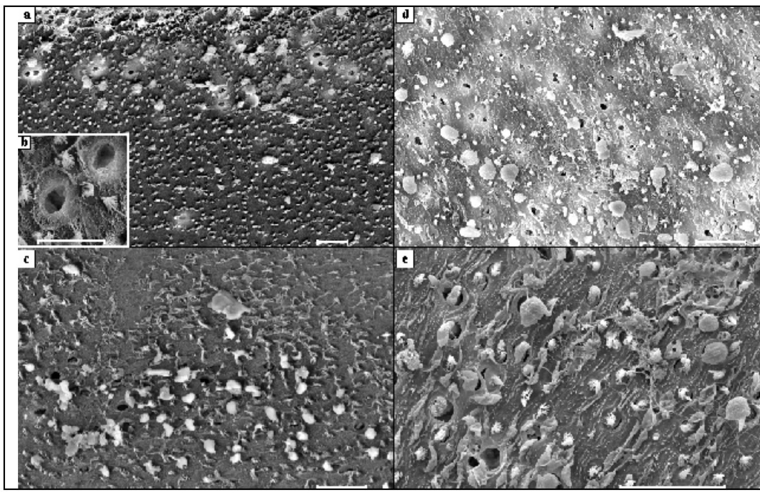
There have been four earlier studies that examined the effects of high intensity sounds on fish ears. Hastings et al. (1996) investigated the effects of intense sound stimulation on the ear and lateral line of a non-specialist freshwater fish (*Astronotus ocellatus*, the oscar). The investigators exposed fish to a sound at 300 Hz and a RL of 180 dB, and found some damage to the sensory hair cells of two of the otolith organs, the lagena and utricle, four days after a continuous signal for one hour. 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 sound has the potential to damage the sensory cells of the ears of fish. However, the sound had to be continuous and had to 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 RL, respectively, for two hours. They found some indications of sensory hair cell damage, but these were not extensive. Enger (1981) determined that some ciliary bundles (the sensory part of the hair cell) on sensory cells of the inner ear of the cod (*Gadus morhua*) were damaged when exposed to sounds at several frequencies from 50 to 400 Hz at 180 dB 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*), as a consequence of exposure to a seismic air gun. Fish were placed in a cage and exposed to emissions of a single seismic air gun that was moved toward and away from the test cage. The air gun used had a SL at 1 m of 222.6 dB (peak to peak), or 203.6 dB (rms). It was deployed at 5 m (16.4 ft) depth and towed from a distance of 400 to 800 m (1312 to 2625 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 air gun survey that is moving back and forth over a study site.

The animals were maintained for varying periods of time post exposure. The fish were then sacrificed, and the ears examined using scanning electron microscopy (SEM) as shown in Figure 4.1-1. The investigators reported that there was considerable damage to the ciliary bundles of the sensory hair cells of the saccular sensory epithelium (the other end organs were not examined), and the extent of damage increased with increase in the time the animals were kept post exposure. 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 fed and appeared to behave normally. While indirect evidence, these observations suggest that there was no other permanent damage to the fish such as damage to the swim bladder.

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 in LFA or other types of human-generated sounds at high signal levels.



Scanning electron micrographs of the saccular sensory epithelium of the pink snapper following exposure to a seismic air gun (see text for parameters). (a, b, c) Epithelia from fish sacrificed 18 hours after exposure to the air gun. The photographs show numerous holes and "blebbing." (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 4.1-1: Scanning electron micrographs of the saccular sensory epithelium of the pink snapper following exposure to a seismic air gun.

As will be discussed below, a recent study on the effects of SURTASS LFA sonar sounds on two species of fish, rainbow trout and channel catfish, also examined long-term effects on sensory hair cells of the ear. In both species, even up to 96 hours post-exposure, there were no indications of any damage to sensory cells (Popper et al., 2005a).

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. 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 (*Astronotus*) that have been damaged by the ototoxic drug[2] gentamicin sulphate will regenerate within 10 to 15 days of the termination of the drug regime. Unlike mammals, fish continue to produce sensory hair cells

[2] Ototoxic drugs are drugs that can cause temporary or permanent hearing loss. They can also make an existing hearing loss worse.

throughout much of their lives (Lombarte and Popper, 1994; Higgs et al., 2001). Since hair cells recover from drug damage, it may be speculated that there might be recovery from at least some levels of noise injury since fish, unlike mammals, appear to maintain the ability to produce sensory hair cells for a long period of life after hatching. It is not possible to say, however, if 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 air gun exposure and, in fact, there was more damage at 58 days than immediately after exposure.

Few studies have directly examined the effects of sound on fish mortality (see review in Hastings and Popper, 2005). One such study by Turnpenny et al. (1994) suggested that sound exposure could produce substantial damage in caged fish. In the Turnpenny study, brown trout (*Salmo trutta*) and whiting (*Merlangius merlangus*) died within 24 hours of being exposed for five minutes to various tones at frequencies from 95 to 410 Hz and at RLs as low as 170 dB (assumed to be rms, but not reported as such). This study does not appear to be the best available science on this issue for several reasons. First, sound pressure levels in the test chamber, a 30 cm x 30 cm x 30 cm mesh cube suspended near the water surface and ensonified by four sound projectors, could not be controlled (Ellison, unpub., 2005). Second, it is likely that the investigators failed to take into account substantial mechanical energy in the tank created by pressure gradients that created oscillatory (i.e., fluctuating) fluid motion. As a result the stimulus sound field would have been unlike any that fish would encounter outside the laboratory. Indeed, several scientists working in this field have criticized the experimental design, acoustic environment, data analysis, and controls used in this study (Popper, 2003; Myrberg, 2003; Ellison, unpub., 2005). Furthermore, no other studies on the potential impacts of underwater sound on fish have reported physical damage or mortality after exposure to such a low sound pressure level for only five minutes. In fact, more recent studies reported by Popper et al. (2005a; Halvorsen et al., 2006) and Wysocki et al. (in prep.) using an LFA sound source transmitting 193 dB RL on rainbow trout, a reasonably close relative to brown trout, in a normal free field resulted in no damage.

In response to the Popper (2003) and Myrberg (2003) critiques of the Turnpenny et al. (1994) study, Turnpenny (2003) provided counter-comments to support his re-affirmation of the report's conclusions via declaration. In a recent memorandum, Popper (unpub. 2005) responds to the Turnpenny (2003) declaration:

> "Turnpenny does clarify some of the issues I raised with respect to the controls and other aspects of the work described in the report, but nothing in the declaration changes the view I expressed in my original declaration that: 'The overall idea behind the experiments reported here are of some interest, and had the studies been executed properly…some interesting (though *very* limited) information might have been provided. However, the experiments…are poorly designed and the results are insufficient to enable anyone to reach any conclusions regarding the effects of sound on fish studied. Most importantly, there is no basis to extrapolate from these results to any potential effects of air guns, sonars, or other anthropogenic sounds on these or any other species of fish.'"

4.1.1.3 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 hours. TTS is quite common in humans and often occurs after being exposed to loud music, such as at a rock concert. The precise physiological mechanism for TTS is not understood. It may result from fatigue of the sensory hair cells as a result of their being over-stimulated or from some small damage to the cells that is repaired over time. The duration of TTS depends on a variety of factors including intensity and duration of the stimulus, and recovery can take minutes, hours, or even days.

Experimental Results

The first TTS study on fish showed that a 149 dB RL exposure to a pure tone for eight continuous hours might cause TTS of more than 10 dB 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) examined the effects of increased background noise on hearing capabilities of the goldfish (*Carassius auratus*) and of 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 TTS after only 10 min of exposure to band-limited noise (0.1 to 10 kHz, approximately 170 dB RL overall spectral sound pressure level). Following three weeks of exposure to the same stimulus, goldfish had a 28-dB TTS 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 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[3] of goldfish before and after noise exposure and found a decrease in temporal resolution capabilities that continued 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) and Wyoscki and Ladich (2005), Smith et al. (2004a) showed no TTS after up to 21 days of noise exposure at 170 dB RL by the hearing generalist tilapia. It is not particularly surprising that the results differ

[3] 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 between different intervals, it has poor ability to discriminate between different sounds.

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 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 air guns (or nearby movement of larger 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 handling or other factors. The first study, dealing with seismic air guns, is of interest from a scientific sense regarding SURTASS LFA sonar, and that it showed there were differences in the effects of air guns on the hearing thresholds of different species. The second study deals directly with SURTASS LFA sonar.

Effects of seismic air guns on fish hearing

Popper et al. (2005b) examined the effects of exposure to a seismic air gun 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 730 in^3 (12,000 cc) air gun array. The signals were fully calibrated and, unlike in earlier studies, exposure was determined not only for rms sound pressure level, but also for peak sound levels and for SELs. In this study, average mean peak SPL was 207 dB RL, the mean 90 percent RMS sound level was 197 dB RL, while the mean SEL was 177 dB SEL.

The study was designed so that 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.[4] Fish were placed in a test cage, exposed to the air gun array, and then tested for hearing immediately after sound exposure and then 24 hours post exposure. Testing was done using the auditory brainstem response (ABR)[5] method used by Smith et al.

[4] 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 in the middle of the survey area 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 air gun to and from the fish twice.

[5] ABR is a method in which recordings are made, non-invasively, of the brain response while the animal is presented with a sound. This is a method that is widely used to rapidly assess hearing in new-born humans, and which is being used more and more in studies of animal hearing, including hearing of marine mammals. The advantages of ABR

(2004a) and Scholnik 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 air gun sound.

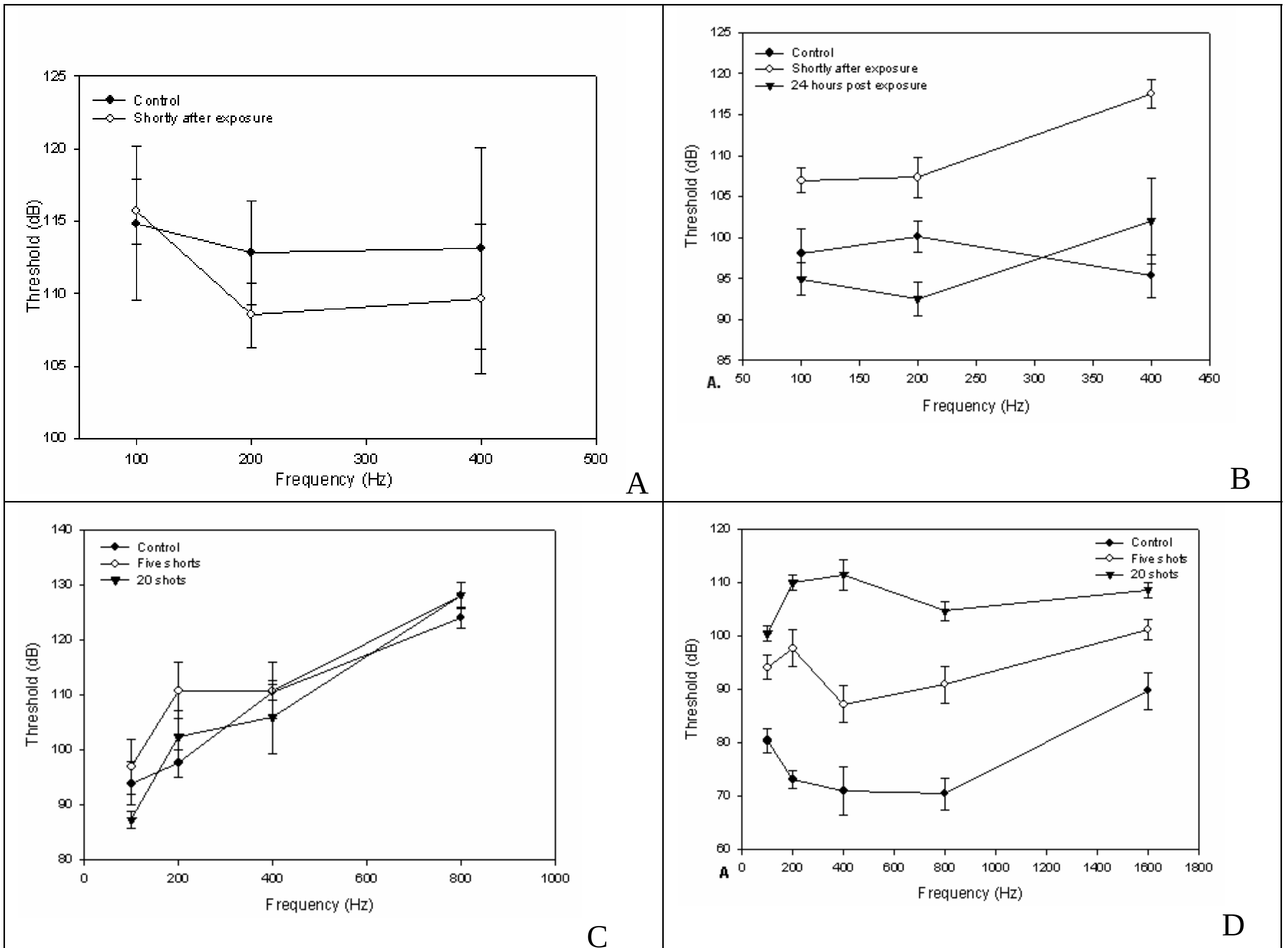
The results (Figure 4.1-2) showed a temporary hearing loss for both lake chub and northern pike, but not for the broad whitefish, to both 5 and 20 air gun shots. There was no hearing loss in the broad whitefish, a relative of salmon. Hearing loss was on the order of 20 to 25 dB at some frequencies for both the northern pike and lake chub, and recovery took place within 24 hours and fish hearing returned 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 ABR testing had intact swim bladders and 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 air guns on the hearing thresholds of different species. 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 sounds.

Effects of SURTASS LFA sonar on fish hearing

Dr. Popper and his colleagues (Popper, et al., 2005a; Halvorsen et al., 2006) have been examining whether exposure to high-intensity, low frequency sonar, such as the Navy's SURTASS LFA sonar, will affect fish. An LFA sonar array has the potential to ensonify fish with sound levels over 180 dB RL within 1 km from the array. Moreover, the 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 of 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 fish is most sensitive in the frequency range in which the sonar operates.

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 ABR only reflects the signal that is in the 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 ABR. 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 ABR, 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, ABR does give an excellent indication of basic hearing loss, and is an ideal method to quickly determine if there is TTS right after sound exposure when results are compared with those from controls.



(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 air gun shots. (D) Lake chub, a hearing specialist, showed substantial hearing loss after 5 shots of the air guns 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 4.1-2. Hearing thresholds for different fish in a study investigating the effects of exposure to a seismic air gun array on fish hearing.

Fish species studied

This study 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; Halvorsen et al., 2006). The study also included analysis of fish behavior before, during, and after sound exposure (Wysocki et al., in prep.).

The rainbow trout is a hearing generalist (or "non-specialist"), while the channel catfish is a specialist. These two species were chosen since there is evidence that there may be a significantly different impact of 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 (e.g., 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 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 already 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). 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*, it is likely that the rainbow trout can serve as the model system in other anthropogenic sound studies, as in the LFA study.

Experimental overview

The SURTASS LFA sonar study was conducted in an acoustic free-field environment that enabled the investigators to have a highly calibrated sound source and to fully monitor the sound field and the behavior of the fish throughout the experiments. The work was conducted at Seneca Lake, Dresden, N.Y. The facility has a large barge in the middle of the lake and a nearby shore support facility that has room for holding animals and doing all hearing and other tests.

In brief, experimental fish were placed in a test tank that was 1 m on a side and made of 1.27 cm (0.5 inch) thick Lexan® clear plastic sheets (see Figure 4.1-3). The tank was designed to allow for 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.

Prior to conducting experiments with live animals, extensive 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 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. The signal used was generated electronically and was very similar to the actual sonar signal train used by the Navy. The bandwidth of the signal was from 170 to 320 Hz.

Figure 4.1-3: Photograph of experimental tank (with rainbow trout) being lifted out of the water.

The photo shows the test tank. The braces to the left and right support the video cameras (black) used to monitor fish behavior 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) monitored the sound outside of the tank.

All fish were from the same supplier. They were randomly assigned to one of the three experimental groups. Baseline group animals were received directly from the supplier with 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; 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 (as per a required 20 percent maximum duty cycle). 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 (see Figure 4.1-4).

All test, control, and baseline animals were evaluated to determine hearing sensitivity using the ABR method. Fish were then sacrificed to determine any effects on inner ear structure. Additional fish from each group were sacrificed for analysis by a highly skilled fish pathologist to determine any effects on gross structure and on tissue pathology.

Results of SURTASS LFA sonar study

As of 30 June 2005, there have been four sets of studies (each lasting one week) on rainbow trout and two on channel catfish. There are several significant findings:

(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.

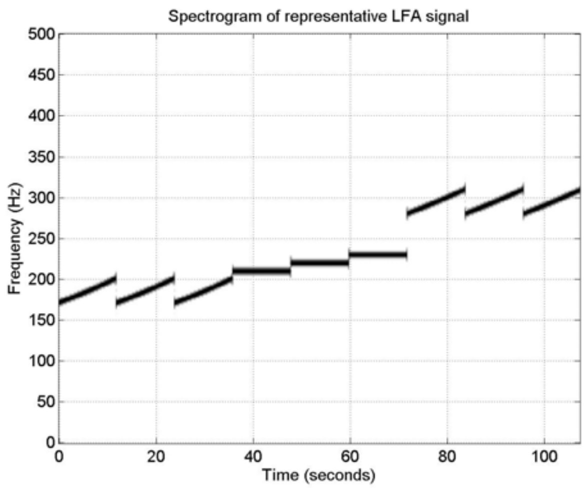


Figure 4.1-4. Schematic of one presentation of the LFA signal used in the SURTASS LFA sonar experiments.

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.

(2) There were no pathological effects from sound exposure. Despite the high level of sound exposure (193 dB RL at the fish), there were no gross effects on fish. Histopathology was done on all major body tissues (brain, swim bladder, heart, liver, gonads, blood, etc.) and no differences were found among sound-exposed fish, controls, or baseline animals.

(3) There were no short- or long-term effects on ear tissue (see Figure 4.1-5). The sensory cells of the ears of both species were healthy and intact both immediately post exposure and then 96 hours after the end of exposure. All earlier studies looking at effects of sound on fish ears only found damage within 96 hours (e.g., Hastings et al., 1996; McCauley et al., 2003) and in each case that was to much more extensive sound exposure.

Figure 4.1-5: Scanning electron micrograph from an experimental rainbow trout that had been exposed to the MAX signal.

The image shows the ciliary bundles that are atop the sensory hair cells and which serve as the transducing portion of the sensory cell (see Chapter 3). While the cilia are somewhat splayed due to processing of the tissue, they are no different than tissue from baseline and control animals.

(4) Fish behavior after sound exposure was no different than 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, and 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[6]" response and slight motion of the body, but then the fish 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 than pre-sound patterns.

(5) Catfish and some specimens of rainbow trout showed 10-20 dB of hearing loss immediately after exposure to the LFA sound when compared to baseline and control animals (see Figure 4.1-6), but hearing appears to return to, or close to, normal within about 24 hours for catfish. Other rainbow trout showed minimal or no hearing loss. Recovery data on rainbow trout that had a hearing loss is still insufficient to reach firm conclusions on the time for recovery, but preliminary data lead to the suggestion 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 (200-1000 Hz) tested for catfish.

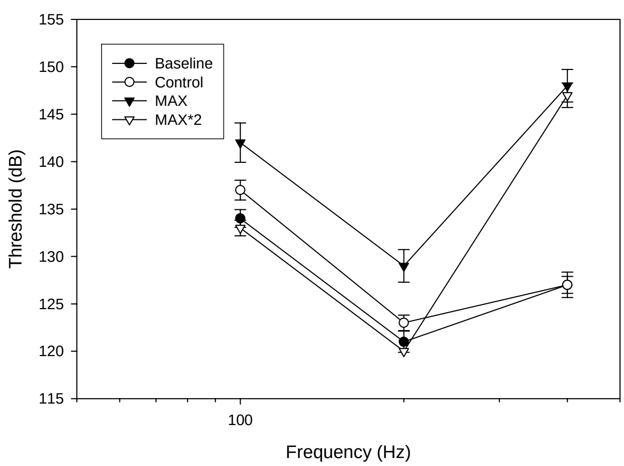


Figure 4.1-6: Examples of hearing data obtained in the SURTASS LFA sonar studies.

These data are for rainbow trout and compare hearing for baseline and control animals and animals that received MAX and MAX*2 signals. Data represent means and standard errors of the means. Note that maximum hearing loss occurred at 400 Hz where there was over a 20 dB TTS. It is not clear why there was more hearing loss after MAX stimulation than MAX*2 but this could be related to signals being closer together in the former. (Note, the "thresholds" shown are not calibrated and so do not reflect the lowest sounds that fish necessarily hear at these frequencies.)

(6) There is potentially interesting variation in the effects of exposure on trout. At some times of the year the trout showed hearing loss, while at other times they did not. All animals received identical treatment, and the only variables between experimental times may have been water temperature and/or how the fish were raised prior to their being obtained for study. The significance here is that not only are 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.

[6] 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 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.

Conclusions from SURTASS LFA sonar study

The critical question addressed in the SURTASS LFA sonar study is 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 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 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 were most 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 fish is moving or not, and its direction of motion and speed). Prior to getting the closest distance to the fish, or after the boat has moved on, the sound level would be much lower. Thus, rather than receiving 108 sec of maximum exposure, a fish would receive much less exposure. Since exposure at 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. And, even then, exposure at maximum output would be for a minimal period of time. It should also be noted that 193 dB RL had no real adverse effects on the fish tested. 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 108 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.

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 of a sonar that will apparently be used by the Norwegian Navy in the near future. In an as yet unpublished report, 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. While the study's authors referred to these sonar sounds as low frequency, the Norwegian sonar signal is higher frequency

(1.5 to 6.5 kHz) than the signal used by SURTASS LFA sonar (100-500 Hz) and closer in frequency to the signals used by mid-frequency sonar.

Fish in this study were placed in plastic bags 3 m from the sonar source and exposed to between four and 100 pulses of 1-second 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 RL. The sounds were designed to mimic those of actual sonar signals that will be 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), and the investigators found no effect on behavior, growth (length and weight), or survival of fish kept as long as 34 days post exposure. All exposed animals were compared to controls that received similar treatment other than for exposure to the actual sound. Similar to the LFA work done by Dr. Popper and his colleagues (Popper, et al., 2005a: Halvorsen et al., 2006), 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, where there was a post-exposure mortality of 20 to 30 percent. 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.

Extrapolation to Other Species

The results of the SURTASS LFA sonar study, as well as the recent study on seismic air guns (Popper et al., 2005b), 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 upon 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 continuous. The same variables may also impact the amount of non-auditory damage that might occur.

At the same time, the rainbow trout in the LFA study and the lake chub, northern pike, and broad whitefish in the seismic study are species that 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 recovery 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 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 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 above threshold at 200 to 250 Hz for the cod. Hastings et al. (1996) derived the values of 90 to 140 dB 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 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 above threshold) (see Figure 3.2-2) indicate RLs of 140-190 dB continuously for at least one hour would be necessary to induce damage to inner ear sensory cells.

The results of Smith et al. (2004a, 2004b) and Scholik and Yan (2001, 2002) provide 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 are 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 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 they are 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 air gun 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 threshold.

Finally, the results from the SURTASS LFA sonar study further support the LINTS hypothesis since both species used generally followed predictable amounts of threshold shift based on the levels of the 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 of different frequencies, intensities, durations, and waveform 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.

4.1.1.4 Behavioral Change

This issue concerns the behavior of fish near a high intensity sound source, beyond effects on the ear itself. That is, 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). There are only a few studies relevant to this issue. 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, California. The RLs were 145 to 153 dB. 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 to the source during playback. Indeed, most fish occupied the zone closest to the sound projector the entire duration of the test and control periods. While these results are of considerable interest, and support the idea that fish do not necessarily try and avoid sounds, it must be noted that the work involved three species of fish in an artificial environment (cage); thus, it is unknown whether the behavioral responses to LF sounds by this species, and under these conditions, can be extrapolated to other species and/or to fish in a normal (open ocean) environment.

These results are somewhat supported by findings during the investigations of the effects of SURTASS LFA sonar sounds on rainbow trout and channel catfish (Popper et al.,2005a; Wysocki et al., in prep.). These studies used video to observe and record the behavior of both species before, during, and after exposure to sounds that were at 193 dB RL. 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[7]" 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.

It should be noted that in both the Klimley and Beavers (1998) study and the more recent SURTASS LFA sonar study (Wysocki et al., in prep.), fish were restrained in tanks and could not move away from the source. How the fish might have reacted if they were able to swim away is not known. However, both of these investigations provide some initial evidence that the sounds used in the studies did not have a marked effect on behavior of the fish studied. One point of interest, however, is that in the case of the rainbow trout, the signal level was much closer to the threshold of hearing than it was in the channel catfish. And, while data are not available on rockfish hearing (something that is very much needed), if these are indeed non-specialist fish, their hearing thresholds are probably more alike those of the rainbow trout than the catfish. Thus, the 153 dB RL signal used by Klimley and Beavers (1998) was possibly not sufficiently above the animal's threshold to result in behavioral changes. It is possible, however, that if the sounds presented to the rockfish or rainbow trout were as far above threshold as it was for catfish, the responses of both species might have been different, and perhaps more like that of the catfish.

[7] 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 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.

Other studies, however, provide some evidence that the LF 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). Similar results have been found for incoherent, impulsive air gun sounds (Engås et al., 1996; McCauley et al., 2000; Engås and Løkkeborg, 2002; Slotte et al., 2004). 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 air gun. 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. It is interesting, however, that using sonar, Slotte et al. (2004) found that fish in the vicinity of the air guns appeared to go to greater depths after air gun exposure compared to their vertical position prior to the air gun 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 may be explained by other factors and that catch rates do not differ significantly from normal seasonal variation over several fishing seasons.

While not directly related to sonar, but of scientific interest, Wardle et al. (2001) used a video system mounted on a reef to examine the behaviors of fish and invertebrates after exposure to emissions from seismic air guns (peak RL of 210 dB at 16 m from the source and 195 dB RL at 109 m from the source). The results showed no observable damage to any animals or that there were changes in behavior, or that any animals left the reef during the course of the study.

The aforementioned studies support the conclusions presented in Subchapter 4.1.1.6 below.

4.1.1.5 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 decrement in ability to detect signals because of other sounds is called masking, which can take place whenever the received level of signal exceeds ambient noise levels or the hearing threshold of the animal.

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 will 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, 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, less is known about masking in non-specialist and marine species. Tavolga (1967) was the first to study the effects of noise on pure-tone detection in two non-specialists. 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. 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 cod, haddock, and pollock. 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. Thus, for SURTASS LFA sonar this would be whatever 30-Hz 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 estimated 7.5 percent 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 percent of the time.

4.1.1.6 Conclusions

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; Halvorsen et al., 2006) provide evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB 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, with emphasis that this value is *highly conservative* and protective of fish. This conclusion supports the discussion at Subchapter 2.5.2.2 on the possibility of employing source shutdown procedures for schools of fish.

To quantify the possible effect of SURTASS LFA sonar on fish catches, an analysis of nominal SURTASS LFA sonar operations in a region off the Pacific Coast of the U.S. was presented in the FOEIS/EIS Subchapter 4.3.1 for the NMFS Fisheries Resource Region—Pacific Coast, defined here to encompass the area from the Canadian to Mexican border, from the shoreline out to 926 km (500 nm). The results of this analysis–that the percent of fish catch potentially affected would be negligible compared to fish harvested commercially and recreationally in the region–remain valid. In fact, because this analysis was based on 180-dB injury level (not 193-

dB) and the maximum 20 percent duty cycle (not 7.5 percent), the results are *highly conservative.*

4.1.2 Potential Impacts on Fish (Class Elasmobranch/Shark) Stocks

It is important to note that unlike other fish species, there is no species of shark protected under the ESA. The analysis for sharks is conducted under NEPA.

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 sharks, the discussion regarding fish in Subchapter 4.1.1.1 of this SEIS will be considered to also apply here. Earlier thinking had been that the primary potential for non-auditory impacts to fish would be resonance of the swim bladder, although the preponderance of recent evidence suggests this is not the case for SURTASS LFA sonar (or for seismic air guns). Moreover, sharks do not have a swim bladder.

4.1.2.2 Permanent Loss of Hearing

Hearing capability in sharks 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. There are also no data on permanent hearing loss, including PTS, in sharks or on damage to the ears. Nevertheless, the utilization of the 180-dB criterion for analysis is also applied to sharks, and its conservativeness is emphasized. A very small fraction of any shark stock would be exposed to these levels, even in the absence of mitigation. While extrapolation from fish to sharks is something that should be done only with caution, since the ears and auditory systems are so different, the lack of substantive effect on non-specialist fish may also be the same for sharks.

4.1.2.3 Temporary Loss of Hearing

There are no scientific data on TTS in sharks. However, because sharks are considered hearing non-specialists and assuming they have similar hearing sensitivities as 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, 2004b) study may potentially apply, indicating that RLs of 220 to 240 dB would be required to temporarily affect hearing capability in the form of TTS. However, without any additional studies on sharks this suggestion must be considered speculative, and probably very conservative.

At the same time, while it is likely that the 180-dB value is highly conservative, it must be noted that extrapolating from bony fish to sharks is difficult, especially since the ears of fish and sharks have some significant differences in terms of associated structures that might be involved in hearing, and in the structure of certain regions of the ear. In particular, the ear structure involved in shark hearing may be the *macula neglecta*, a sensory receptor that, while very large in sharks, is tiny or not present in other vertebrates (Corwin, 1981; Popper and Fay, 1997). Because the *macula neglecta* has a somewhat different mechanism of sound-induced stimulation than do the otolithic organs of fish ears (i.e., the ear organs of fish that were damaged in the Hastings et al. [1996] study), extrapolation on the effects of intense sounds must be provisional.

Due to the lack of more definitive data on 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 a sound transmission. Therefore, the aforementioned is based on the assumption that the stocks are evenly distributed. Further, the five SURTASS LFA sonar operational parameters listed at the start of Subchapter 4.1 provide additional support to the conclusion that there would be minimal impact on any substantial fraction of a shark stock through TTS.

4.1.2.4 Behavioral Change (Attraction/Repulsion)

Some sharks are attracted to pulsing LF sounds. It has been proposed that such sounds mimic the thrashing of struggling fish that are potential prey for the sharks (Nelson and Gruber, 1963; Nelson and Johnson, 1972, 1976). Since the structure of SURTASS LFA sonar signals is unlike sounds made by struggling marine animals, it is highly unlikely that this sound would be attractive to sharks.

Several shark species, including the oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*), have been observed withdrawing from pulsed LF sounds played from an underwater speaker (Myrberg et al., 1978; Klimley and Myrberg, 1979). Lemon sharks exhibited withdrawal responses to pulsed low to mid frequency sounds (500 to 4,000 Hz) raised 18 dB at an onset rate of 96 dB/sec to a peak amplitude of 123 dB RL from a continuous level, just masking broadband ambient noise (Klimley and Myrberg, 1979). Sharks withdrew from a normally attractive pulsed sound composed of frequencies of 150 to 300 Hz at RLs $\geq$111 dB. The "pulsed" signals referred to was those signals used by the researchers (Nelson and Johnson, 1972). In their study, lemon sharks withdrew from artificial sounds which included 10 pulses/second (continuous), 10 pulses/second (intermittent, and 15 to 7.5 decreasing pulses/second (intermittent). Myrberg et al. (1978) utilized sounds that simulated orca screams and a pure tone. In a more recent study, Myrberg (2001) stated that sharks have demonstrated highest sensitivity to LF sound (40 to 800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity thus resembling a struggling fish. These signals, some "pulsed," are substantially different from the LFA signals.

Myrberg et al. (1978) reported that a silky shark withdrew 10 m (33 ft) from a speaker broadcasting a 150 to 600 Hz sound with a sudden onset and a peak SL of 154 dB. These sharks avoided a pulsed LF attractive sound when its SL 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. These results do not rule out that such sounds may have been harmful to them after habituation; the tests were not designed to examine that point (Myrberg, pers. comm., 1999). Klimley (unpublished data) also noted the increase in tolerance of lemon sharks during successive sound playback tests. The pelagic whitetip (*Carcharhinus longimanus*) also showed a withdrawal response during limited tests (Myrberg et al., 1978).

Since the likelihood of a significant portion of any shark stock being in the vicinity of the SURTASS LFA sonar source at any one time is low, and given that the LFA signals are not "pulsed" or structured is like sounds made by struggling marine animals, this attraction or repulsion behavioral response is not considered an issue of concern.

4.1.2.5 Behavioral Change (Migration)

There is a body of scientific evidence that oceanic sharks make directional migrations. The most rigorous study demonstrating this phenomenon involved placing a miniature heading sensor to track scalloped hammerhead sharks (*Sphyrna lewini*) and tracking them (Klimley, 1993). The movements of these sharks between their daytime aggregations at a seamount and their nighttime feeding grounds at other surrounding seamounts were highly directional. Their paths generally coincided with magnetic ridges and valleys leading from a seamount, which may be characterized by a strong dipole field that could serve as a landmark. In addition, movements of the sharks often were along the edge of a magnetic lineation, oriented roughly in a north-south direction.

These results have led to the theory that sharks often migrate along magnetic "roads" that run north-south (coincident with magnetic lineations) and aggregate at "cities" that are seamounts and islands (with dipole fields) (Klimley, 1995).

In assessing the potential for SURTASS LFA sonar signals to affect shark migrations, it is noted that the SURTASS LFA sonar 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. Furthermore, the LFA signal usually has no ramp-up, an acoustic property that has been shown to provoke withdrawal in an inshore species (*Negapion brevirostris*) (Klimley and Myrberg, 1979) and two pelagic species (*Carcharhinus falciformis and C. longimanus*) (Myrberg et al., 1978). These studies suggest that sharks can detect sounds with intensities below 180 dB RL. The issue is whether one or more SURTASS LFA sonar transmissions could possibly cause displacement of a shark from its migratory path, such that this activity might be disrupted to such an extent that the shark would not be able to reestablish its direction along the path.

The sharks are believed to be migrating along the edges of the magnetic lineations, where the gradients are greatest, moving back and forth across the gradient (estimated travel +/- 0.5 km [0.27 nm] either side) at an approximate speed of 1 m/sec (Klimley, pers. comm., 2000). Given that the maximum SURTASS LFA sonar signal length is 100 sec, a shark that was annoyed and moved away from the sound would travel approximately 100 m (328 ft) during that time. In the worst case, the ship would be positioned so that the shark's movement would be away from the gradient, and the shark would be at its maximum distance from the gradient at the time of the transmission. Assuming 100 m (328 ft) maximum displacement in this case, it would be likely that the shark would be able to eventually reestablish its direction along the path. Thus, the conclusion here is 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 (Banner, 1972; Myrberg et al., 1972; Nelson and Johnson, 1972; Myrberg et al., 1976; Nelson and Johnson, 1976), and this detection ability may potentially be affected by masking. By way of example, Nelson and Johnson (1970) measured a lemon shark's hearing sensitivity to a 300 Hz, 130 dB 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 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 (measured in sea state 1). This represented differences in masking ranges (distance from animal that a sound or sounds would be masked) (due to sea state alone) of 45 m (148 ft) for sea state 2 versus 1; 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 would 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 an estimated 7.5 percent 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. Long-term effects of masking sounds on hearing and potential injury to shark hearing by intense sounds have not been studied. 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 percent of the time.

4.1.2.7 Conclusions

Some sharks in the SURTASS LFA sonar operations area could possibly be affected by LF sounds, but only if they were very close to the sound source. However, a negligible portion of any shark stock would be exposed to levels at or above 180 dB RL on an annual basis due to the small size of the LFA mitigation zone (180-dB sound field) relative to the open ocean areas inhabited by shark stocks.

Despite the ability of sharks to detect LF 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 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 than the SURTASS LFA sonar signals. This section 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 and sea turtles would spend less time in the LFA mitigation zone (180-dB sound field); therefore, with a ship speed of less than 5 knots, the potential for animals being in the sonar transmit beam during the estimated 7.5 to 10 percent of the time the sonar is actually transmitting is very low; and
- Small size of the LFA mitigation zone (180-dB 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 a sound transmission.

4.2.1 Injury

Very little is known about sea turtle hearing and what may cause injury to it. However, the New England Aquarium acoustic data collection discussion below supports the premise that, using a 180-dB injury threshold, a sea turtle would have to be within the LFA mitigation zone when the sonar was transmitting to be at risk of injury, including permanent loss of hearing (i.e., PTS). The five SURTASS LFA sonar operational parameters listed above also apply to this conclusion.

4.2.2 Permanent Loss of Hearing

Data on sea turtle sound production and hearing are few. There is little known about the mechanism of sound detection by turtles, including the pathway by which sound gets to the inner ear and the structure and function of the inner ear of sea turtles (Bartol and Musick, 2003). However, assumptions have been made based on research on other species of turtles. Based on the structure of the inner ear, there is some evidence to suggest that marine turtles primarily hear sounds in the low frequency range and this hypothesis is supported by the limited amount of physiological data on turtle hearing. Bartol and Musick (2003) said that the amount of pressure needed to travel through the bone channel of the ear increases with an increase in frequency. For this reason, it is believed that turtles are insensitive to high frequencies and that they primarily hear in a low frequency range. A description of the ear and hearing mechanisms can be found in Bartol and Musick (2003). The few studies completed on the auditory capabilities of sea turtles also 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. The study concluded that the maximum sensitivity for one animal was 300 Hz, and for another 400 Hz. At the 400 Hz frequency, the turtle's hearing threshold was about 64 dB in air (re: 20µPa). At 70 Hz, it was about 70 dB (re: 20µPa) in air. 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.

Bartol et al. (1999) measured the hearing of juvenile loggerhead sea turtles using auditory evoked potentials to LF tone bursts and found the range of hearing via Auditory Brainstem Response[8] (ABR) recordings from LF tone bursts indicated the range of hearing to be from at least 250 to 750 Hz. The lowest frequency tested was 250 Hz and the highest was 1000 Hz.

More recently, Streeter and colleagues (pers. comm., 2005) were able to train a female green sea turtle to respond to acoustic signals. The results from this study showed a hearing range of at least 100 to 500 Hz (the maximum frequency that could be used in the study, as opposed to what may be a wider hearing range) with hearing thresholds of 120-130 dB RL. However, there are several important caveats to these results. First, the study was done in a relatively noisy oceanarium at the New England Aquarium. Thus, the thresholds reported may have been masked by the background noise and the "absolute thresholds" (the lowest detectable signal within a noisy environment) may be several dB lower than the reported results. Second, data are for a single animal who is well into middle age (over 50 years old) and who had lived in an oceanarium all its life. While there are no data on effects of age on sea turtle hearing, data for a variety of mammals (including humans) show there is a substantial decrement in hearing with age, and this may have also happened in this animal. This too may have resulted in thresholds being higher than in younger animals (as used by Ridgway et al., 1969). Finally, the data are for one animal and so nothing is known about variability in hearing, or whether the data for this animal are typical of the species.

Despite the lack of scientific data on the potential effects of LF sound on sea turtle hearing and on PTS in sea turtles caused by LF sound and the conclusion stated in Subchapter 4.2.1 above, the potential for SURTASS LFA sonar to cause PTS in sea turtles must be considered to be negligible. Moreover, the majority of sea turtle species inhabit the earth's oceanic tropical, subtropical, and temperature zones (generally, 40 deg N to 35 deg S longitude, except for the leatherback which is found from 71 deg N to 47 deg S). These are areas where sound propagation is usually characterized by downward refraction (higher transmission loss, shorter range), rather than ducting (lower transmission loss, longer range) which is usually found in colder-water regimes. Hence, transmission ranges within the principal water-column habitat for most sea turtles—the near-surface region—are relatively shorter in the warmer-water regimes

[8] ABR is a method in which recordings are made, non-invasively, of the brain response while the animal is presented with a sound. This is a method that is widely used to rapidly assess hearing in new-born humans, and which is being used more and more in studies of animal hearing, including hearing of marine mammals. The advantages of ABR 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 ABR only reflects the signal that is in the 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 ABR. 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 ABR, 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, ABR does give an excellent indication of basic hearing loss, and is an ideal method to quickly determine if there is TTS right after sound exposure when results are compared with those from controls.

versus ranges in colder-water regimes. Further, the five SURTASS LFA sonar operational parameters listed above further support this conclusion.

4.2.3 Temporary Loss of Hearing

As with PTS, there are no published scientific data on TTS in sea turtles caused by LF sound. As there are no new data that contradict any of the assumptions or conclusions regarding Subchapter 4.1.2 (Sea Turtles) in the FOEIS/EIS, its contents are incorporated by reference herein. Further, the five SURTASS LFA sonar operational parameters listed above further 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

Tagging studies have shown that sea turtles can travel many kilometers per day in the open ocean (Keinath, 1993). They 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, 1999).

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 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, olive ridley, hawksbill, Kemp's ridley), for which displacement from preferred benthic habitats could be construed as more serious.

Behavioral responses to human activity have only been investigated for two species of sea turtles: green and loggerhead (O'Hara and Wilcox, 1990; McCauley et al., 2000). Both studies reported behavior changes of sea turtles in response to seismic air guns. O'Hara and Wilcox (1990) reported avoidance behaviors by loggerhead sea turtles in response to air guns with sound levels (RL) of 175-176 dB. McCauley et al. (2000) reported noticeable increases in swimming behavior for both green and loggerhead turtles at RLs of 166 dB. At 175 dB RL both green and loggerhead turtles displayed increasingly erratic behavior (McCauley et al., 2000). However, it is important to note that air guns have an impulsive signal with a large bandwidth, high energy, and a short duration. Therefore, air gun signals should not 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.

If a sea turtle happened to be within proximity of a SURTASS LFA sonar operations area, it may 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. This is particularly due to: 1) the low number of SURTASS LFA sonars that would be deployed in the open ocean, 2) the geographic restrictions imposed on system employment, 3) the narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz bandwidth), 4) the fact that the ship is always moving (coupled with low system duty cycle [estimated 7.5 percent], which means sea turtles would have less opportunity to be located in a sound field that could possibly cause a behavioral change), and 5) short at-sea mission times.

4.2.5 Masking

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 severe because of the 7.5 to 20 percent duty cycle, the maximum 100-second 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 Conclusions

Sea turtles could be affected if they are inside the LFA mitigation zone (180-dB sound field) during a SURTASS LFA sonar transmission. Given that received levels from SURTASS LFA sonar operations would be below 180 dB (RL) within 22 km (12 nm) or greater distance of any coastlines and offshore biologically important areas, effects to a sea turtle stock could occur only if a significant portion of the stock encountered the SURTASS LFA sonar vessel in the open ocean. Further, the majority of sea turtle species inhabit the earth’s oceanic temperate zones, where sound propagation is predominantly characterized by downward refraction (higher transmission loss, shorter range), rather than ducting (lower transmission loss, longer range) which is usually found in cold-water regimes. These factors, plus the low distribution and density of sea turtles at ranges from the coast greater than 22 km (12 nm) equate to a very small probability, if any, that a sea turtle could be found inside the LFA mitigation zone during a SURTASS LFA sonar transmission.

The above analysis focuses on the potential impacts to individual sea turtles. However, the issue of potential impact to sea turtle stocks must also be addressed. To quantify the potential impact on sea turtle stocks, the analysis provided in Subchapter 4.1.2.1 of the FOEIS/EIS was updated based on more current information for leatherback sea turtles in the Pacific Ocean. The leatherbacks were chosen for this analysis because they are the largest, most pelagic, and most widely distributed of any sea turtle found between 71°N and 47°S (Plotkin, 1995), inhabit the oceanic zone and are highly migratory (Morreale et al., 1996; Hughes et al., 1998), and are capable of transoceanic migrations (Eckert, 1998). They are rarely found in coastal waters and are deep, nearly continuous divers with usual dive depths around 250 m (820 ft) (Hays et al., 2004). The volume of Pacific Ocean habitat for leatherback sea turtles was calculated as 4.4×10^{16} m^3 by multiplying the total ocean area (National Geographic, 2005) by a leatherback turtle diving depth of 250 m (820 ft). An annual deployment (432 transmit hours per vessel) of SURTASS LFA sonar would ensonify approximately 4.2×10^{11} m^3 to a depth of 91 m (300 ft) to levels ≥ 180 dB (RL) at a distance of 1,000 m (3,281 ft). This is 0.00001 of the ocean volume. The total worldwide population of leatherback sea turtles has been estimated at 20,000 to 30,000

(Plotkin, 1995). Therefore, a conservative estimate of 20,000 leatherback sea turtles was used for the Pacific basin.

Even though the leatherback distribution in the Pacific is patchy and the data on their whereabouts are sparse, SURTASS LFA sonar operations would cover enough ocean area that it is assumed that the number of animals potentially impacted would average out. The default assumption for pelagic animals is to assume even distribution for population estimates; thus, an even distribution of leatherbacks throughout the ocean volume is used here. Given this, the possible number of times a leatherback sea turtle may be within the 180-dB sound filed of the SURTASS LFA sonar vessel would be less than 0.2 animals per year per vessel (20,000 animals x 0.00001 ocean volume = 0.2 animals). Therefore, the potential for SURTASS LFA sonar operations to expose leatherback sea turtle stocks to injurious levels is negligible, even when up to four systems are considered.

In the unlikely event that SURTASS LFA sonar operations coincide with a sea turtle "hot spot," the narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz bandwidth), the fact that the ship is always moving (coupled with low system duty cycle [estimated 7.5 percent], which means sea turtles would have less opportunity to be located in the LFA mitigation zone during a transmission), and the monitoring mitigation incorporated into the alternatives (visual and active acoustic [HF] monitoring) would minimize the probability of impacts on animals in the vicinity .

4.3 Potential Impacts on Marine Mammal Stocks

The types of potential effects on marine mammals from SURTASS LFA sonar operations can be broken down into non-auditory injury, permanent loss of hearing, temporary loss of hearing, behavioral change, and masking. The analyses of these potential impacts were presented in the SURTASS LFA sonar FOEIS/EIS. Updated literature reviews and research results indicate that there are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS; thus, its findings regarding potential impacts on marine mammals remain valid and are incorporated by reference herein.

4.3.1 Non-Auditory Injury

There are several potential areas for non-auditory injury to marine mammals from SURTASS LFA 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.

Tissue Damage

In response to the resonance issue raised by letters and comments to NMFS's Proposed Rule, Cudahy and Ellison (2002) analyzed the potential for injury related to resonance from SURTASS LFA sonar signals. Their analysis did not support the claim that resonance from SURTASS LFA sonar will cause injury. Physical injury due to resonance will not occur unless it will increase stress on tissue to the point of damage. Therefore, the issue is not whether resonance occurs in air/gas cavities, but whether tissue damage occurs. Cudahy and Ellison (2002) indicate that the potential for *in vivo* tissue damage to marine mammals from exposure to underwater low frequency sound will occur at a damage threshold on the order of 180 to 190 dB RL or higher. These include: 1) transluminal (hydraulic) damage to tissues at intensities on the order of 190 dB RL or greater; 2) vascular damage thresholds from cavitation at intensities in the 240-dB RL regime; 3) tissue shear damage at intensities on the order of 190 dB RL or greater; and 4) tissue damage in air-filled spaces at intensities above 180 dB RL.

In a workshop held April 24 and 25, 2002, an international group of 32 scientists with backgrounds in acoustics met at NMFS Headquarters in Silver Spring, Maryland, to consider the question of acoustic resonance and its possible role in tissue damage in marine mammals. The group concluded that it is not likely that acoustic resonance in air spaces plays a primary role in tissue damage in marine mammals exposed to intense acoustic sources. Tissue displacements are too small to cause damage, and the resonant frequencies of marine mammal air spaces are too low to be excited by most sounds produced by humans. Resonance of non-air containing tissues was not ruled out. While tissue trauma from resonance in air spaces seems highly unlikely, the group agreed that resonance in non-air-containing tissues cannot be considered negated until certain experiments are performed (NOAA/NMFS, 2002).

In summary, 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 sound pressure level of 180 dB RL. Because the Draft and FOEIS/EISs used 180 dB RL as the criterion for the determination for the potential for injury to marine life and for the implementation of geographic and monitoring mitigation measures, any non-auditory physiological impacts associated with resonance were accounted for. The 145-dB RL restriction for known recreational and commercial dive sites will provide an additional level of protection to marine animals in these areas.

Additionally, it has been claimed that air space resonance impacts can cause damage to the lungs and large sinus cavities of cetaceans, that low frequency sound could induce panic and subsequent problems with equalization, and that low frequency sound could cause bubble growth in blood vessels. With regard to the specific impacts to lungs and sinus cavities, there is abundant anatomical evidence that marine mammals have evolved and adapted to dramatic fluctuations in pressure during long, deep dives that seem to exceed their aerobic capacities (Williams et al., 2000; CNN, 2000). For example, marine mammal lungs are reinforced with more extensive connective tissues than their terrestrial relatives. These extensive connective tissues, combined with the probable collapse of the alveoli at the depths at which significant SURTASS LFA sonar signals can be heard, make it very unlikely that significant lung resonance effects could be realized. The panic response concern is addressed in Subchapter 4.4.3 (Marine Mammal Strandings) below.

Acoustically Mediated Bubble Growth

Presently, there is controversy among researchers on whether or not marine mammals can suffer from a form of decompression sickness. It is theorized that this may be caused by diving and then surfacing too quickly, forcing nitrogen bubbles to form in the bloodstream and tissues. In

2002, NMFS held "The Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans," focusing on the March 2000 Bahamas strandings. The purpose of the workshop was to present any evidence for the possible mechanisms by which mid-frequency active sonar could lead to strandings of beaked whales. The November 2002 report on this workshop discussed needed research on acoustically mediated bubble growth and listed the major issues surrounding the hypothesis (NOAA/NMFS, 2002). The issues listed included:

- Using trained animals to test the theory of bubble growth;
- Studying the tissues damaged by bubble growth/decompression sickness and comparing this with the injuries in beaked whales already studied;
- Obtaining needed information on the rise of acoustic waves in enhancing bubble nucleation and activation in tissues that are supersaturated to upwards of 300 percent;
- Devising methods to acquire, preserve, and test tissue samples from stranded animals so that the presence of bubbles in tissues can be investigated; and
- If beaked whales are shown to have bubble growth from any cause, then determining the lowest sound pressure level at which bubble growth can be triggered, and which sonars have transmission characteristics most likely to trigger this bubble growth.

Jepson et al. (including Fernandez) (2003) (P. D. Jepson is from the School of Geography and the Environment, University of Oxford, UK) published a brief communication in *Nature* magazine on gas-bubble lesions found in stranded cetaceans (Canary Islands stranding, 2002, see Subchapter 4.4.3.1). They presented findings of acute and chronic tissue damage in stranded cetaceans that they believe resulted from the formation of *in vivo* (in the living body) gas bubbles, and stated that the animals showed severe, diffuse vascular congestion and marked, disseminated microvascular hemorrhages associated with widespread fat emboli in vital organs, particularly the liver. They also stated that the lesions were consistent with acute trauma due to *in vivo* bubble formation that results from rapid decompression, which occurs in decompression sickness. A response to this article was posted in *Nature* by Piantadosi and Thalmann (2004) of the Duke University Medical Center and Divers Alert Network (DAN) stating that whales do not develop sufficient gas supersaturation in the tissues on ascent to cause extensive bubble formation in the liver. The gas that would be available for supersaturation is located in the lungs at the onset of each held breath. According to Piantadosi and Thalmann (2004), during descent the thorax is compressed and the residual gas volume in the compliant lungs is forced**,** by Boyle's law contraction and alveolar collapse, into non-respiratory conducting airways, where it is sequestered from circulation. They explain that not enough gas is taken up to produce bubbles, except possibly during multiple rapid dives to depths approaching the lung's closing volume. Fernandez et al. (including Jepson) (2004) stated in their own brief communication that they did not present their findings as conclusive evidence of decompression sickness. All communications agree, though, that further investigation is needed, including an analysis of the composition of the gas in the bubbles (Jepson et al., 2003; Piantadosi and Thalmann, 2004; Fernandez et al., 2004).

Scientists from WHOI have documented bone lesions in the rib and chevron bones of sperm whales, which may have been caused by tissue damage from nitrogen bubbles (Moore and Early, 2004). They studied 16 partial or complete skeletons that died up to 111 years ago from both the Atlantic and Pacific Oceans. Studying the skeletons, they noted a series of changes in bones attached to the backbone, mainly the rib bones, and other small bones in the tail region. The changes are patches where the bone died due to an obstructed blood supply to the joint surfaces of the bone. One theory suggests that the lesions were caused by a decompression-like sickness (Dawicki, 2004).

The issue of bubble growth via rectified diffusion was evaluated in the FOEIS/EIS, Record of Decision and Final Rule. Crum and Mao (1996) stated that RL would have to exceed 190 dB in order for there to be the possibility of significant bubble growth via rectified diffusion (one form of the growth of gas bubbles in liquids) due to supersaturation of gases in the blood.

4.3.2 Permanent Loss of Hearing

Hearing Threshold

The hearing of marine mammals varies based on individuals, absolute threshold of the species, masking, localization, frequency discrimination, and the motivation to be sensitive to a sound (Richardson et al., 1995). Younger animals typically have better hearing sensitivity than older animals and hearing sensitivity also varies by species. 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 of the sound. Background noise may mask the sounds that a marine mammal detects; masking can come from both natural and man-made noises (Richardson et al., 1995).

The hearing mechanism for marine mammals is similar to that of terrestrial mammals. It is comprised of an outer ear, a fluid-filled inner ear with a frequency-tuned membrane interacting with sensory cells, and an air-filled middle ear, which provides a connection between the outer ear and inner ear (Nedwell et al., 2004).

Odontocetes

Behavioral audiograms have been conducted for 11 species of toothed whales, including oceanic dolphins, river dolphins, porpoises, and monodonts (narwhals and belugas). Odontocetes have a broad acoustic range, with recent hearing thresholds measured between 75 Hz and about 180 kHz (Richardson et al., 1995; Finneran et al., 2002). According to one study, the best hearing for the beluga whale seems to be between 40 and 100 kHz (Johnson et al., 1989); however, their hearing at low frequencies seems poor (Richardson et al., 1995). A 2001 audiogram study on bottlenose dolphins showed that the male dolphin’s hearing was the best between 20 and 40 kHz while the female dolphin’s best hearing was between 20 and 120 kHz (Nedwell et al., 2004). Most small to medium-sized odontocetes seem to have good hearing in high frequencies, extending up to 150 kHz in some individuals (Richardson et al., 1995). Audiograms from killer whales have shown that they have upper frequency limits near 120 kHz (Richardson et al., 1995). A study in 1999 examined the hearing ability of killer whales between 1 and 100 kHz, which showed that behaviorally, the killer whales reacted between 4 and 100 kHz (Szymanski et al., 1999).

Pinnipeds

Hearing capabilities and sound production is 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, 2002; Frankel, 2002; Van Parijs and Kovacs, 2002). 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. 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 low frequency sound in the water, as sea lions have a higher hearing threshold (116 to 119 dB RL) at frequencies of 100 Hz. Harbor seals are approximately 20 dB more sensitive to signals at 100 Hz compared to California sea lions and thus are more likely to hear low frequency anthropogenic noise. Elephant seals are the most sensitive to low frequency sound underwater with a hearing threshold of around 90 dB RL at 100 Hz. Elephant seals also are deep divers, which may expose them to higher sound levels in the deep sound channel. Kastak and Schusterman (1996, 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.

In a 2002 study, the California sea lion was most sensitive between approximately 2.5 and 10 kHz (Kastak and Schusterman, 2002). Other otariid species (eared seals) with documented vocalizations are the South American sea lions and northern fur seals (Fern'ndez-Juricic et al., 1999; Insley, 2000). Otariid hearing abilities are thought to be intermediate between Hawaiian monk seal and other phocids (true seals), 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; both *in* Richardson et al., 1995).

Other sound experiments have shown some pinniped sensitivity to low frequency sound. 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 (Møhl, 1968; Terhune and Ronald, 1972, 1975b; Terhune, 1991).

Mysticetes

There have been no psycho-acoustical or electrophysiological studies reported on baleen whales. However, some species react behaviorally to certain calls and anthropogenic sounds. Most reactions to anthropogenic sounds were below 1 kHz. Fin whales have responded to calls from the same species at 20 Hz. Observed reactions have been seen with gray, humpback, and bowhead whales from air gun pulses and underwater playbacks of recorded anthropogenic sounds. The dominant frequencies were in the 50 to 500 Hz range (Richardson et al., 1995). All mysticetes produce low frequency sounds, although no direct measurements of auditory (hearing) thresholds have been made (Clark, 1983, 1990; Richardson et al., 1995; Edds-Walton, 1997; Tyack, 2000; Evans and Raga, 2001). Based on a study of the morphology of cetacean auditory mechanisms, Ketten (1994) hypothesized that mysticete hearing is in the low to infrasonic (sound frequencies too low to be audible to humans, generally below 20 Hz) range. It is generally believed that baleen whales have frequencies of best hearing where their calls have the greatest energy—below 1,000 Hz (Dahlheim and Ljungblad, 1990; Frankel et al., 1995; Ketten, 2000).

Summary

The updated literature reviews and research results noted above indicate that there are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS; thus, its findings regarding the potential for permanent loss of hearing from SURTASS LFA sonar operations remains valid. That is, that the potential impact on any stock of marine mammals from injury (such as permanent loss of hearing) is considered negligible.

4.3.3 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 hours. TTS is quite common in humans and often occurs after being exposed to loud music, such as at a rock concert. The precise physiological mechanism for TTS is not understood. It may result from fatigue of the sensory hair cells as a result of their being over-stimulated or from some small damage to the cells, which is repaired over time. The duration of TTS depends on a variety of factors including intensity and duration of the stimulus, and recovery can take minutes, hours, or even days. Therefore, animals suffering from TTS over longer time periods, such as hours or days, may be considered to have a change in a biologically significant behavior, as they could be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators.

There have been no substantial changes to the knowledge or understanding for the potential effects of LF sound 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.

4.3.4 Behavioral Change

Biologically Significant Behavior

The primary potential deleterious effect from SURTASS LFA sonar is change in a biologically significant behavior. An activity is biologically significant when it affects an animal’s ability to grow, survive, and reproduce (NRC, 2005).

The 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 and how those responses scaled relative to RL and context. 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)

In a 1998 SURTASS LFA sonar playback experiment, migrating gray whales avoided exposure to LFA signals (source levels of 170 and 178 dB) when the source was placed within their migration corridor. Responses were similar for the 170-dB SL LFA stimuli and for the 170-dB SL one-third octave band-limited noise with timing and frequency band similar to the LFA stimulus. However, during the SURTASS 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 outside of the migration corridor, but with SL increased so as to reproduce the same sound field inside the corridor, the whales continued their migration unabated. This result stresses the importance of context in interpreting animals' responses to underwater sounds.

Prey fish within the 180-dB sound field of the SURTASS LFA sonar source could potentially be affected, which would suggest that this could presumably affect the foraging potential for some localized marine mammals to some extent. However, recent results from low frequency sonar exposure studies conducted on trout and channel catfish indicated that the impact from low frequency sonar is likely to be minimal, if not negligible; and certainly there is no potential for any measurable fish stock mortalities from SURTASS LFA sonar operations (see Subchapter 4.1.1). Therefore, marine mammal foraging will not be affected.

Eight weekly aerial surveys of humpback whales were flown north of the Hawaiian Island of Kauai each year when the NPAL source was not transmitting in 2001 and when it was transmitting in 2002 and 2003 during the peak residency period of humpback whales (February through March) (Mobley, 2005). The goal of the NPAL program was to extend the earlier thermometry findings of the ATOC experiment over a longer time to determine ocean-basin scale trends in temperature. The results of these surveys suggest that exposure to the NPAL source during the two years sampled with the source on, did not change the numbers of whales north of Kauai. It did not produce any noticeable distributional changes as measured by distance from the source and from shore, nor did it produce any noticeable changes in the depths of sighting locations. These results contrast somewhat with the results from the ATOC and MMRP studies, which found a slight change in distribution and behavior, although no change in abundance (Frankel and Clark, 2000; 2002). After four years of exposure to the ATOC/NPAL transmissions, the humpback whales continue to return to their wintering grounds near Kauai and show little changes in their normal pattern of distribution (Mobley, 2005).

4.3.5 Masking

There have been no substantial changes to the knowledge or understanding for the potential effects of LF sound on masking with regard to marine mammals. The information in Subchapter 4.2.7.7 of the FOEIS/EIS remains valid and the contents are incorporated by reference herein. Two papers have been published fairly recently on low frequency masking in three pinniped species (northern elephant seal, harbor seal, California sea lion) that focused specifically on comparative amphibious capabilities, and revealed some LF characteristics of masking that bear on cochlear mechanics (Southall, 2000; 2003). The former paper used behavioral techniques to determine underwater masked hearing thresholds for the three test animals. The latter paper reported on direct measurements of critical bandwidth at low frequencies and basically concluded that results are directly relevant to underwater masking because both arise from common cochlear processes in either media (air or water). Results indicate that LF signals can be masked by LF noise. However, combined data suggest that LF critical masking ratios are relatively low in both media for pinnipeds (as in much of the other marine mammal data), which would suggest less potential for masking at low frequencies.

4.3.6 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 SURTASS LFA sonar signal transmissions is not expected to be severe and would be temporary.

4.4 Analysis of SURTASS LFA Sonar Operations under Current MMPA Rule

As a requirement of the regulations for the taking of marine mammals incidental to Navy operations of SURTASS LFA Sonar, 50 CFR 216 Subpart Q (67 FR 46785-89), the Navy must provide annual reports with an unclassified summary of the classified quarterly reports of SURTASS LFA operations onboard the USNS IMPECCABLE (T-AGOS 23) and R/V *Cory Chouest* in accordance with the requirements of the LOAs issued by the US DOC, NOAA, and the NMFS. The primary purpose of this annual report is to provide NMFS with unclassified SURTASS LFA sonar operations information to assist them in their evaluation of future Navy LOA applications. As of May 2006, four annual reports have been submitted to NMFS (DON, 2003a; 2004a; 2005a, 2006a). In accordance with 50 CFR 216 Subpart Q, the Navy provided a final comprehensive report to NMFS summarizing and analyzing the first four LOA periods (DON, 2007). Table 4.4-1 summarizes the SURTASS LFA operations for this period by LOA.

4.4.1 Risk Assessment Approach

The SEIS was developed based on the analyses in the SURTASS LFA sonar FOEIS/EIS (DON, 2001), the Applications for Letters of Authorization (DON, 2002; 2003b; 2004b; 2005b), updated literature reviews, and additional underwater acoustical modeling. The analytical process is summarized below. The FOEIS/EIS provided detailed risk assessments of potential impacts to marine mammals covering the major ocean regions of the world: North and South Pacific Oceans, Indian Ocean, North and South Atlantic Oceans, and the Mediterranean Sea.

Table 4.4-1. Summary of SURTASS LFA Sonar Operations

	Number of Missions	Sites[1]	Length of Mission (days)	Active Transmission Time (hours)	Mitigation Protocol Suspensions/ delays
LOA 1					
R/V *Cory Chouest*	7	2, 4	34.2	82.2	3
LOA 1 Total			**34.2**	**82.2**	**3**
LOA 2					
R/V *Cory Chouest*	5	3	46.2	110.7	10
USNS IMPECCABLE	5	1, 2, 3	26.3	63.0	8
LOA 2 Total			**72.5**	**173.7**	**18**
LOA 3					
R/V *Cory Chouest*	3	2, 3, 4	13.1	19.2	12
USNS IMPECCABLE	2	2	9.4	22.7	1
LOA 3 Total			**22.5**	**41.9**	**13**
LOA 4					
R/V *Cory Chouest*	12	2, 3, 5	73.1	133.8	58
USNS IMPECCABLE	6	2, 4, 7	22.5	39.4	5
LOA 4 Total			**95.6**	**173.2**	**63**

[1]See Figure 4.4-2

The 31 acoustic modeling sites are shown in Figure 4.2-1 and Table 4.2-1 of the FOEIS/EIS. 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 selected to represent reasonable sites for each of the three major underwater sound propagation regimes where SURTASS LFA sonar could be employed.

Acoustic analysis included underwater sound transmission via the following propagation paths:

- 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 for effects from the use of SURTASS LFA sonar incorporating the following factors:

- Closest plausible proximity to land (from a SURTASS LFA sonar operations standpoint) where biological densities are higher, and/or offshore biologically important areas (particularly for animals most likely to be affected);
- Acoustic propagation conditions that allow minimum propagation loss, or transmission loss (TL) (i.e., longest acoustic transmission ranges); and
- Time of year selected for maximum animal abundance.

These sites represent the upper bound of impacts (both in terms of possible acoustic propagation conditions, and in terms of marine mammal population and density) that can be expected from operation of the SURTASS LFA sonar system. Thus, if SURTASS LFA sonar operations were conducted in an area that was not acoustically modeled in the FOEIS/EIS, the potential effects would most likely be less than those obtained from the most similar site in the analyses presented here.

Effectively, the conservative assumptions of the FOEIS/EIS are still valid. Moreover, 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. Thus, it is not necessary to reanalyze the potential acoustic impacts in the Supplemental EIS. 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 areas of operation. The LOA application analytical process is described below with the actual sensitivity/risk analysis performed for the fourth-year LOA application provided as a sample case study. It utilizes a conservative approach by integrating mission planning needs and a cautious assessment of the limited data available on specific marine mammal populations, and seasonal habitat and activity. Because of the incorporation of conservative assumptions, it is likely that the aggregate effect of such assumptions was an overestimation of risk—a prudent approach for environmental conservation when there are data gaps and other sources of uncertainty. This approach for estimating risk to marine mammal stocks was not intended to forecast the expected outcome from SURTASS LFA sonar operations but, rather, to determine reasonable upper bounds. If this type of practical analysis presented an outcome that was acceptable, then the activity would clearly satisfy the regulatory requirement to assess environmental risk. The total annual risk for each stock of marine mammal species was estimated by summing a particular species' risk estimates within that stock, across mission areas. Each stock, for a given species, was then examined. Based on this approach, the highest total annual estimated risk (upper bound) for any marine mammal species' stock was provided in the fourth year application for LOAs (DON, 2005b).

Figure (4.4-1) provides a flowchart that depicts the sensitivity/risk process. The left side of the flowchart illustrates the process that is initially carried out for all potential mission areas, which starts with the Navy's ASW requirements to be met by SURTASS LFA sonar. Based on this information, mission areas are proposed by the CNO and fleet commands. Thereupon, available published data are collected, collated, reduced and analyzed with respect to marine mammal populations and stocks, marine mammal habitat and seasonal activities, and marine mammal behavioral activities. Where data are unavailable, best scientific 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.

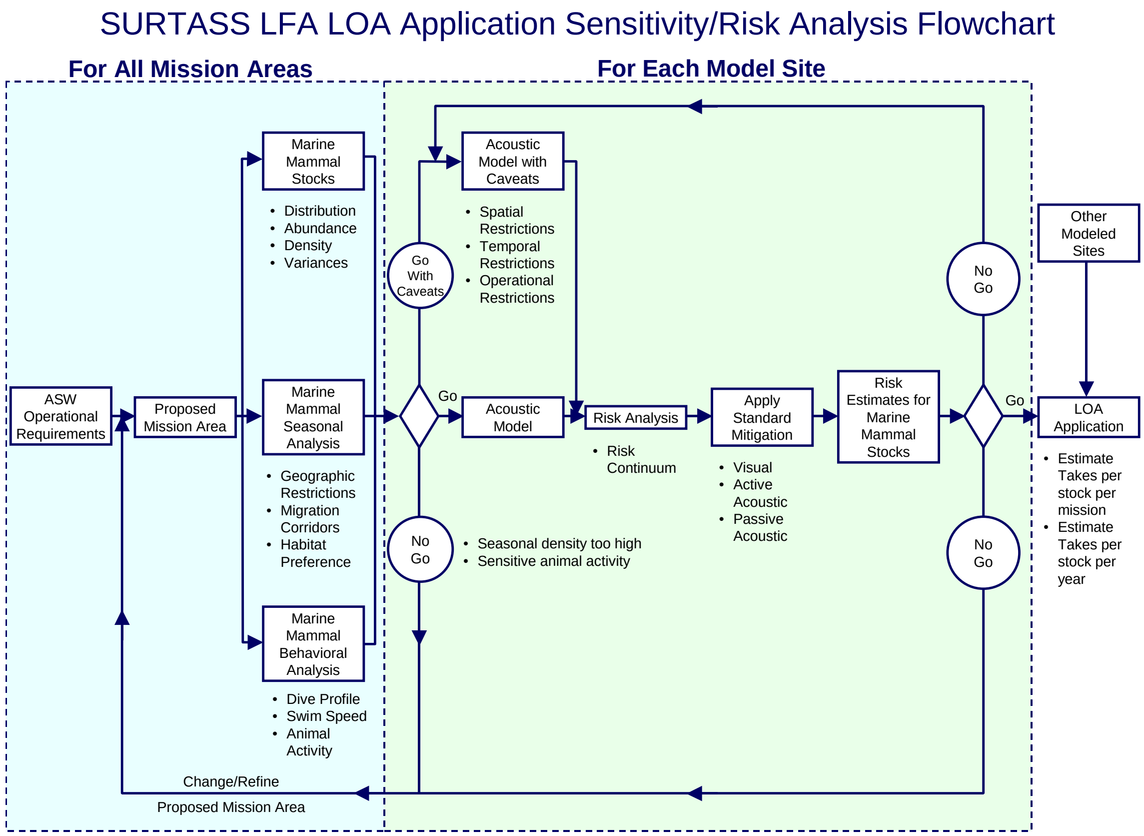


Figure 4.4-1. SURTASS LFA sonar LOA application sensitivity/risk analysis flowchart.

The right side of the flowchart portrays the process that is applied to mission sites 1 through 9 (see Figure 4.4-2) individually. The individual generic steps of this process are summarized as follows:

- Based on results from the initial process for all potential mission areas, there are three possible alternatives, which are indicated in the flow chart. If, for one or more of the proposed mission areas, seasonal densities prove to be high and/or sensitive animal activities are expected there, those mission areas are changed and/or refined and the process is re-initiated, as shown in the flow chart.
- The other two alternatives are: 1) standard acoustic modeling is performed, or 2) acoustic modeling with caveats (e.g., spatial, temporal or operational restrictions) is performed.
- After acoustic modeling, risk analysis is undertaken, using the risk continuum.
- Standard mitigation is applied.
- Risk estimates for marine mammal stocks are calculated.

- Based on these estimates, the next decision point is reached. Again, there are three possible alternatives, two of which are: 1) more acoustic modeling with changed or refined caveats is performed and the "each model site" process is re-initiated, or 2) the proposed mission area is changed or refined and the entire process is re-initiated.
- The other alternative is to move to the next step and input the risk estimates for marine mammal stocks to the LOA application, which are also combined with the estimates derived from the same process for all other modeled mission areas/sites to derive the risk estimates for marine mammal stocks for the entire LOA period of applicability (one year).

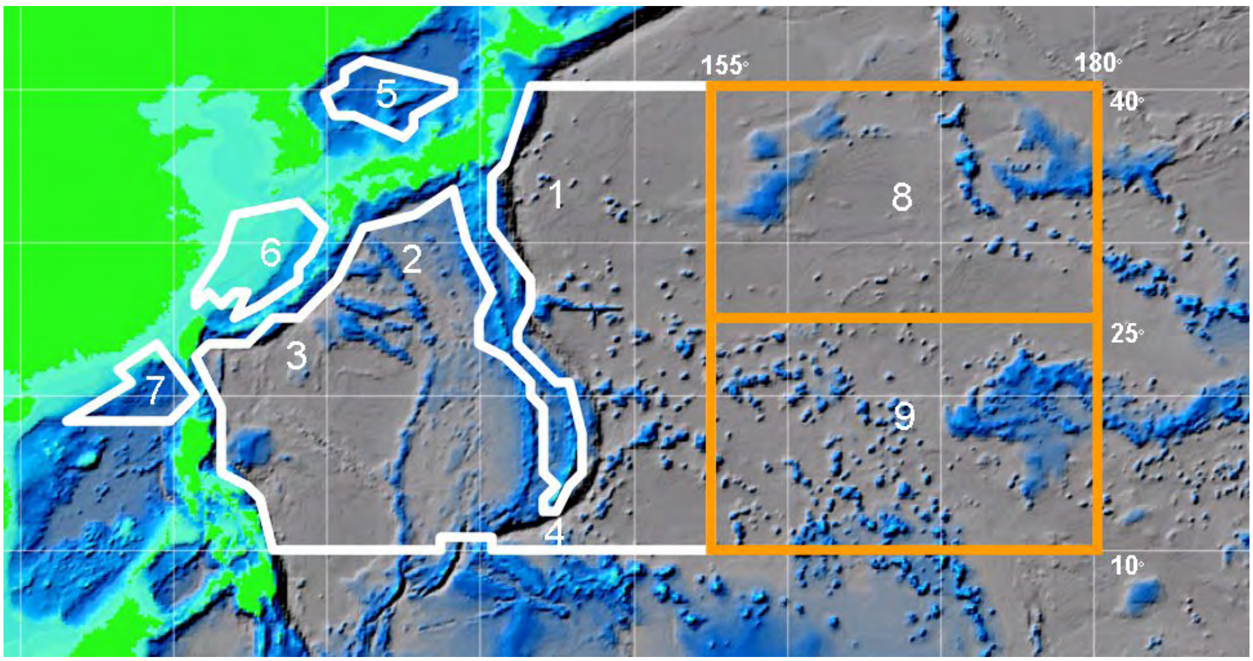


Figure 4.4-2. SURTASS LFA sonar western Pacific operational areas.

4.4.2 Risk Assessment Case Study

The same analytical methodology utilized in the application for the current LOAs (DON, 2005b) was utilized to provide reasonable and realistic estimates of the potential effects to marine mammal stocks specific to the potential mission areas as presented in the application. It is not feasible to analyze all potential mission areas throughout the oceanic regions pertinent to this SEIS (Atlantic, Mediterranean, Pacific, and Indian), for all species' stocks for all seasons. In the case study, sites and seasons are based on reasonable and realistic choices for SURTASS sonar operations proposed in the LOA application. The CNO's mission for SURTASS sonar operations to be conducted under the requested LOAs is to train the Navy crews manning the vessels and to test and operate the SURTASS LFA sonar systems in as many and varied at-sea environments as possible. The Navy has determined that the SURTASS LFA sonar testing and training operations that are the subject of NMFS's July 16, 2002, Final Rule constitute a military readiness activity as that term is defined in Public Law 107-314 (16 U.S.C. § 703 note) 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."

Information on how the density and stock/abundance estimates are derived for the selected mission sites are given in the LOA applications. These data are derived from current, available published source documentation, and provide general area information for each mission area with species-specific information on the animals that could potentially occur in that area, including estimates for their stock/abundance and density.

Tables 4.4-2 through 4.4-10 provide a set of annual estimates of potential effects to marine mammal stocks for 16 missions at nine mission sites (see Figure 4.4-2). Tables 4.4-2 through 4.4-10 provide estimates of marine mammal stocks potentially affected potentially affected by SPE levels less than 180 dB (% affected < 180 dB) and equal to or greater than 180 dB (% affected ≥ 180 dB).The values in the tables support the conclusion that estimates of potential effects to marine mammal stocks are below the criteria delineated by NMFS in its current Final Rule. Furthermore, "small numbers" and "specified geographical region" are no longer requirements under the MMPA as amended by the National Defense Authorization Act of Fiscal Year 2004 (NDAA, FY04).

Table 4.4-2. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 1, Summer Season.

East of Japan				
Mission Site 1	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Blue whale	9250	0.10	0.00
	Fin whale	9250	0.10	0.00
	Sei whale	37000	0.07	0.00
	Bryde's whale	22000	0.12	0.00
	Minke whale	25000	0.69	0.00
	N. Pacific right whale	922	0.05	0.00
	Sperm whale	102112	0.04	0.00
	Kogia	350553	0.04	0.00
	Baird's beaked whale	8000	1.52	0.00
	Cuvier's beaked whale	90725	0.25	0.00
	Ginkgo-toothed beaked whale	22799	0.09	0.00
	Hubbs' beaked whale	22799	0.09	0.00
	False killer whale	16668	1.15	0.00
	Pygmy killer whale	30214	0.37	0.00
	Short-finned pilot whale	53608	1.20	0.00
	Risso's dolphin	83289	0.72	0.00
	Common dolphin	3286163	0.14	0.00
	Bottlenose dolphin	168791	0.62	0.00
	Spinner dolphin	1015059	0.00	0.00
	Pantropical spotted dolphin	438064	0.35	0.00
	Striped dolphin	570038	0.11	0.00
	Rough-toothed dolphin	145729	0.24	0.00
	Fraser's dolphin	220789	0.11	0.00
	Pacific white-sided dolphin	67769	0.71	0.00

Note: Based on one operation at this site

Table 4.4-3. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 2, Winter Season.

North Philippine Sea				
Mission Site 2	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Bryde's whale	22000	0.11	0.00
	Minke whale	25000	0.56	0.00
	N. Pacific right whale	922	0.04	0.00
	Sperm whale	102112	0.04	0.00
	Kogia	350553	0.03	0.00
	Cuvier's beaked whale	90725	0.23	0.00
	Blainville's beaked whale	8032	0.24	0.00
	Ginkgo-toothed beaked whale	22799	0.09	0.00
	Killer whale	12256	0.14	0.00
	False killer whale	16668	0.73	0.00
	Pygmy killer whale	30214	0.29	0.00
	Melon-headed whale	36770	0.14	0.00
	Short-finned pilot whale	53608	1.20	0.00
	Risso's dolphin	83289	0.64	0.00
	Common dolphin	3286163	0.08	0.00
	Bottlenosed dolphin	168791	0.44	0.00
	Spinner dolphin	1015059	0.00	0.00
	Pantropical spotted dolphin	438064	0.14	0.00
	Striped dolphin	570038	0.26	0.00
	Rough-toothed dolphin	145729	0.18	0.00
	Fraser’s dolphin	220789	0.08	0.00
	Pacific white-sided dolphin	67769	0.79	0.00

Note: Based on one operation at this site

Table 4.4-4. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 3, Fall Season.

West Philippine Sea				
Mission Site 3	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Fin whale	9250	0.36	0.00
	Bryde's whale	22000	0.45	0.00
	Minke whale	25000	1.14	0.00
	Humpback whale (winter only)	394	0.00	0.00
	Sperm whale	102112	0.12	0.00
	Kogia	350553	0.06	0.00
	Cuvier's beaked whale	90725	0.03	0.00
	Blainville's beaked whale	8032	0.84	0.00
	Ginkgo-toothed beaked whale	22799	0.30	0.00
	False killer whale	16668	2.79	0.00
	Pygmy killer whale	30241	1.11	0.00
	Melon-headed whale	36770	6.21	0.00
	Short-finned pilot whale	53608	2.25	0.00
	Risso's dolphin	83289	2.34	0.00
	Common dolphin	3286163	0.30	0.00
	Bottlenose dolphin	168791	1.59	0.00
	Spinner dolphin	1015059	0.00	0.00
	Pantropical spotted dolphin	438064	0.54	0.00
	Striped dolphin	570038	0.51	0.00
	Rough-toothed dolphin	145729	0.72	0.00
	Fraser's dolphin	220789	0.33	0.00
	Pacific white-sided dolphin	67769	6.39	0.00

Note: Based on three operations at this site

Table 4.4-5. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 4, Spring and Summer Seasons.

Guam				
Mission Site 4	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affetced (w/mit) ≥ 180 dB**
	Blue whale	9250	0.21	0.00
	Fin whale	9250	0.21	0.00
	Bryde's whale	22000	0.45	0.00
	Minke whale	25000	0.09	0.00
	Humpback whale (winter only)	4005	0.00	0.00
	Sperm whale	102112	0.09	0.00
	Kogia	350553	0.03	0.00
	Cuvier's beaked whale	90725	0.56	0.00
	Blainville's beaked whale	8032	1.50	0.00
	False killer whale	35132	1.68	0.00
	Melon-headed whale	36770	3.39	0.00
	Short-finned pilot whale	53608	0.51	0.00
	Risso's dolphin	83289	0.15	0.00
	Bottlenose dolphin	168791	0.27	0.00
	Spinner dolphin	1015059	0.15	0.00
	Pantropical spotted dolphin	438064	3.81	0.00
	Striped dolphin	570038	1.68	0.00
	Rough-toothed dolphin	145729	0.63	0.00

Note: Based on three operations at this site

Table 4.4-6. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 5, Fall Season.

Sea of Japan				
Mission Site 5	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Fin whale	9250	0.98	0.00
	Bryde's whale	22000	0.04	0.00
	Minke whale	25000	0.16	0.00
	Minke J stock	893	1.80	0.00
	Gray whale	100	1.00	0.00
	N. Pacific right whale	922	0.15	0.00
	Sperm whale	102112	0.06	0.00
	Stejneger's beaked whale	8000	1.56	0.00
	Baird's beaked whale	8000	0.34	0.00
	Cuvier's beaked whale	90725	0.42	0.00
	Ginkgo-toothed beaked whale	22799	0.20	0.00
	False killer whale	9777	3.24	0.00
	Melon-headed whale	36770	0.00	0.00
	Short-finned pilot whale	53608	0.30	0.00
	Risso's dolphin	83289	1.18	0.00
	Common dolphin	3286163	0.32	0.00
	Bottlenose dolphin	105138	0.12	0.00
	Spinner dolphin	1015059	0.00	0.00
	Pantropical spotted dolphin	219032	0.78	0.00
	Pacific white-sided dolphin	67769	0.54	0.00
	Dall's porpoise	76720	8.36	0.00

Note: Based on two operations at this site

Table 4.4-7. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 6, Summer Season.

East China Sea				
Mission Site 6	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Fin whale	500	1.90	0.00
	Bryde's whale	22000	0.13	0.00
	Minke whale	25000	0.69	0.00
	Minke J stock	893	7.68	0.00
	Gray whale (winter only)	100	0.48	0.00
	N. Pacific right whale	922	0.05	0.00
	Sperm whale	102112	0.04	0.00
	Kogia	350553	0.02	0.00
	Cuvier's beaked whale	90725	0.22	0.00
	Blainville's beaked whale	8032	0.44	0.00
	Ginkgo-toothed beaked whale	22799	0.09	0.00
	False killer whale	9777	0.72	0.00
	Pygmy killer whale	30214	0.04	0.00
	Melon-headed whale	36770	0.26	0.00
	Short-finned pilot whale	53608	0.30	0.00
	Risso's dolphin	83289	0.68	0.00
	Common dolphin	3286163	0.06	0.00
	Bottlenose dolphin	105138	0.74	0.00
	Spinner dolphin	1015059	0.01	0.00
	Pantropical spotted dolphin	219032	0.32	0.00
	Striped dolphin	570038	0.14	0.00
	Rough-toothed dolphin	145729	0.20	0.00
	Fraser’s dolphin	220789	0.09	0.00
	Pacific white-sided dolphin	67769	0.21	0.00

Note: Based on one operation at this site

Table 4.4-8. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 7, Fall Season.

South China Sea				
Mission Site 7	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Fin whale	9250	0.09	0.00
	Bryde's whale	22000	0.65	0.00
	Minke whale	25000	0.07	0.00
	Gray whale (winter only)	100	0.00	0.00
	Sperm whale	102112	0.03	0.00
	Kogia	350553	0.01	0.00
	Cuvier's beaked whale	90725	0.01	0.00
	Blainville's beaked whale	8032	0.17	0.00
	Ginkgo-toothed beaked whale	22799	0.07	0.00
	False killer whale	9777	0.82	0.00
	Pygmy killer whale	30214	0.31	0.00
	Melon-headed whale	36770	1.06	0.00
	Short-finned pilot whale	53608	0.64	0.00
	Risso's dolphin	83289	0.75	0.00
	Common dolphin	3286163	0.07	0.00
	Bottlenose dolphin	105138	0.82	0.00
	Spinner dolphin	1015059	0.01	0.00
	Pantropical spotted dolphin	219032	0.33	0.00
	Striped dolphin	570038	0.15	0.00
	Rough-toothed dolphin	145729	0.15	0.00
	Fraser's dolphin	220789	0.10	0.00

Note: Based on one operation at this site

Table 4.4-9. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 8, Summer Season.

Offshore North of 25-40ºN				
Mission Site 8	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Blue whale	9250	0.30	0.00
	Fin whale	9250	0.10	0.00
	Sei whale	37000	0.00	0.00
	Bryde's whale	22000	0.02	0.00
	Minke whale	25000	0.12	0.00
	Sperm whale	102112	0.02	0.00
	Kogia	350553	0.12	0.00
	Baird's beaked whale	8000	0.10	0.00
	Cuvier's beaked whale	90725	0.16	0.00
	Mesoplodon spp	22799	0.18	0.00
	False killer whale	16668	2.30	0.00
	Pygmy killer whale	30214	0.00	0.00
	Melon-headed whale	36770	0.00	0.00
	Short-finned pilot whale	53608	0.00	0.00
	Risso's dolphin	83289	0.14	0.00
	Common dolphin	3286163	0.30	0.00
	Bottlenose dolphin	168791	0.04	0.00
	Spinner dolphin	1015059	0.00	0.00
	Pantropical spotted dolphin	438064	0.48	0.00
	Striped dolphin	570038	1.04	0.00
	Rough-toothed dolphin	145729	0.61	0.00
	Pacific white-sided dolphin	67769	1.23	0.00

Note: Based on two operations at this site

Table 4.4-10. Estimates of percentage of marine mammal stocks potentially affected for Mission Site 9, Summer Season.

Offshore South of 10-25ºN				
Mission Site 9	**Animal**	**# Animals Stock**	**% Affected <180 dB**	**% Affected (w/mit) ≥ 180 dB**
	Bryde's whale	22000	0.02	0.00
	Sperm whale	102112	0.02	0.00
	Kogia	350553	0.02	0.00
	Cuvier's beaked whale	90725	0.16	0.00
	False killer whale	16668	1.34	0.00
	Short-finned pilot whale	53608	0.16	0.00
	Risso's dolphin	83289	0.38	0.00
	Common dolphin	3286163	0.30	0.00
	Bottlenose dolphin	168791	0.06	0.00
	Spinner dolphin	1015059	0.10	0.00
	Pantropical spotted dolphin	438064	2.16	0.00
	Striped dolphin	570038	0.22	0.00
	Rough-toothed dolphin	145729	0.10	0.00

Note: Based on two operations at this site

4.4.3 Marine Mammal Strandings

4.4.3.1 Cetacean Stranding Events

Marine mammal strandings are not a rare occurrence. The Cetacean Stranding Database (www.strandings.net) registers that over a hundred strandings occurred worldwide in the year 2004. However, mass strandings[9], particularly multi-species mass strandings, are relatively rare. Acoustic systems are becoming increasingly implicated with marine mammal strandings. Many theories exist as to why noise may be a factor in marine mammal strandings. One theory is that they become disoriented, or that the noise forces them to surface too quickly which may cause symptoms similar to decompression sickness, or that they are physically injured by the sound pressure.

A review of historical data (mostly anecdotal) maintained by the Marine Mammal Program in the National Museum of Natural History, Smithsonian Institution reports 49 beaked whale mass stranding events between 1838 and 1999. The largest beaked whale mass stranding occurred in the 1870s in New Zealand when 28 Gray's beaked whales (*Mesoplodon grayi*) stranded. Blainsville's beaked whale (*Mesoplodon densirostris*) strandings are rare, and records show that

[9] Mass strandings are defined as a stranding involving two or more animals that are not a cow-calf pair (Geraci and Lounsburg, 1993: in Podesta et al., 2006)

they were involved in one mass stranding in 1989 in the Canary Islands. Cuvier's beaked whales (*Ziphius cavirostris*) are the most frequently reported beaked whale to strand, with at least 19 stranding events from 1804 through 2000 (DOC and DON, 2001; Smithsonian Institution, 2000). By the nature of the data, much of the information on strandings over the years is anecdotal, which has been condensed in various reports, and some of the data have been altered or possibly misquoted.

Strandings within the western Pacific region have been compiled from various, mostly uncorroborated, public sources. Uncertainties exist in many cases as to exact location, and species identification, due to the anecdotal nature of these reports. The paucity of independent scientific verification of strandings in this region can partly be explained by regional language differences between conservation programs and publications, cultural preferences, and some inherent media restrictions. The best source of stranding information for Japan, the Marine Mammal Stranding Database from the National History Museum, Tokyo, currently has only made data publicly available through 2001.

Strandings related to natural causes

There are many known causes for strandings. Stranded marine mammals may be ill. They could have a disease or parasites, or pollution could cause illness. They may follow prey and get too close to shore or they could follow a sick member of the pod and strand. Climatic cycles may also change the ecological composition of species in a region, bringing in new species, which could lead to more strandings of the new species. Strandings can also be caused by animal disorientation with respect to geomagnetic fields when they are used as a source of directional information.

Between March 10 and April 13, 2004, 107 bottlenose dolphins stranded dead along the Florida Panhandle. In addition to the dolphins, many fish and invertebrates were also found dead. An "Interim Report on the Bottlenose Dolphin (*Tursiops turncatus*) Unusual Mortality Event Along the Panhandle of Florida, March-April 2004" has been released by the NOAA and the Florida Fish and Wildlife Conservation Commission (NOAA and USFWS, 2004). The interim report outlines the initial findings and the ongoing analyses of the investigation on the unusual mortality event. The analyses conducted found brevetoxins, naturally occurring neurotoxins produced by *Karenia brevis*, the Florida red tide, at high levels in the stomach contents of all dolphins examined to the date of the publication of the Interim Report. The concentrations of the brevetoxins in the subsamples of the stomach contents were greater than or equal to those observed in previous marine mammal mortality events associated with Florida red tides in the Gulf of Mexico. Military exercises were being conducted off the coast of the Florida Panhandle in March 2004, but were a significant distance from the stranded animals. From the examination of 22 dolphins, no physical evidence of blast or acoustic trauma was found, and based on the stomach contents of the stranded animals, brevetoxins are believed to have caused this unusual mortality event.

On November 28, 2004, 73 long-finned pilot whales and 25 bottlenose dolphins stranded on a beach on King Island in Tasmania. On November 29, 2004, 53 long-finned pilot whales stranded at Maria in Tasmania and 55 long-finned pilot whales stranded on the Coramandle

Peninsula in New Zealand (WDCS, 2004a). Statements were made in newspapers that strandings are fairly frequent in Tasmania, the Bass Strait, and in New Zealand during that time of year (ECBC, 2004). The Whale and Dolphin Conservation Society (WDCS) of Australia released a statement that Tasmanian researchers reported on research in July 2004 at the Australian Marine Science Association's conference linking a series of whale stranding in southern Australia to climatic cycles (WDCS, 2004b). Some scientists believe that the cyclical winds were pushing sub-Antarctic cold, nutrient-rich waters closer to the surface which may have led the whales and dolphins to strand in November (ECBC, 2004).

MacLeod et al. (2005) investigated whether recent oceanic climate change had been significant enough to alter the local cetacean community off northwest Scotland and what it could mean for the conservation of the cetaceans. Since 1981, there has been an increase in temperature of local waters of 0.2 to 0.4ºC per decade. Based on this study, the authors suggest that the warming of local waters has led to changes in the cetacean community, increasing the occurrence of warm-water species, the common dolphin (*Delphinis delphis*), and the addition of new warm-water species, the striped dolphin (*Stenella coeruleoalba*). There has also been a decline in occurrence of a cold-water species, such as the white-beaked dolphin (*Lagenorhynchus albirostris*). This change in the cetacean community has led to a decline of strandings of white-beaked dolphins and an increase in common and striped dolphin strandings (MacLeod et al., 2005).

Strandings potentially related to anthropogenic sound

As stated above, there have been recent stranding events that have been publicly reported and which may, or may not, have been attributed to anthropogenic sound. The ICES in its "Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish" listed 44 beaked whale strandings involving two or more animals from 1914 to 2002 (ICES, 2005). Several of these are discussed below. SURTASS LFA sonar has not been implicated in any of these events and, in fact, there is no record of it ever being implicated in any stranding event since LFA prototype systems were first operated in the late 1980s.

In May 1996, 12 or 13 Cuvier's beaked whales stranded on the Greek coast. Seven of the whales were examined, all of them adolescents with fresh food in their stomachs. They were tested for viruses with negative results, but there was no investigation of their inner ears. NATO was conducting Shallow Water Acoustic Classification exercises, using low- and mid-frequency sonar, in the Kyparissiakos Gulf in the area of the strandings. The frequencies of the sources were between 450 and 3,300 Hz. Since the inner ears were not examined, though, an acoustic link could not be established or eliminated (NATO, 1998).

From 15 to 17 March 2000, 17 cetaceans stranded in the Bahamian islands of Grand Bahama, Abaco, and smaller surrounding islands. Four species were involved, including Cuvier's beaked whales, Blainville's beaked whales, minke whales (*Balaenoptera acutorostrata*), and spotted dolphins (*Stenella ssp.)*. Seven animals died and ten animals were returned to the water alive. According to the June 2003 Beaked Whale Necropsy Findings by Darlene R. Ketten, Ph.D., there was no evidence of near-field blast damage (Ketten, 2003). However, there were deposits of blood within some of the inner ear chambers, and, in one animal, the blood trail could be traced to a hemorrhage in a region of the fluid spaces around the brain and the animal also had clotting on the dorsal surfaces of both lateral ventricles of the brain. The necropsy findings suggest pressure-related trauma in the stranded beaked whales. The pattern of the hemorrhaging suggested that the animals were alive at the time of injury. There was also hemorrhaging in the "acoustic" fats of the jaws. The level of hemorrhaging was consistent with acoustic trauma, but did not necessarily indicate permanent hearing loss or mortality. In addition, the animals that were returned to sea did not re-strand, which is consistent with non-permanent trauma (Ketten, 2003). The DOC and DON published a Joint Interim Report on the Bahamas Marine Mammal Stranding (DOC and DON, 2001). This Report concluded:

> "A combination of specific physical oceanographic features, bathymetry, presence of beaked whales, and specific sound sources were present. Six of the whales and one dolphin (unassociated) died after stranding on beaches. Ten whales returned to the sea alive. The four dead whales from which specimen samples could be collected showed signs of inner ear damage and one showed signs of brain tissue damage. While the precise causal mechanisms of tissue damage are unknown, all evidence points to acoustic or impulse trauma. Review of passive acoustic data ruled out volcanic eruptions, landslides, other seismic events, and explosive blasts, leaving mid-range tactical Navy sonars operating in the area as the most plausible source of the acoustic or impulse trauma. This sound source was active in a complex environment that, as noted above, included the presence of a surface duct, unusual underwater bathymetry, constricted channel with limited egress, intensive use of multiple active sonar units over an extended period of time, and the presence of beaked whales that appear to be sensitive to the frequencies produced by these sonars. The investigation team concludes that the cause of this stranding event was the confluence of the Navy tactical mid-range frequency sonar and the contributory factors noted above acting together." (DOC and DON, 2001)

Between 10 and 14 May 2000, three Cuvier's beaked whales stranded in the Madeira Islands. NATO multiple-ship exercises occurred concurrent with these strandings (Freitas, 2003; Cox et al., 2006). Ketten (2005) reported that several observations of these beaked whales are consistent with those of the Bahamas stranding specimens. Blood was found in and around the eyes, there were lesions in the kidneys, pleural hemorrhage, lung congestion, and also subarachnoid and ventricular hemorrhages in one animal. The findings are consistent with Bahamian specimen pathologies that are consistent with stress and pressure related trauma.

On September 24, 2002, 14 animals of multiple species of beaked whales stranded in the Canary Islands of Spain. This event coincided with a Spanish-led Navy maneuver in nearby waters. Five animals were found dead, three were found alive, but later died, and six animals were returned to the sea. On September 25, two dead beaked whales appeared, and on September 26, two more dead beaked whales appeared. Specimens from September 24 underwent a necropsy by members of the Veterinary University of Las Palmas as well as the Society for the Study of Cetaceans of the Canaries Archipelago (Martin et al., 2004). Efforts to study the whale specimens from this incident continue and a report has not yet been published.

4.4.3.2 Pinniped Stranding Events

There are many causes for pinniped strandings, such as disease, climatic conditions, injuries and domoic acid[10]. One study focused on the causes of live strandings of California sea lions along the central California coast from 1991 to 2000 (Greig et al., 2005). Diseases may reflect environmental changes such as pollution, a shift in prey, and global warming. Natural environmental changes, such as storm surges and El Niño events have been correlated to the number of pinniped strandings. However, detection rate is also dependent upon human effort, better public awareness, and the accessibility to stranded animals. Data collections from strandings are opportunistic and can vary based on season, weather conditions, and the number of people on the beach. According to this study, malnutrition was the most common reason for pinniped strandings (32 percent); followed by leptospirosis (a bacterial disease that affects humans and animals) (27 percent); trauma (e.g., gunshot wounds, entanglement, shark bites, propeller wounds) (18 percent); domoic acid intoxication (9 percent); and cancer (3 percent). In past surveys conducted by The Marine Mammal Center from 1975 to 1990, the major causes of strandings were malnutrition, renal disease, and pneumonia. In the 1991 to 2000 study, the causes of the strandings were determined from clinical experimentations, hematology and serum biochemistry parameters, radiographs, gross necropsy, histopathologic examination of tissues, fecal sedimentation for parasites, bacterial culture, and biotoxin assays. The results of this study showed that the annual number of live California sea lion strandings along the central California coast increased since 1975. Furthermore, a greater number of strandings occurred during the El Niño events of 1983/1984, 1991/1992, and 1997/1998 (Greig et al., 2005).

4.4.3.3 Analysis of SURTASS LFA Sonar's Potential to Cause Strandings

There are different types of anthropogenic sounds potentially associated with possible impacts to and strandings of marine mammals. Accounts of many of these strandings events are associated with loud naval sonars or military sonars. A wide range of naval sonars are used to detect, localize and classify underwater targets. For the purposes of the SURTASS LFA SEIS analysis, these systems are categorized as LFA (< 1000 Hz) and mid frequency active (MFA) (1 to 10 kHz). Differences in operational parameters dictate that the potential for LFA and MFA to affect marine mammals is not the same.

Cox et al. (2006) provided a summary of common features shared by the strandings events in Greece (1996), Bahamas (2000), and Canary Islands (2002). These included deep water close to land (such as offshore canyons), presence of an acoustic waveguide (surface duct conditions), and periodic sequences of transient pulses (i.e., rapid onset and decay times) generated at depths less than 10 m (32.8 ft) by sound sources moving at speeds of 2.6 m/s (5.1 knots) or more during sonar operations (D'Spain et al., 2006). Several of these features do not relate to LFA operations. First, the SURTASS LFA vessel operates with a horizontal line array (SURTASS: a passive

[10] Domoic acid is produced by a neurotoxic phytoplankton by the name of *Pseudo-nitzschia australis*, which occurs naturally in California's waters. When there is a significant algal bloom, which has happened every spring for the last several years, an abundant amount of the poisonous domoic acid is produced. The toxin then amasses within the bodies of the sardines and anchovies that feed on the poisonous phytoplankton. The acid accumulates as it climbs the food chain into progressively larger animals like the sea lions and dolphins. As the toxin is absorbed into the body, it affects the neural pathways of sea mammals and inhibits the neurochemical processes of those it afflicts.

listening system) of 1,500 m (4,921 ft) length at depths below 150 m (492 ft) and a vertical line array (LFA sonar source) at depths greater than 100 m. Second, operations are limited by mitigation protocols to at least 22 km (12 nm) offshore. For these reasons SURTASS LFA sonar cannot be operated in deep water that is close to land. Also the LFA signal is transmitted at depths well below 10 m (32.8 ft), and the vessel has a slow speed of advance of 1.5 m/s (3 knots).

While it is true that there was a LF component in the Greek stranding in 1996, only mid-frequency components were present in the strandings in the Bahamas in 2000, Madeira 2000, and Canaries in 2002. This supports the logical conclusion that the LF component in the Greek stranding was not causative (ICES, 2005; Cox et al., 2006). In its discussion of the Bahamas stranding, Cox et al. (2006) stated, “The event raised the question of whether the mid-frequency component of the sonar in Greece in 1996 was implicated in the stranding, rather than the low-frequency component proposed by Frantzis (1998).” The ICES in its “Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish” raised the same issue as Cox et al., stating that the consistent association of MF sonar in the Bahamas, Madeira, and Canary Islands strandings suggest that it was the MF component, not the LF component, in the NATO sonar that triggered the Greek stranding of 1996 (ICES, 2005).

Most odontocetes have relatively sharply deceasing hearing sensitivity below 2 kHz. If a cetacean cannot hear a sound of a particular frequency or hears it poorly, then it is unlikely to have a significant behavioral impact (Ketten, 2001). Therefore, it is unlikely that LF transmissions from LFA would induce behavioral reactions from animals that have poor LF hearing, e.g. beaked whales, bottlenose dolphins, striped dolphins, harbor porpoise, belugas, and orcas (summarized in: Nedwell et al., 2004).

The ICES (2005) report concluded that no strandings, injury, or major behavioral change has yet to be associated with the exclusive use of LF sonar.

4.4.3.4 Conclusion

The important point here is that there is no record of SURTASS LFA sonar ever being implicated in any stranding event since LFA prototype systems were first operated in the late 1980s. The logical conclusion that LFA sonar is not related to marine mammal strandings is supported by the 2004 Workshop on Understanding the Impacts of Anthropogenic Sound on Beaked Whales convened by the MMC (Cox et al., 2006) and the ICES AGISC (ICES, 2005).

4.4.4 Multiple Systems Analysis

Given that there are no new data that contradict any of the assumptions or conclusions presented in Subchapter 4.2.7.4 of the FOEIS/EIS, its contents are incorporated by reference herein. In summary, simply adding the potential impacts from each of the sources conservatively bounds the effect of multiple systems being employed in proximity.

4.5 Socioeconomics

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.

4.5.1 Commercial and Recreational Fisheries

SURTASS LFA sonar operations are geographically restricted such that SURTASS LFA sonar RLs are less than 180 dB RL at least 22 km (12 nm) 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 (Popper et al., 2005a; Halvorsen et al., 2006) provide evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB 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, 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.

4.5.2 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 regarding swimming, snorkeling and diving; hence, its contents are incorporated by reference herein.

Wolfson (1977) stated that whale watching along the North America west coast gray whale migration route was not well-regulated and that activity, in combination with commercial fishing and vessel operations, may cause gray whales to migrate further offshore. Bursk (1989) reported that gray whales often changed speed and deviated from their course in the presence of whale watching boats.

SURTASS LFA sonar operations are restricted to less than 180 dB RL within at least 22 km (12 nm) from coastlines and offshore biologically important areas during biologically important seasons, and will not exceed 145 dB RL for known recreational and commercial dive sites. One reason for the geographic restrictions imposed on SURTASS LFA sonar operations is because these areas can have concentrations of marine mammals (which may be prime whale watching locations). There are no significant impacts to whale watching activities as a result of the employment of SURTASS LFA sonar primarily because the operations avoid prime whale watching areas. In addition, the 145-dB RL restriction for commercial and recreational dive sites would help protect whales and the whale watching industry. Moreover, given that whale watching continues to grow in popularity and as an industry, it can be logically construed that SURTASS LFA sonar operations have not had any impact on the whale watching industry.

4.5.3 Research and Exploration Activities

It is not believed that SURTASS LFA sonar operations will affect research submersibles, nor is it expected that SURTASS LFA sonar operations will affect seafloor cable-laying. SURTASS LFA sonar could potentially affect oceanographic research activities and oil and gas exploration, as they use equipment such as air guns, hydrophones, and ocean-bottom seismometers. If in the vicinity of a research or exploration activity, SURTASS LFA sonar could possibly interfere with or saturate the hydrophones of these other operations. Research activities and oil and gas exploration, though, could also potentially interfere with SURTASS LFA sonar operations. For these reasons, SURTASS LFA sonar operations are not expected to be close enough to these activities to significantly affect them.

4.6 Potential Cumulative Impacts

Cumulative impacts, which can result from individually minor, but collectively significant, actions taking place over time and space, have been defined by the Council on Environmental Quality (CEQ) in 40 CFR 1508.7 as:

> Impacts on the environment which result 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.

Three areas were evaluated for the incremental cumulative impacts 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; and
- Socioeconomics.

4.6.1 Cumulative Impacts from Anthropogenic Oceanic Noise

The potential cumulative impact issue associated with SURTASS LFA sonar operations is the addition of underwater sound to oceanic ambient noise levels, which in turn could have impacts on 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).

The potential impact that up to four SURTASS LFA sonars may have on the overall oceanic ambient noise level are reviewed in the following contexts:

- Recent changes to ambient sound levels in the world’s oceans;

- Operational parameters of the SURTASS LFA sonar system, including proposed mitigation;
- The contribution of SURTASS LFA sonar to oceanic noise levels relative to other human-generated sources of oceanic noise; and
- Cumulative impacts and synergistic effects.

4.6.1.1 Recent Changes in Oceanic Noise Levels

Ambient noise is environmental background noise. It is generally unwanted sound—sound that clutters and masks other sounds of interest (Richardson et al., 1995). Thus, any potential for cumulative impact should be put into the context of recent changes to ambient sound levels in the world's oceans. Research and statements made regarding recent changes in oceanic noise levels before 2001 can be found in the SURTASS LFA sonar FOEIS/EIS, Subchapter 4.4.1.

Sources of oceanic ambient noise, both natural and man-made are presented in the FOEIS/EIS Subchapter 3.1.1. Discussions regarding recent changes in oceanic noise levels before 2001 can be found in the FOEIS/EIS Subchapter 4.4.1. These subchapters are incorporated by reference herein to the SEIS.

In a more recent study, 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 in the frequency range of 20 to 80 Hz and 200 and 300 Hz, and about 3 dB at 100 Hz over a 33-year period. A possible explanation for the rise in ambient noise is the increase in shipping noise.

Commercial Shipping

The Final Report of the NOAA International Symposium on "Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology" stated that the worldwide commercial fleet has grown from approximately 30,000 vessels in 1950 to over 85,000 vessels in 1998 (NRC, 2003; Southall, 2005). Between 1950 and 1998, the U.S. flagged fleet declined from approximately 25,000 to less than 15,000 and currently represents only a small portion of the world fleet. Foreign waterborne trade in the U.S. has increased from 718 to 1,164 million gross metric tons from 1981 to 2001. From 1985 to 1999, world seaborne trade doubled to 5 billion tons and currently includes 90 percent of the total world trade, with container shipping movements representing the largest volume of seaborne trade. It is unknown how international shipping volumes and densities will continue to grow. However, current statistics support the prediction that the international shipping fleet will continue to grow at the current rate or at greater rates in the future. Shipping densities in specific areas and trends in routing and vessel design are as, or more, significant than the total number of vessels. Densities along existing coastal routes are expected to increase both domestically and internationally. New routes are also expected to develop as new ports are opened and existing ports are expanded. Vessel propulsion systems are also advancing toward faster ships operating in higher sea states for lower operating costs; and container ships are expected to become larger along certain routes (Southall, 2005).

Vessel Noise Sources

Boats and ships produce sound due to propeller cavitation (or propeller singing) as well as other machinery. Propeller singing has a frequency between 100 and 1,000 Hz (Richardson et al., 1995). Noise from propulsion machinery enters the water through the hull of the ship. Propulsion machinery sources include rotating shafts, gear reduction transmissions, reciprocating parts, gear teeth, fluid flow turbulence, and mechanical friction. Other sources of noise include pumps, non-propulsion engines, generators, ventilators, compressors, flow noise from water dragging on the hull, and bubbles breaking in the wake. Medium and large vessels generate frequencies up to approximately 50 Hz, primarily from propeller blade rate and secondarily from the engine cylinder firing rates and shaft rotation (Richardson et al., 1995). Propeller cavitation and flow noise can produce frequencies as high as 100 kHz but generally peak energy occurs between 50 and 150 Hz; and auxiliary machinery (pumps and compressors) may produce frequencies up to several kilohertz (Richardson et al., 1995). Moreover, most (83 percent) of the acoustic field surrounding large vessels is the result of propeller cavitation (Southall, 2005). Larger ships generally are diesel-powered and have two propellers, which are larger and slower rotating. These propellers typically have four blades, which turn at a rate of approximately 160 rpm and have a frequency of 10 to 11 Hz (Richardson et al., 1995). It is generally believed that acoustic source levels are not a function of speed for modern diesel vessels across most of their common operations (Heitmeyer et al., 2004). Supply ships often have bow thrusters to help maneuver the ship. A bow thruster may create a harmonic tone with a high fundamental frequency, depending on the rotation rate of the thrusters. One study found nine harmonics, extending up to 1,064 Hz. In another study, the noise increased by 11 dB when the bow thrusters began operating.

Small boats with large outboard engines produce SLs of 175 dB, at frequencies up to several hundred Hertz (Richardson et al., 1995). A study was conducted on the effects of boat noise from whale-watching vessels on the interaction of humpback whales (Au and Green, 2000). Two boats were inflatables with outboard engines. Two were larger coastal boats with twin inboard diesel engines, and the fifth boat was a small water plane area twin hull (SWATH) ship. The study concluded that it is unlikely that the levels of sounds produced by the boats in the study would have any serious effect on the auditory system of humpback whales.

Another study was conducted on the effects of boat noise from whale-watching vessels on pods of killer whales. The average number of whale-watching vessels around the whales has increased approximately fivefold from 1990 to 2000. This study found no significant difference in the duration of primary calls as a function of the presence and absence of boats during 1977 to 1981 and 1989 to 1992, but there was a significant increase in call duration for all three pods studied in the presence of boats from 2001 to 2003 (Foot et al., 2004).

A study was also conducted on the effects of watercraft noise on the acoustic behavior of bottlenose dolphins in Florida (Buckstaff, 2004). The study focused on short-term changes in whistle frequency range, duration, and rate of production. The frequency range and duration of signature whistles did not significantly change due to approaching vessels. However, dolphins whistled more often at the onset of approaching vessels compared to during and after vessel approaches. The whistle rate also increased more at the onset of a vessel approach than when there were no vessels present.

Oil and Gas Industry

According to the NRC (2003), the oil and gas industry has five categories of activities which create sound: seismic surveys, drilling, offshore structure emplacement, offshore structure removal, and production and related activities. Seismic surveys are conducted using air guns, sparker sources, sleeve guns, innovative new impulsive sources and sometimes explosives, and are routinely conducted in offshore exploration and production operations in order to define subsurface geological structure. The resultant seismic data are necessary for determining drilling location and currently seismic surveys are the only method to accurately find hydrocarbon reserves. Since the reserves are deep in the earth, the low frequency band (5 to 20 Hz) is of greatest value for seismic surveys, because lower frequency signals are able to travel farther into the seafloor with less attenuation.

Air gun firing rate is dependent on the distance from the array to the substrate. The typical inter-shot time is 9 to 14 seconds, but for very deep water surveys, inter-shot times are as high as 42 sec. Air gun acoustic signals are broadband and typically measured in peak-to-peak pressures. Peak levels from the air guns are generally higher than continuous sound levels from any other ship or industrial noise. Broadband SLs of 248 to 255 dB from zero-to-peak are typical for a full-scale array. The most powerful arrays have source levels as high as 260 dB, zero-to-peak with air gun volumes of 130 L (7,900 in^3). Smaller arrays have SLs of 235 to 246 dB, zero-to-peak. For deeper-water surveys, most emitted energy is around 10 to 120 Hz. However, some pulses contain energy up to 1,000 Hz (Richardson et al., 1995), and higher.

Drill ship activities are one of the noisiest at-sea operations because the hull of the ship is a good transmitter of all the ship's internal noises. Also, the ships use thrusters to stay in the same location rather than anchoring. Auxiliary noise is produced during drilling activities, such as helicopter and supply boat noises. Offshore drilling structure emplacement creates some localized noise for brief periods of time, and emplacement activities can last for a few weeks and occur worldwide. Additional noise is created during other oil production activities, such as borehole logging, cementing, pumping, and pile driving. Although sound pressure levels for some of these activities have not yet been calculated, others have (e.g., pile-driving). More activities are occurring in deep water in the Gulf of Mexico and offshore west Africa areas.

These oil and gas industry activities occur year-round (not individual surveys, but collectively) and are usually operational 24 hours per day and 7 days per week, as compared to the limited and intermittent SURTASS LFA sonar transmissions.

Military and Commercial Sonar

Active sonar was probably the first wide-scale, intentional use of anthropogenic noise within the oceans. The outbreak of World War (WW) I in 1914 was the impetus for the development of a number of military applications of sonar (Urick, 1983); and by 1918, both Britain and the U.S had built active sonar systems. The years of peace following WWI saw a steady, though extremely slow, advance in applying underwater sound to practical needs. By 1935 several adequate sonar systems had been developed, and by 1938 with the imminence of WWII, quantity production of sonar sets started in the U.S. (Urick, 1983). The NRC (2003) notes that there are both military and commercial sonars: military sonars are used for target detection, localization, and classification; and commercial sonars are typically higher in frequency and lower in power and are used for depth sounding, bottom profiling, fish finding, and detecting obstacles in the water. Commercial sonar use is expected to continue to increase, although it is not believed that the acoustic characteristics will change.

4.6.1.2 SURTASS LFA Sonar Combined with Other Human-Generated Sources of Oceanic Noise

The potential for cumulative impacts and synergistic 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 in 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. The potential for acoustically-induced stress from LFA transmissions is discussed below.

Ambient Noise Levels and Masking

Broadband, continuous low-frequency shipping noise is more likely to affect marine mammals than narrowband, low duty cycle SURTASS LFA sonar. Moreover, SURTASS LFA sonar bandwidth 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 percent of the time. Most mysticete vocalizations are in the low frequency band below 1 kHz. No direct auditory measurements have been made for any mysticete, but it is generally believed that their frequency band of best hearing is below 1,000 Hz, 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 percent, masking would be temporary. For these reasons, any masking effects from SURTASS LFA sonar are expected to be negligible and extremely unlikely.

Odontocetes have a broad acoustic range and hearing thresholds measure between 400 Hz and 100 kHz (Richardson, et al., 1995; Finneran et al., 2002). It is believed that odontocetes communicate above 1,000 Hz and echolocate above 20 kHz (Würsig and Richardson, 2002). While the upward spread of masking is known to exist, the phenomenon has a limited range in frequency. Yost (2000) showed that magnitude of the masking effect decreases as the difference between signal and masking frequency increase; i.e., the masking effect is lower at 3 times the frequency of the masker than at 2 times the frequency. Gorga et al. (2002) demonstrated that for a 1.2-kHz masking signal, the upward spread of masking was extinguished at frequencies of 6 kHz and higher. Therefore, while the phenomenon of upward spread of masking does exist, it is unlikely that LFA would have any significant effect on the hearing of higher frequency animals.

Gorga et al. (2002) also demonstrated that the upward spread of masking is a function of the received level of the masking signal. Therefore, a large increase in the masked bandwidth due to upward masking would only occur at high received levels of the LFA signal.

In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (U.S.) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. On an annual basis, four SURTASS LFA systems are estimated to have a total energy output of 6.8 x 10^{11} Joules/yr. Seismic air gun arrays were two orders of magnitude greater with an estimated annual output of 3.9 x 10^{13} Joules/year. MFA and super tankers were both greater at 8.5 x 10^{12} and 3.7 x 10^{12} Joules/year, respectively (Hildebrand, 2004). Hildebrand concluded that increases in anthropogenic 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. 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. The percentage of the total anthropogenic acoustic energy budget added by each LFA source is actually closer to 0.5 percent per system (or less), when other man-made sources are considered (Hildebrand, 2004). 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.

In a recently released report entitled “Ad-Hoc Group on the Impact of Sonar on Cetaceans,” the International Council for the Exploration of the Sea (ICES, 2005) concluded that shipping accounts for more than 75 percent of all human sound in the sea, and sonar amounts to no more than 10 percent or so. It further stated that sonar (noise budget) will probably never exceed 10 percent, but that sonar deployment seems likely to increase in the future.

Therefore, because LFA transmissions will not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from the proposed four SURTASS LFA sonar systems for masking are not a reasonably foreseeable significant adverse impact on marine animals.

Stress

Stress can be defined as a threat to homeostasis[11] (Fair and Becker, 2000) and is frequently measured with changes in blood chemistry (Romano et al., 2004; Smith et al., 2004a). These two last studies examined changes in blood chemistry in response to acoustic stimuli. Smith et al. (2004a) exposed goldfish (a hearing-specialist fish) to continuous background noise of 160-170 dB RL. There was a “transient spike” in blood cortisol levels within 10 minutes of the onset of noise that was loud enough to cause TTS. However, this cortisol spike did not persist and there was no long-term physiological stress reaction in the animals.

[11] Homeostasis is the property of an open system, especially living organisms, to regulate its internal environment to maintain a stable, constant condition, by means of multiple dynamic equilibrium adjustments, controlled by interrelated regulation mechanisms.

Thomas et al. (1990) exposed captive belugas to recorded industrial noise for 30 minutes at a time, with a total exposure of 4.5 hours over 13 days with a source level of 153 dB. Catecholamine blood levels were checked both before and after noise exposure; however, no significant differences in blood chemistry were observed. Another experiment that measured blood chemistry, but also varied the sound level is described in Romano et al. (2004). In this experiment, a beluga was exposed to varying levels of an impulsive signal produced by a watergun. The levels of three stress-related blood hormones (norepinephrine, epinephrine and dopamine) were measured after control, low-level sound (171-181 dB SEL) exposure and high-level (184–187 dB SEL) sound exposure. There were no significant differences between low-level sound exposure and control, while the high-level sound exposure did produce elevated levels for all three hormones. Furthermore, regression analysis demonstrated a linear trend for increased hormone level with sound level.

These data support a linear dose-response function (like the LFA risk continuum) for sound exposure and the onset of stress, with only high levels of sound possibly leading to a stress reaction. The extrapolation of the response thresholds from the Romano et al. (2004) experiment (based on watergun signals) to the LFA situation is tenuous because of the differences in the signals, but the relationship between sound level and stress is supported by several studies. There are some recent data (e.g., Evans, 2003) implicating synergistic effects from multiple stressors, including noise. Although there are no data to support synergistic effects, similar impacts might occur with marine mammals, given the multiple stressors that often occur in their environment. This indicates that while stress in marine animals could possibly be caused by operation of the LFA source, it is likely to be constrained to an area much smaller than the zone of audibility, more similar in size to the mitigation zone around the vessel.

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 (2003) stated that although techniques are being developed to identify indicators of stress in natural populations, determining the contribution of noise exposure to those stress indicators will be very difficult, but important, to pursue in the future when the techniques are fully refined. There are scientific data gaps regarding the potential for LFA to cause stress in marine animals. Even though an animal's exposure to LFA may be more than one time, the intermittent nature of the LFA signal, its low duty cycle, and the fact that both the vessel and animal are moving mean that there is a very small chance that LFA exposure for individual animals and stocks would be repeated over extended periods of time, such as those caused by shipping noise.

Even though there are scientific data gaps concerning stress and marine animals, there is enough known to make an informed decision regarding the proposed action. Because LFA transmissions will not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from stress are not a reasonably foreseeable significant adverse impact on marine animals from exposure to LFA.

Synergistic Effects with Other Oceanic Noise Sources

The potential for synergistic effects of the operation of SURTASS LFA sonar with overlapping sound fields from other anthropogenic sound sources was initially analyzed based on two LFA sources in proximity as discussed in the FOEIS/EIS Subchapter 4.2.7.4, and SEIS Subchapter 4.4.4. 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, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, and duty cycle. In the very unlikely event that this ever occurred, the analysis demonstrated that the "synergistic" sound field generated would be 75 percent or less of the value obtained by adding the results. Therefore, adding the results conservatively bounds the potential effects of employing multiple LFA sources. In the areas where marine mammals would potentially be affected by significant behavioral changes, they would be far enough away that they would discern each LFA sonar as an individual source. Standard operational employment of two SURTASS LFA sonars calls for the vessels to be nominally at least 185 km (100 nm) apart, as analyzed in the FOEIS/EIS Subchapter 4.2.7.4. Moreover, LFA sources would not normally operate in proximity to each other and would be unlikely to transmit in phase as noted above. Based on this and the coastal standoff restriction, it is unlikely that LFA sources, under any circumstances, could produce a sound field so complex that marine animals would not know how to escape it if they desired to do so.

Because of the potential for seismic surveys to interfere with the reception of passive signals and return echoes, SURTASS LFA sonar operations are not expected to be close enough to these activities to have any synergistic effects. Because of the differences between the LFA coherent signal and seismic air gun impulsive "shots," there is little chance of producing a "synergistic" sound field. Marine animals would perceive these two sources of underwater sound differently and any addition of received signals would be insignificant. This situation would present itself only rarely, as LFA testing and training operations have not been, and are not expected to be conducted in proximity to any seismic survey activity.

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.

Therefore, because of major differences in signal characteristics between LFA, MFA, and seismic air guns, there is negligible chance of producing a "synergistic" sound field. It is also unlikely that LFA sources, if operated in proximity to each other would produce a sound field so complex that marine animals would not be able to escape.

4.6.2 Cumulative Impacts 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.

Bycatch

Bycatch is the industry term for the inadvertent capture of non-target species in fishing gear. Besides cetaceans and other marine mammals, sea turtles, seabirds and non-commercial fish species also are regularly caught and killed unintentionally as bycatch. World Wildlife Fund convened a summit of the world's leading cetacean experts in January 2002 in Annapolis, MD, which was attended by 25 scientists from six continents. The group reached consensus that the single biggest threat facing cetaceans worldwide is death as bycatch in fishing gear. More whales die every year by getting entangled in fishing gear than from any other cause. Researchers at Duke University and the University of St. Andrews estimate a global annual average of nearly 308,000 deaths per year—or nearly 1,000 per day (CBRC, 2005). Fishing gear that poses the biggest danger to cetaceans includes: gillnets, set nets, trammel nets, seines, trawling nets and longlines. Because of their low cost and widespread use, gillnets are responsible for a very high proportion of global cetacean bycatch.

Increases in 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. As discussed above, because LFA transmissions are intermittent and will not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from masking by LFA signals are not a reasonably foreseeable significant adverse impact on marine animals from exposure to LFA.

Ship Strikes

Marine mammals are often injured or killed from ship strikes throughout the world. Jensen and Silber (2003) used the best available data to report the known large-whale ship strikes through 2002. However, it is likely that many ship strikes go undetected or unreported each year. For that reason, the number of ship strikes is possibly significantly greater than those reported. There have been 292 reported ship strikes since 1885, with 11 species confirmed to be victims of ship strikes. Of the recorded 292 ship strikes, 48 were known to result in injury and 198 were fatal. In many injury cases, however, the fate of the whale is unknown. The impact to the whale was unknown in 39 reports and 7 incidents report that there appeared to be no sign of injury to the whale (Jensen and Silber, 2003).

Ship strikes are generally not an issue for SURTASS LFA sonar vessels because of their slow operational speed (3 to 5 knots) and transit speed (10 to 12 knots). However, increases in ambient noise levels have the potential to mask an animal's ability to detect approaching vessels, thus increasing their susceptibility to ship strikes. As discussed above, because LFA transmissions are intermittent and will not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from ship strikes due to masking from LFA signals are not a reasonably foreseeable significant adverse impact on marine animals from exposure to LFA.

Authorized Whale Takes

As discussed in subchapter 3.3.1.3, there are authorized whale kills including those for scientific research and subsistence whaling. Based on extensive evaluation in both this document and the FOEIS/EIS, the operation of SURTASS LFA sonar with monitoring and mitigation will result in no lethal takes. Therefore, there are no cumulative impacts in this area due to LFA operations.

Conclusion

Based on extensive evaluation in both this document and the FOEIS/EIS, 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, 2007). Moreover, there has been no new information or data that contradict the FOEIS/EIS finding that the potential effect from SURTASS LFA sonar operations on any stock of marine mammals from injury (non-auditory or permanent loss of hearing) is considered not more than negligible.

As stated in Subchapter 4.6.1 above, LFA transmissions are not expected to have synergistic effects on ambient noise levels, masking, or stress when operated with other anthropogenic noise sources. Therefore, there are no synergistic effects from LFA that would lead to injury or lethal takes of marine animals.

4.6.3 Socioeconomic

Subchapter 4.5 addressed the potential impacts to commercial and recreational fisheries, other recreational activities, and research and exploration activities that could result from implementation of the alternatives under consideration. It was concluded that these activities would not be substantially affected. Therefore, socioeconomic cumulative impacts and synergistic effects are not reasonably foreseeable.

4.6.4 Summary of Cumulative Impacts

The operations of up to four SURTASS LFA sonars were evaluated for the potential for cumulative impacts and synergistic effects in the following foreseeable areas:

- Anthropogenic oceanic noise levels;
- Injury and lethal takes from anthropogenic causes; and
- Socioeconomics.

Given the information provided in this subchapter, the potential for cumulative impacts and synergistic effects from the operations of up to four SURTASS LFA sonars is considered to be small and 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, 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 turtle and marine mammal stocks are exposed. Moreover, SURTASS LFA sonar will cause no lethal takes of marine mammals.

Therefore, cumulative impacts and synergistic effects of the operation of up to four SURTASS LFA sonar systems are not reasonably foreseeable.

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 those that are practical and feasible from a technical and economic standpoint. 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 LFA, 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; Table 1-1; and RTCs 1-1.3, 1-2.1, 1-2.2, and 1-2.3. These were also addressed in the NMFS Final Rule and the ROD (67 FR 48152). 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. It was concluded in the FOEIS/EIS 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 to be practical and/or feasible for technical and economic reasons.

The Court found that, “Defendants’ alternatives analysis is arbitrary and capricious” and that, “…defendants’ second alternative, full deployment with no mitigation or monitoring, is a phantom option. Moreover, plaintiffs have demonstrated that defendants should have considered training in areas that present a reduced risk of harm to marine life and the marine environment when practicable…” The SEIS alternative analysis herein addresses these findings. In particular, the latter Court finding is addressed in Subchapter 2.5.2.1.

This subchapter provides an analysis of the proposed alternatives for the employment of SURTASS LFA sonar, as summarized in Table 4.7-1. In addition to the No Action Alternative, four alternatives were analyzed to address the Court’s findings 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 nm), 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 distance to 46 km (25 nm); and
- Alternative 4—Alternative 1 with additional OBIAs, extended coastal standoff distance to 46 km (25 nm), and shutdown procedures for fish schools.

Table 4.7-1. SURTASS LFA sonar system alternatives matrix.

Proposed Restrictions/ Monitoring	**No Action Alternative**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Dive Sites (RL)	145 dB	145 dB	145 dB	145 dB	145 dB
Coastline Restrictions (RL)	NA	<180 dB at 12 nm	<180 dB at 12 nm	<180 dB at 25 nm	<180 dB at 25 nm
Seasonal Variations	NA	Yes	Yes	Yes	Yes
Original OBIAs	NA	Yes	Yes	Yes [1]	Yes[1]
Additional OBIAs	NA	No	Yes	No	Yes
Shutdown procedures for fish schools	NA	No	No	No	Yes
Visual Monitoring	NA	Yes	Yes	Yes	Yes
Passive Acoustic Monitoring	NA	Yes	Yes	Yes	Yes
Active Acoustic Monitoring	NA	Yes	Yes	Yes	Yes
Reporting	NA	Yes	Yes	Yes	Yes

Note 1: Only those OBIAs, or a portion thereof, which are outside of 46 km (25 nm) are analyzed in Alternatives 3 and 4.

4.7.1 No Action Alternative

Under the No Action Alternative, the SURTASS LFA sonar system would not be deployed. The No Action Alternative would fail to meet the U.S. need for improved capability in detecting quieter and harder-to-find foreign submarines at long range. Thus, U.S. forces would not have adequate time to react to, and defend against, potential submarine threats while maintaining a safe distance from a submarine's effective weapons range. The effects of the No Action Alternative are those effects, going forward, that can be expected if the proposed project is not implemented. Given that the primary detection method for quiet diesel submarines, particularly in the littorals, would still be active sonar, shorter-range tactical sonars would need to compensate for the loss of long-range detection capability afforded by SURTASS LFA sonar. Any attempt to achieve a near-comparable level of security for U.S. and allied ships and the personnel who man them, would require a greater number of tactical sonars (deployed from ships and aircraft). In some cases, this greater number could be somewhat reduced by having the tactical sonar ships and aircraft spend more time at sea (i.e., above standard deployment schedule). However, in all cases the number of ships/aircraft and sonars would be greater than the number of SURTASS LFA sonars required. This, in turn could lead to increased underwater noise, both spatially and temporally, albeit in a different frequency regime (i.e., MF vice LF), so that relevant impacts on marine species could be different. In addition, there would be an increase in fuel consumption and expenditure of energy resources associated with additional ships or increased time at sea, most likely accompanied by an increase of petroleum by-product pollution, and solid and liquid wastes. Thus, there would be environmental impacts resulting from implementation of this alternative.

4.7.2 Alternative 1

Alternative 1 is the same as Alternative 1 of the FOEIS/EIS. This alternative proposes the employment of SURTASS LFA sonar technology with geographical restrictions to include maintaining sound pressure level below 180 dB RL within 22 km (12 nm) of any coastline and within the originally designated OBIAs (see Table 2-3 of the FOEIS/EIS) that are outside of 22 km (12 nm). Restrictions for OBIAs are year-round or seasonal, as dictated by marine animal abundances. SURTASS LFA sonar sound fields will not exceed 145 dB RL 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.

4.7.3 Alternative 2 (the preferred alternative)

Alternative 2 is the Navy’s preferred alternative. It is the same as Alternative 1, but with additional OBIAs (as listed in Table 2-4), including seasonal restrictions.

4.7.4 Alternative 3

Alternative 3 is the same as Alternative 1, but with a greater coastal standoff distance. This alternative proposes the employment of SURTASS LFA sonar technology with geographical restrictions to include maintaining sound pressure levels to below 180 dB RL within 46 km (25 nm) of any coastline and within designated OBIAs that are outside of 46 km (25 nm).

4.7.5 Alternative 4

Alternative 4 is the same as Alternative 1, but with additional OBIAs, extended coastal standoff distance to 46 km (25 nm), and shutdown procedures for schools of fish.

4.7.6 Analysis of Alternatives

This subchapter analyses the above alternatives. The additional criteria that are analyzed here are additional OBIAs, shutdown procedures for fish schools, and increasing the coastal standoff from 22 km (12 nm) to 46 km (25 nm).

Offshore Biologically Important Areas (OBIAs)

The Navy has addressed the Court-defined deficiency regarding additional OBIAs in its preferred alternative, Alternative 2. The additional OBIAs presented in Table 2-4 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.

Shutdown procedures for schools of fish

Recent scientific results from fish controlled exposure experiments (CEEs) 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 harm is negligible (see Subchapter 4.1.1.6). Therefore, based on scientific research, mitigation protocols for fish are not required. Furthermore, these protocols are infeasible and impractical when applied to military readiness and training activities as discussed in Subchapter 2.5.2.2.

Generic Analytical Methodology for Coastal Standoff Range Comparison

Increasing the coastal standoff by 24 km (13 nm) would be more significant in terms of differences in potential impacts to meeting the Navy's stated purpose and need versus potential impacts to the marine environment. Analyses in the FOEIS/EIS and this SEIS support the argument that the highest potential for impact from SURTASS LFA sonar operations is to marine mammals. Accompanying Table 4.7-2 below is a generic analytical methodology to determine the difference in potential impact to marine animals (including fish, sharks, and sea turtles, but particularly for marine mammals) between a 22 km (12 nm) and a 46 km (25 nm) coastal standoff for SURTASS LFA sonar operations.

The methodology used to assess the change in potential impacts to marine animals was designed to utilize several sets of simplified assumptions in order to determine a relative trend in these potential impacts for a variety of oceanic and biological conditions. This approach allows one to assess the trends without the extensive process of modeling all of the conditions that exist.

The first assumption is that the propagation loss from the source is spherical (i.e., 20 Log(range)) for the first 1,000 m (0.54 nm), and cylindrical (i.e., 10 Log(range)) beyond that, regardless of bathymetry or propagation mode. Generally, the spherical spreading assumption is correct and even conservative for water greater than 1,000 m (3,281 ft) deep. For shallower waters, the additional losses due to bottom interactions tend to compensate for the slight overestimation of the spreading loss. The fact that no absorption, volume scattering, or boundary losses are included in this assumption also makes it more conservative. Finally, the likelihood that a surface duct or a convergence zone could negate this propagation assumption is unlikely because if the propagation loss has been slightly underestimated for a specific case, the same conditions will apply to both coastal standoff cases (22 km [12 nm] vs. 46 km [25 nm]). This would have the effect of increasing the representative zone of influence (ZOI) annuluses[12] shown in Figure

[12] The annulus is the horizontal one-dimensional area delineated by two concentric circles representing two different levels of RL (in dB).

4.7-1 and increasing the final percentages in Table 4.7-7. It should be noted that the annulus is the area within and between two ZOIs.

Table 4.7-2. Analytical methodology for comparing potential for impacts on marine animals between 22 km (12 nm) and 46 km (25 nm) coastal standoff ranges.

Step	Action	Reference	Product/Result
1	Determine which SPE values to go forward with for comparing 22 km (12 nm) vs. 46 km (25 nm) standoff range.	FOEIS/EIS Subchap 4.2.3: Definition of Biological Risk and Determination of Risk Function. Fig 4.2-2b: Single Ping Equivalent Risk Function.	FOEIS/EIS analyses indicate 155-180 dB SEL should be addressed; 6 SELs chosen: 155-160, 160-165, 165-170, 170-175, 175-180 and >180 dB.
2	For each of the 6 SPE values determine a ZOI radius, based on average SURTASS LFA sonar operating conditions.	FOEIS/EIS Subchap. 4.2.6: Sample Model Run. Fig 4.2-3: SURTASS LFA sonar Risk Analysis Flowchart.	TL spherical to 1 km, cylindrical beyond 1 km.
3	Assume 3 coastal shelf cases where SURTASS LFA sonar operations could occur: 1. Shelf Case A 2. Shelf Case B 3. Shelf Case C	FOEIS/EIS Subchap 3.1.2.1: Geology and Bottom Topography. Table 3.1-3: Generalized Summary of Oceanic Regimes. Subchap 3.1.3.2: Shallow Water Bottom Interaction.	Shelf Case A: Within <u>5 nm of coast</u> (e.g., Hawaii) Shelf Case B: Within <u>5-20 nm of coast</u> (e.g., Charleston) Shelf Case C: <u>> 20 nm off coast</u> (e.g., Jacksonville, East China Sea)
4	Assume 3 generic biology (i.e., marine mammal) types that SURTASS LFA sonar operations could affect. 1. Shelf Species: Biology Type 1 2. Shelf Break Species: Biology Type 2 3. Pelagic Species: Biology Type 3	SEIS Subchap 3.2.4: Cetaceans (Mysticetes). Table 3.2-3: Information Summary for Mysticetes. Subchap 3.2.5: Cetaceans (Odontocetes). Table 3.2-4: Information Summary for Odontocetes. Subchap 3.2.6: Pinnipeds (Sea Lions, Fur Seals, and Hair Seals). Table 3.2-5: Information Summary for Otariids. Table 3.2-6: Information Summary for Phocids.	1. <u>Shelf species</u>: assume species in this category have abundances/densities $\geq$ 2x same species' abundances/ densities at shelf break, and beyond in deep water. 2. <u>Shelf break species</u>: assume species in this category have abundances/ densities in vicinity of shelf break $\geq$ 2x that on shelf and in deep water. 3. <u>Pelagic species</u>: assume species in this category have abundances/densities beyond the shelf break in deep water $\geq$ 2x that in vicinity of shelf break.
5	For the two cases (12 vs. 25 nm coastal standoff), determine ZOI annulus areas and correct for risk areas: e.g., for 12 nm case, 180 dB annulus will be beyond 12 nm, but the lower RL ZOIs (160-175 dB) will be inside 12 nm and some will be truncated by shallow water/land.	N/A	1. Table for 12 nm coastal standoff case. 2. Table for 25 nm coastal standoff case.
6	For each shelf case and biology type, integrate corrected risk areas to provide: 1. Potential impacts to marine animals for 3 shelf cases vs. 3 biology types; for 12 nm coastal standoff case. 2. Potential impacts to marine animals for 3 shelf cases vs. 3 biology types; for 25 nm coastal standoff case.	N/A	1. Table for 12 nm coastal standoff case. 2. Table for 25 nm coastal standoff case. Note: See Subchapter 4.7.6.1 for a detailed methodology.

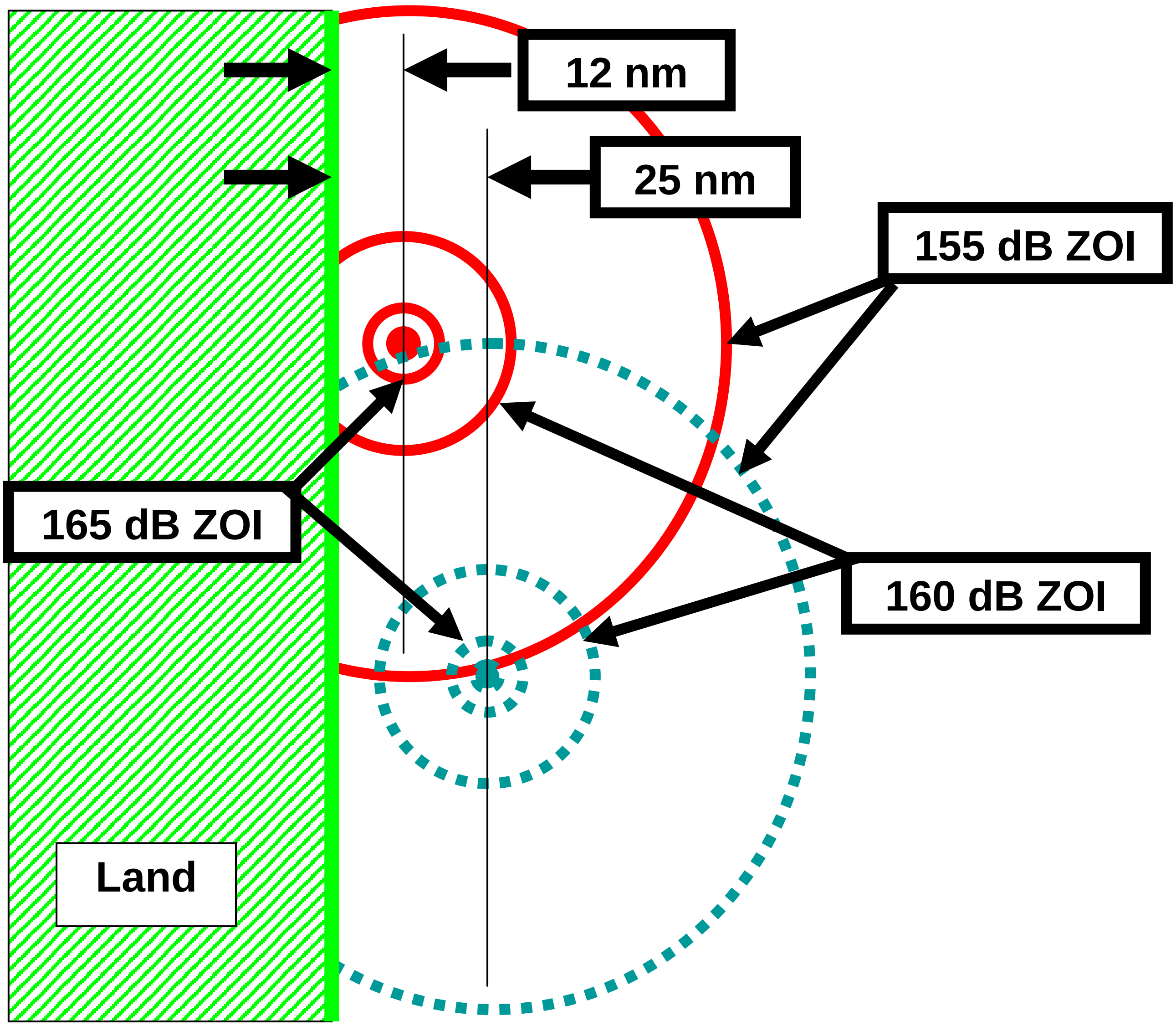


Figure 4.7-1. 12 nm (solid line) versus 25 nm (dotted line) standoff distance from the coast (dB values are SELs).

Tables 4.7-3 and 4.7-4 provide several of the descriptive quantities for each of the ZOI annuluses identified. These annuluses correspond to an approximate area in which an animal receives a single ping equivalent (SPE[13]) exposure to an underwater acoustic signal. Thus, an animal in the outer-most annulus receives an SPE between 155 and 160 dB SEL. For this annulus, the SPE Risk Function curve (FOEIS/EIS Figure 4.2-2B) is used to determine that the SPE risk runs from 0.9 (or 9.0 percent) (for an SPE of 155 dB SEL) to 0.27 (or 27.0 percent) (for an SPE of 160 dB SEL). Moreover, this annulus has been assessed an average risk of 0.18 (or 18.0 percent) (e.g., {(9+27)/2} =18), as shown in Tables 4.7-3 and 4.7-4. These tables also show the area of each annulus that is in the water. When the water area is multiplied by the average risk for that annulus the result is the "corrected risk area," which is also provided in these tables. Once the relative densities of marine animals are qualitatively established and normalized, the corrected risk areas can be multiplied by those densities to determine the "relative risk" in each annulus, and the total relative risk for each source placement (i.e., 22 km [12 nm] vs. 46 km [25 nm] coastal standoff ranges).

Table 4.7-3. ZOI annulus vs. corrected risk area for 22 km (12 nm) coastal standoff case.

ZOI Annulus (SEL)	Water Area (km^2)	Average Risk	Corrected Risk Area
> 180 dB	0.3	100.0	0.3
180-175 dB	2.8	91.5	2.6
175-170 dB	28.3	80.5	22.8
170-165 dB	282.7	61.5	173.9
165-160 dB	2601.2	38.5	1001.5
160-155 dB	17530.1	18.0	3155.4

Table 4.7-4. ZOI annulus vs. corrected risk area for 46 km (25 nm) coastal standoff case.

ZOI Annulus (SEL)	Water Area (km^2)	Average Risk	Corrected Risk Area
> 180 dB	0.3	100.0	0.3
180-175 dB	2.8	91.5	2.6
175-170 dB	28.3	80.5	22.8
170-165 dB	282.7	61.5	173.9
165-160 dB	2827.4	38.5	1088.6
160-155 dB	24033.2	18.0	4326.0

[13] SPE (single ping equivalent) is the methodology used during the acoustic modeling of potential impacts to marine animals from exposure to LF sound. This method estimates the total exposure of each individually modeled animal, which was exposed to multiple sonar pings over an extended period of time. This was accomplished by the summation of the intensities for all received pings into an equivalent exposure from one ping, which is always at a higher level than the highest individual ping received, and is expressed in SEL units (dB re 1 µPa^2-s).

To qualitatively determine relative marine animal densities, two generic quantities need to be identified and approximated. The first of these is the relative width of the continental shelf for possible cases. For this analysis, the shelf is assumed to end at the shelf break, which is defined here as the 200 m (656 ft) bathymetric curve. For simplicity, three shelf cases have been identified. They are:

- Shelf Case A, a narrow shelf; ending at the shelf break within 9.3 km (5 nm) from the coast; a nominal 5 nm shelf break is used in this analysis;
- Shelf Case B, a medium-width shelf, ending at the shelf break within 9.3-37 km (5-20 nm) from the coast; a nominal 28 km (15 nm) shelf break is used in this analysis; and
- Shelf Case C, a wide shelf, ending at the shelf break beyond 37 km (20 nm) from the coast; a nominal 148 km (80 nm) shelf break is used in this analysis.

Figure 4.7-2 graphically represents Shelf Cases A, B and C. Additionally, for simplicity, the shelf slope (i.e., the region from the shelf break to the deep abyssal plane) is assumed to be half as wide as the continental shelf.

The remaining input to qualitatively estimate relative marine animal densities for this analysis is to identify potential bathymetric-based animal behavior and assign relative animal densities for that type of behavior. For the purposes of this analysis, three generic behavior types were identified and used. They are:

- Biology type 1, a shelf species whose habitat is predominantly on the shelf, but may have a lesser density on the continental slope area;
- Biology type 2, a continental shelf break or slope species whose habitat is predominantly in proximity of the shelf break and/or on the slope, but may have a lesser density on half the continental shelf area or the deep water areas adjacent to the slope; and
- Biology type 3, a pelagic species whose habitat is predominantly in deep water, but may have a lesser density on the continental slope area.

Figure 4.7-3 graphically portrays each of the normalized marine animal density regions. Note that in each case the primary location for that species type was assessed a normalized density of 1.0[14] at its primary site, where the majority of animals are expected to be (e.g., Biology type 1, shelf species, have a density of 1.0 on the shelf, etc.), 0.5 (i.e., 0.5 animal/sq km) at secondary areas and 0.0 (i.e., no animals) in all other areas, where the fewest animals are expected to be.

[14] i.e., 1.0 animal/sq km or approximately 4 animals/sq nm, which is an unrealistic animal density but the 1.0 value is optimal for subsequent mathematical calculations

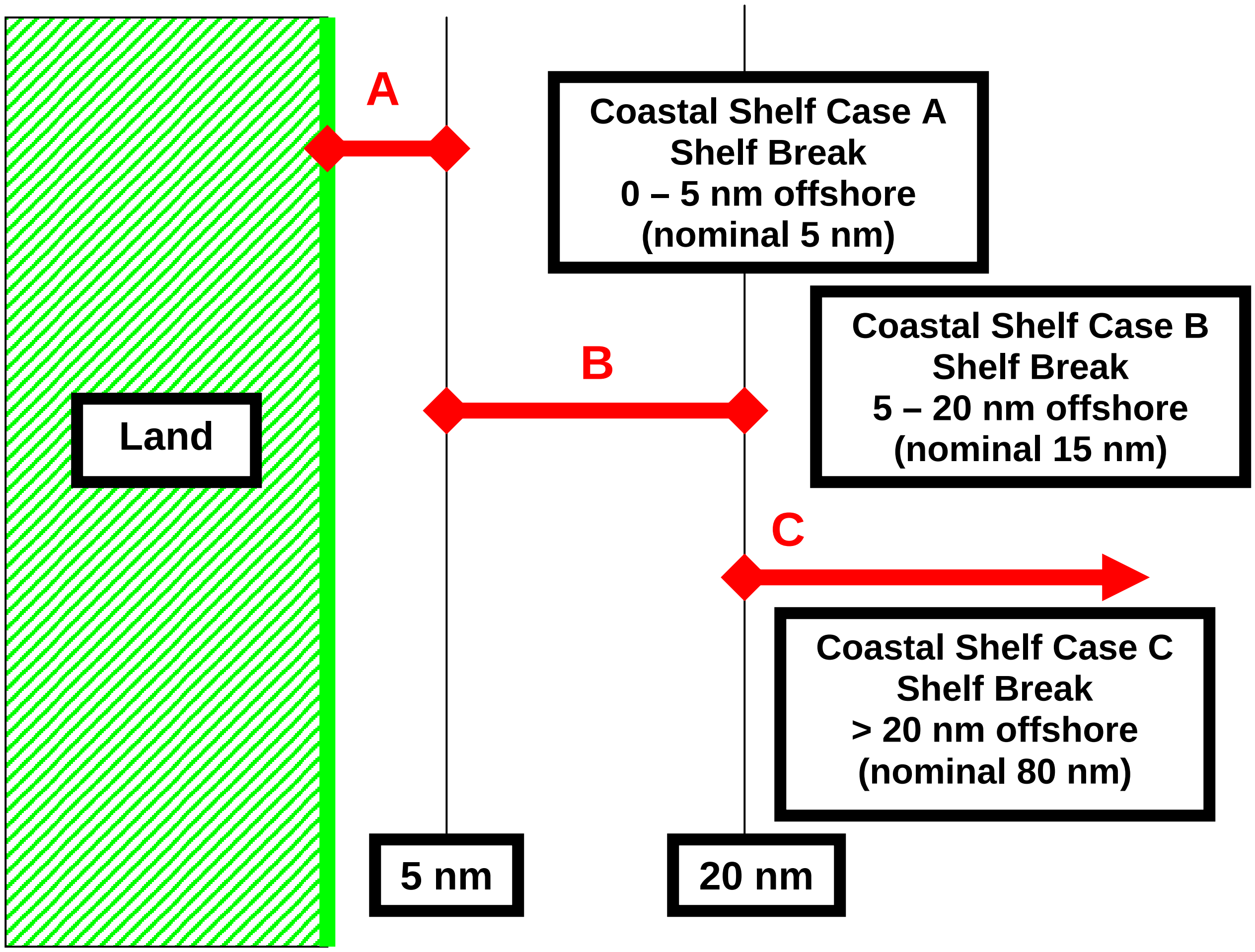


Figure 4.7-2. Coastal Shelf Cases.

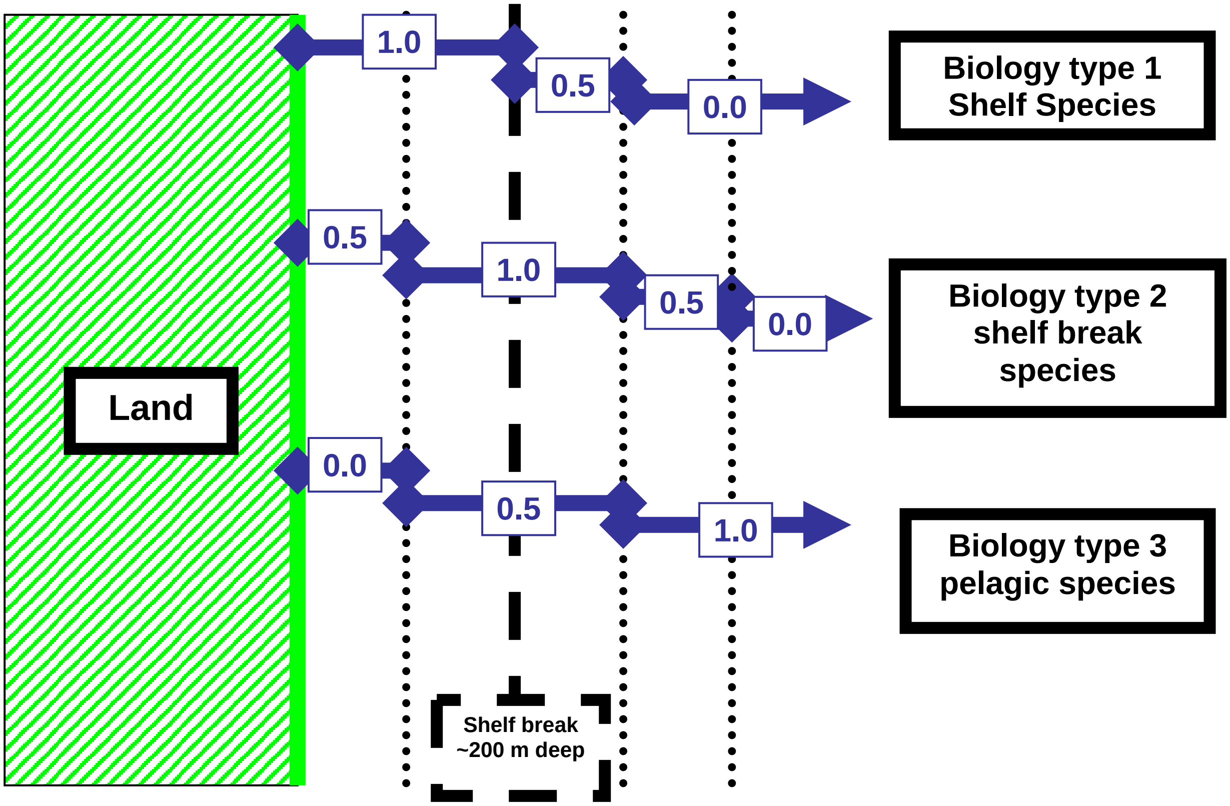


Figure 4.7-3. Normalized density regions for assumed biologic types.

For each of the nine possible combinations of shelf case vs. biology type, the normalized densities of marine animals in each of the six ZOI annuluses can now be identified for each coastal standoff range (22 km [12 nm] vs. 46 km [25 nm]):

a. The percentage of each annulus's area that overlays each normalized density region was determined and multiplied by the appropriate normalized density to get the "relative density";
b. Then for each annulus, the "corrected risk area" of each of the six annuluses (see Tables 4.7-3 and 4) was multiplied by the "relative density" to determine the "relative risk" for each of the six annuluses;
c. The six annulus values were then summed for each of the nine possible combinations of shelf case vs. biology type (see Tables 4.7-5 and 6) for each coastal standoff range option (this summation produces the large relative values in those tables); and
d. The percentage change of the 46 km (25 nm) standoff option over that of the 22 km (12 nm) standoff option is provided in Table 4.7-7.

Table 4.7-5. Total relative risk (corrected risk area multiplied by normalized densities) for 3 shelf cases and 3 biology types; for 22 km (12 nm) coastal standoff case.

		Shelf Case (shelf break range from coast)		
		Within 5 nm (A)	**Within 5-20 nm (B)**	**> 20 nm (C)**
Biology type	**Shelf Species (1)**	762	2,117	4,041
	Shelf Break Species (2)	929	2,224	2,992
	Pelagic Species (3)	3,565	2,687	631

Table 4.7-6. Total relative risk (corrected risk area multiplied by normalized densities) for 3 shelf cases and 3 biology types; for 46 km (25 nm) coastal standoff case.

		Shelf Case (shelf break range from coast)		
		Within 5 nm (A)	**Within 5-20 nm (B)**	**> 20 nm (C)**
Biology type	**Shelf Species (1)**	508	2,118	4,100
	Shelf Break Species (2)	1,146	2,618	4,390
	Pelagic Species (3)	5,165	4,075	1,461

Table 4.7-7. Percent Change in Estimated Risk for the 46 km (25 nm) coastal standoff case (Alternatives 3 and 4, Table 4.7-6) versus the 22 km (12 nm) coastal standoff case (Alternatives 1 and 2, Table 4.7-5).

		Shelf Case (shelf break range from coast)		
		Within 5 nm (A)	**Within 5-20 nm (B)**	**> 20 nm (C)**
Biology type	**Shelf Species (1)**	-33.3 percent	0.1 percent	1.5 percent
	Shelf Break Species (2)	23.4 percent	17.7 percent	46.7 percent
	Pelagic Species (3)	44.9 percent	51.7 percent	131.5 percent

Coastal Standoff Range Comparison Results

Under Alternatives 3 and 4, additional geographical restrictions would be levied on SURTASS LFA sonar operations through the increase in the coastal standoff range from 22 km (12 nm) to 46 km (25 nm). Tables 4.7-5 and 4.7-6 indicate that this change in geographical restrictions only decreases the potential impacts in one out of nine cases, while increasing the potential impacts in six out of nine cases. Thus, for example, increasing the coastal standoff range from 22 km (12 nm) to 46 km (25 nm) decreases the potential impacts to shelf species (Biology type 1) within 9.3 km (5 nm) of the coastline (Shelf Case A) by about 33 percent, but increases potential impacts for all other combinations of Shelf Case and Biology types. This is most apparent for Shelf Case C with Biology type 2, and all Shelf Cases with Biology type 3. These results are summarized in Table 4.7-7. Based on the analysis of the risk areas and the potential impacts to marine animals, increasing the coastal standoff range does decrease exposure to higher received levels for the concentrations of marine animals closest to shore (shelf species [1]); but does so at the expense of increasing exposure levels for shelf break species (2) and pelagic species (3).

4.7.7 Conclusions

The following conclusions are supported by the analyses addressing the operations of up to four SURTASS LFA sonar systems in the FOEIS/EIS, which is incorporated by reference herein; and the supplementary analyses undertaken in this SEIS, which also encompass the at-sea operations of up to four systems.

No Action Alternative

In summary, the No Action Alternative would avoid all environmental effects of employment of SURTASS LFA sonar. It does not, however, support the Navy’s stated priority ASW need for long-range underwater threat detection. The implementation of this alternative would allow potentially hostile submarines to clandestinely threaten U.S. Fleet units and land-based targets. Without this 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.

Alternative 1

Under Alternative 1, as was concluded in the FOEIS/EIS the potential impact 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 and possible indirect impacts to marine mammals due to potential impacts on prey species 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 impact on any stock of fish, sharks or sea turtles from injury is also considered to be negligible, and the effect on the stock of any fish, sharks or sea turtles from significant change in a biologically important behavior is considered to be negligible to minimal. Any auditory masking in fish, sharks or sea turtles is expected to be of minimal significance and, if occurring, would be temporary.

Alternative 2 (the preferred alternative)

Under Alternative 2, additional geographical restrictions would be levied on SURTASS LFA sonar operations through the inclusion of more OBIAs. The general summary provided in the above paragraph for Alternative 1 would also apply to this alternative. Potential impacts to marine animals from SURTASS LFA sonar operations from this alternative would be slightly decreased when compared to Alternative 1 conclusions.

Alternative 3

Under Alternative 3, additional geographical restrictions would be levied on SURTASS LFA sonar operations through the increase in the coastal standoff range from 22 km (12 nm) to 46 km (25 nm). The general summary provided in the above paragraph for Alternative 1 would also apply to this alternative. Based on the analysis of the risk areas and the potential impacts to marine animals, increasing the coastal standoff range does decrease exposure to higher received levels for the concentrations of marine animals closest to shore (shelf species [1]); but does so at the expense of increasing exposure levels for shelf break species (2) and pelagic species (3). The "Coastal Standoff Range Comparison Results" paragraph above discusses this further.

Alternative 4

Under Alternative 4, the additional geographical restrictions of both Alternative 2 (additional OBIAs) and Alternative 3 (increase in coastal standoff range from 22 km [12 nm] to 46 km [25 nm]), plus shutdown procedures for schools of fish would be combined. The general summary provided for Alternative 1 above also applies here, as do the results from Alternative 2 regarding additional OBIAs and Alternative 3 regarding the increased standoff range.

Based on recent controlled exposure experiments on fish (University of Maryland), it was determined that LFA received levels up to 193 dB did not produce injury or mortalities (see Subchapter 4.1.1). Therefore, the opportunity for a fish or a school of fish to be exposed to sound pressure levels from SURTASS LFA transmissions that could cause harm must be considered to be negligible, and mitigation protocols for fish are not required. In the SEIS, Subchapter 2.5.2.2, it was stated that the implementation of fish mitigation procedures was impractical, given that visual monitoring (daylight only) cannot be relied upon to detect fish schools, passive acoustic detection is infeasible, and active acoustics would give so many false alarms that the impact on the effectiveness of the military readiness activity (and, hence impact on National Security) would be very high. Therefore, mitigation for fish is not warranted.

Results Summary

It is important to note that the results of the analysis of Alternative 3, as well as Alternative 4, may at first appear counter-intuitive. The analysis shows that overall there is a greater risk of potential impacts to marine animals with the increase of the coastal standoff distance from 22 km (12 nm) to 46 km (25 nm). This is due to an increase in affected area, as shown in Figure 4.7-1, with less of the ensonified annuluses overlapping land for the 46 km (25 nm) standoff distance than for the 22 km (12 nm) standoff distance. Essentially, by locating the array in waters further from land, nominally the same animal density regions are typically ensonified, but more water area is affected. This is true for all of the examined test cases, except for the shelf area closest to shore (the 5 nm-wide Shelf Case A) with a shelf species (Biology type 1). In this case, the act of moving the source further offshore lowers the received level (i.e., lowers the average risk by placing a lower risk annulus over the shelf) and therefore lowers the potential impact on the shelf where the highest animal densities are, thus lowering the overall impact. Therefore, this does decrease exposure to higher received levels for the concentrations of marine animals closest to shore (shelf species [1]); but does so at the expense of increasing exposure levels for shelf break species (2) and pelagic species (3). It should be emphasized that even though Table 4.7-8 portrays some large percent differences between the 22 km (12 nm) and 46 km (25 nm) coastal standoff ranges, no injury (MMPA Level A harassment) is expected and all potential biologically significant behavioral impacts remain minimal, if not negligible.

Table 4.7-8 provides a qualitative estimate of the ability of each alternative to meet the Navy's purpose and need. Alternative 2 (additional OBIAs) would be expected to decrease to some extent the littoral areas where SURTASS LFA sonar could operate outside of 22 km (12 nm); thus the detection of threats in the littorals and training in the littorals would remain high but may be slightly degraded compared to Alternative 1. Alternatives 3 and 4, the expansion of the coastal standoff range from 22 km (12 nm) to 46 km (25 nm), and the expansion of the coastal standoff range with the additional OBIAs would be expected to impose the greatest impact on meeting the Navy's purpose and need, and military readiness, as a much larger portion of the littorals would be restricted from the conduct of SURTASS LFA sonar operations.

Table 4.7-8. Estimate of ability to meet the Navy's Purpose and Need/Military Readiness/Training for Alternatives 1 through 4.

	Detection of threats in open ocean	Detection of threats in littorals	Training in open ocean	Training in littorals
No Action Alternative	N/A	N/A	N/A	N/A
Alternative 1	H	H	H	H
Alternative 2	H	H	H	H
Alternative 3	H	M/H	H	M/H
Alternative 4	H	M/H	H	M/H

N/A = Does not meet/not applicable
M = Medium level
L = Low level
H = High level

Given the results from the alternatives analysis presented above and Table 4.7-8, the Navy's preferred alternative is Alternative 2.

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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. Four alternatives are presented in Chapter 2 and analyzed in Chapter 4 for the employment of SURTASS LFA sonar that 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 measures presented for the SURTASS LFA sonar are similar to those in the FOEIS/EIS and authorized in the ROD (67 FR 48145). The primary differences are coastal geographic restrictions of both 22 km (12 nm) and 46 km (25 nm), and consideration of additional offshore biologically important areas.

The objective of these mitigation measures is to avoid risk of injury to marine mammals, sea turtles, and human divers. This objective is met by:

- Ensuring that coastal waters within 22 km (12 nm) or 46 km (25 nm) of shore, depending on the determination made in the ROD, are not exposed to SURTASS LFA sonar signal levels ≥ 180 dB RL;
- Ensuring that no offshore biologically important areas are exposed to SURTASS LFA sonar signal levels ≥ 180 dB RL during critical seasons;
- Minimizing exposure of marine mammals and sea turtles to SURTASS LFA sonar signal levels below 180 dB RL by monitoring for their presence and suspending transmissions when one of these organisms enters this zone; and
- Ensuring that no known recreational or commercial dive sites are subjected to LF sound pressure levels greater than 145 dB RL.

Strict adherence to these measures should ensure that there will be no significant impact on marine mammal stocks, sea turtle stocks, and recreational or commercial divers.

5.1 Geographic Restrictions

The following geographic restrictions apply to the employment of SURTASS LFA sonar:

- SURTASS LFA sonar-generated sound field would be below 180 dB RL within 22 km (12 nm) or 46 km (25 nm), depending on the determination made in the ROD, of any coastlines and in offshore areas outside this zone that have been determined by NMFS and the Navy to be biologically important;
- When in the vicinity of known recreational or commercial dive sites, SURTASS LFA sonar would be operated such that the sound fields at those sites would not exceed 145 dB RL; and
- SURTASS LFA sonar operators would estimate 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 the 180-dB and 145-dB RL sound field criteria cited above.

5.1.1 Offshore Biologically Important Areas

There are certain areas of the world's oceans that are biologically important to marine mammals and sea turtles as determined in the ROD. 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 180 dB RL within 22 km (12 nm) (or 46 km [25 nm]) of any coastline and in any designated offshore biologically important areas that are outside these zones during the biologically important season for that particular area. The 22 km (12 nm) or 46 km (25 nm) restriction, depending on the determination made in the ROD, includes many marine-related critical habitats and sanctuaries (e.g., Hawaiian Islands Humpback Whale National Marine Sanctuary). The SURTASS LFA sonar sound field would be estimated in accordance with the guidelines in Subchapter 5.1.3 of the SEIS.

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 145 dB RL. Recreational dive sites are generally defined as coastal 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 in Subchapter 5.1.3 of the SEIS.

5.1.3 Sound Field Modeling

SURTASS LFA sonar operators estimate SPLs 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 the sound field criteria cited in Subchapter 5.1 of this SEIS.

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 listed in Subchapter 5.1 were exceeded, the sonar operator would notify the 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.

5.2 Monitoring to Prevent Injury to Marine Animals

The following monitoring to prevent injury to marine animals is required when employing SURTASS LFA sonar:

- **Visual monitoring** for marine mammals and sea turtles from the vessel during daylight hours by personnel trained to detect and identify marine mammals and sea turtles;
- **Passive acoustic monitoring** using the passive (low frequency) SURTASS 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.

5.2.1 Visual Monitoring

Visual monitoring includes daytime observations for marine mammals and sea turtles from the vessel. Daytime is defined as 30 min before sunrise until 30 min after sunset. Visual monitoring begins 30 min before sunrise or 30 min before the SURTASS LFA sonar is deployed. Monitoring continues until 30 min 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.

These 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 of the LFA mitigation zone, the observer notifies the OIC. The 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, the OIC orders the delay or suspension of SURTASS LFA sonar transmissions when the animal enters the LFA mitigation zone. If the animal is visually observed within 2 km (1.1 nm) and 45 degrees either side of the bow, the OIC orders the immediate delay or suspension of SURTASS LFA sonar transmissions. 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, the observer notifies the 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 Long Term Monitoring (LTM) Program as discussed in FOEIS/EIS Subchapter 2.4.2 to monitor for potential long-term environmental effects.

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 OIC who alerts the HF/M3 sonar operator and visual observers. If prior to or during transmissions, the OIC then orders the delay or suspension of SURTASS LFA sonar transmissions when the animal enters the LFA mitigation zone.

All contacts are recorded in the log and provided as part of the LTM Program to monitor for potential long-term environmental effects.

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 min 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 min from 180 dB SL in 10-dB increments until full power (if required) is attained to ensure that there are no inadvertent exposures of local animals to RLs $\geq$ 180 dB 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, 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, the sonar operator notifies the OIC. The OIC then orders the delay or suspension of transmissions when the animal is predicted to enter the LFA mitigation zone.

Second, if a contact is detected by the HF/M3 sonar within the LFA mitigation zone, the observer notifies the 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 min 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.

5.3 Summary of Mitigation

Table 5-1 is a summary of the proposed mitigation, the criteria for each, and the actions required.

Table 5-1. Summary of Mitigation

Mitigation	Criteria	Actions
Geographic Restrictions		
22 km (12 nm) or 46 km (25 nm), depending on the determination made in the Record of Decision, from coastline and offshore biologically important areas during biologically important seasons outside of 22 km (12 nm) or 46 km (25 nm)	Sound field below 180 dB RL, based on SPL modeling.	Delay/suspend SURTASS LFA sonar operations.
Recreational and commercial dive sites[1]	Sound field not to exceed 145 dB RL, based on SPL modeling.	Delay/suspend SURTASS LFA sonar operations.
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.	Notify OIC.
	Potentially affected species sighted within 2 km (1.1 nm) and 45 degrees either side of the bow or inside of the LFA mitigation zone.	Delay/suspend SURTASS LFA sonar operations.
Passive Acoustic Monitoring	Potentially affected species detected.	Notify OIC.
Active Acoustic Monitoring	Contact detected and determined to have a track that would pass within the LFA mitigation zone.	Notify OIC.
	Potentially affected species detected inside of the LFA mitigation zone.	Delay/suspend SURTASS LFA sonar operations.
Notes: 1. Recreational dive sites are generally defined as coastal areas from the shoreline out to the 40-m (130-ft) depth contour.		

5.4 Evaluation of the Use of Small Boats and Aircraft for Pre-operational Surveys

In its Opinion and Order of 26 August 2003, the Court found that the defendants failed to assess the use of aerial surveys or observation vessels for LFA sonar missions operated close to shore. The Court did not define the term "close to shore," and did not include this requirement in the tailored Permanent Injunction issued on 14 October 2003, which incorporated a stand-off distance of 30 nm (55.6 km). As discussed in Subchapter 1.2.2 of this SEIS, the National Defense Authorization Act for Fiscal Year 2004 (NDAA, 2004) was passed by Congress as HR 1588 and signed into law on 24 November 2003. Several of the provisions of NDAA 2004 concerned revisions to the Marine Mammal Protection Act as they relate to military readiness activities. These revisions to the MMPA did not eliminate the requirement for mitigation and monitoring, but emphasized that mitigation and monitoring decisions should take into account safety, practicality of implementation, and impact on effectiveness of the military readiness activity.

In the evaluation of the feasibility of conducting pre-operational aerial and small craft surveys, the following assumptions were made:

- Surveys would be for areas outside of the 2-km (1.08 nm) mitigation and buffer zones.
- Survey objectives would be to identify unexpected areas of high marine mammal density—primary survey effort would be between ship and shore, where highest densities of marine mammals would be expected.
- Surveys would not be conducted during LFA operations and there would be no post-operational surveys.
- Surveys would occur only during daylight hours, weather permitting.
- Aircraft would only fly under visual flight rules (VFR) conditions (i.e., in good visibility, as opposed to instrument flight rules (IFR) wherein the pilot is allowed to fly in poor visibility by using his instruments to navigate.
- Aircraft would fly a maximum of 100 nm from its home airfield.
- Small boat would only be used in Beaufort Sea State (SS) 3 or less (Beaufort SS3 = 7-10 knots sustained wind; maximum wave height 0.6 m, 2.0 ft). This limitation is primarily because the survey small boat would be launched from the SURTASS LFA vessel, all of which have very high freeboard (distance between waterline and main deck).
- Small boat would remain in visual range of the SURTASS LFA vessel.
- Surveys would be conducted by a single aircraft or single small boat.
- Aircraft would be of the standard type used for visual surveys (not military aircraft), but would stage from U.S. military airfields when SURTASS LFA operations are off a foreign coast. LFA vessels generally do not operate with other fleet assets, so naval aircraft would normally not be available.

Small Craft

The following factors were considered in the evaluation of the use of a small craft for pre-operational marine mammal surveys:

- Safety: Because of the configuration of all SURTASS LFA vessels (very high freeboard), it is difficult to launch a small boat at sea. It is considered that it would be unsafe to launch and operate a small boat from a SURTASS LFA ship at sea in seas greater than Beaufort SS3.
- Impacts to Marine Mammals: In order to survey an area for marine mammals, the small boat would have to traverse the area frequently, at relatively high speed, which may subject any marine mammals in the area to additional anthropogenic noise.
- Scientific Research Program (SRP): The surveys utilized in the SRP cannot be compared to the type of surveys believed to be envisioned by the Court. These surveys were effective because they were conducted either from shore stations or very close to shore (in some cases 1 to 2 nm, 1.85 to 3.70 km) and in areas of known concentrations of marine mammals. These surveys were permitted under NMFS permit #875-1401.
- Ineffectiveness: Large-area survey from a small boat will not be effective because:
    - There is limited horizontal, visual range from craft at water level.
    - Green and Green (1990) reported that humpback whales' reactions to approaching and departing boats included altering their behavior by often reducing the proportional amount of time on the surface, taking longer dives, altering direction, and spending more time underwater. This could potentially make them more difficult to see.

Aerial Surveys

The following factors were considered in the evaluation of the use of an aircraft for pre-operational marine mammal survey:

- Safety: Aerial surveys can be hazardous, particularly since they are often conducted at low altitudes and over open water. In 2002, four people died when their aerial observation plane crashed off the coast of Florida. They were conducting visual surveys for northern right whales for the New England Aquarium. Subsequently, all visual survey aircraft were grounded until the investigation into the mishap was concluded. New regulations require a co-pilot on all aerial survey flights; this and other new requirements have increased the costs markedly.
- The above loss of life, and the growing evidence that passive acoustics yields more and better data on vocalizing marine mammals, has convinced NOAA to invest more heavily in passive acoustic data collection, particularly for those marine mammals that spend little time on the surface.
- Equipment and personnel: The appropriate civilian aircraft would need to be leased in advance, and include pilot and co-pilot and two aircraft-qualified visual observers. The formation of this "team" would also require that they be able to communicate with the SURTASS LFA vessel and provide a written post-flight report.

- Airfield proximity: The distances from the closest U.S. military airfield to a SURTASS LFA operating area off a foreign coast could be significant. This factor would make these kinds of surveys more expensive, logistically difficult and probably more dangerous (particularly if there is no divert field near the operating area).
- Logical option: Given the time, effort and expense to carry this out, it would be more meaningful and logical to carry out a scientifically-based research survey effort under the Long Term Monitoring/Research Program. This would be for an area where LFA operations are expected to occur and there is a paucity of marine mammal distribution and density data available.
- SURTASS LFA vessels' aircraft capabilities: None of the SURTASS LFA vessels are designed to support aircraft (helicopter) operations.
- Effectiveness of aerial surveys is diminished by high sea states, low visibility, and diving habits of the specific animal.
- Impacts of aerial surveys: Marine mammals may be harassed by low-flying aircraft.

Summary

As demonstrated above, small boat and pre-operational aerial surveys for SURTASS LFA operations are not feasible because they are not practicable, not effective, may increase the harassment of marine mammals, and are not safe to the human performers. Therefore, under the revisions to the MMPA by the NDAA FY04, pre-operational surveys are not considered as a viable mitigation option.

In its comments on the Draft SEIS, the Marine Mammal Commission stated that small boat or aerial surveys immediately before and during SURTASS LFA sonar operations in the various offshore training areas would not be a practical mitigation option (see Subchapter 10.3.3 RTC 5.4.1).

6 RELATIONSHIP OF THE PROPOSED ACTION TO FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

Operation of the SURTASS LFA sonar system complies with all applicable federal, state, regional, and local laws and regulations. The following environmental statutes have been considered in addition to those reviewed in the FEIS:

- National Defense Authorization Act;
- Interjurisdictional Fisheries Act;
- Executive Order 13158: Marine Protected Areas;
- Oceans Act of 2000;
- Executive Order 13178: Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; and
- Executive Order 13196: Final Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve.

6.1 National Defense Authorization Act

In order 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 and training operations that are the subject of NMFS’s July 16, 2002, Final Rule constitute a military readiness activity 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 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.

- Amended definition of "harassment" as it applies to military readiness activities and 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[1].
- NMFS's 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 amended definition of "harassment" focuses authorization of military readiness and scientific research activities on biologically significant impacts to marine mammals, a science-based approach.

These revisions to the MMPA do not eliminate the requirement for mitigation and monitoring. The Navy still must operate under the Final Rule and is required to obtain annual LOAs from NMFS for each vessel. Congress also commended DoD and the Navy for their extensive marine mammal research, but directed an annual report be provided to Congress on research conducted and accompanying funding to ensure a continued level of effort of at least $7 million per year.

6.2 Interjurisdictional Fisheries Act

The Interjurisdictional Fisheries Act of 1986 provides for the management of interjurisdictional commercial fisheries. It promotes state activities in support of the management of interjurisdictional fishery resources and promotes the management of fishery resources throughout their range. The Interjurisdictional Fisheries Act applies to the individual states in the same manner that the Magnuson-Stevens Fisheries Conservation and Management Act applies to the Nation. The operation of the SURTASS LFA sonar system does not involve the alteration of essential fish habitats or reduce the productive capacity of any fish stock. Therefore, the Act is not applicable.

6.3 Executive Order 13158

Executive Order (EO) 13158, "Marine Protected Areas," protects the significant natural and cultural resources within the marine environment for the benefit of present and future

[1] On 31 June 2006 and 23 June 2007, the Deputy Secretary of Defense invoked the national defense exemption under the MMPA for certain mid-frequency sonar activities. Neither of these national defense exemptions apply to SURTASS LFA sonar employment as detailed in this SEIS.

generations by strengthening and expanding the Nation's system of marine protected areas (MPAs). Because the SURTASS LFA sonar system is not operated less than 22 km (12 nm) from any coastline, including offshore islands or biologically important areas. Marine Protected Areas should not be affected by SURTASS LFA sonar system operations.

6.4 Oceans Act of 2000

The Oceans Act of 2000 created the Commission on Ocean Policy to make recommendations for coordinated and comprehensive national ocean policy that would promote:

- the protection of life and property against natural and manmade hazards;
- responsible stewardship;
- the protection of the marine environment and prevention of marine pollution;
- the enhancement of marine-related commerce and transportation;
- the expansion of human knowledge of the marine environment;
- the continued investment in and, development and improvement of the capabilities, performance, use, and efficiency of technologies for use in ocean and coastal activities; and
- close cooperation among all government agencies and departments, and the private sector.

On December 17, 2004, the Commission on Ocean Policy published the U.S. Ocean Action Plan highlighting short-term and long-term goals, such as establishing a new cabinet-level Committee on Ocean Policy, working with regional fisheries councils to promote greater use of market-based systems for fisheries management and developing an ocean research priorities plan and implementation strategy. The Oceans Act of 2000 has no effect on the SURTASS LFA sonar system operations.

6.5 Executive Order 13178

EO 13178, "Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve," provides a strong and lasting protection for the coral reef ecosystem of the Northwestern Hawaiian Islands. The Secretaries of Commerce and the Interior are directed to work with the State of Hawaii and consult with the Western Pacific Fishery Management Council to develop recommendations for a new, coordinated management regime to increase protection of the coral reef ecosystem of the Northwestern Hawaiian Islands and provide for sustainable use of the area. The SURTASS LFA sonar system is not operated less than 22 km (12 nm) from any coastline, including offshore islands or biologically important areas. The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve will not be affected by the SURTASS LFA sonar system operations.

6.6 Executive Order 13196

EO 13196, "Final Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve," permanently establishes the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve with modifications. Included in these modifications are that current levels of fishing effort and take shall be capped and regulated. The Secretary of Commerce will manage the Reserve pursuant to Executive Order 13178, as modified by this order, under the Act. The Secretary shall also initiate the process to designate the Reserve as a National Marine Sanctuary, as required by the Act. The SURTASS LFA sonar system is not operated less than 22 km (12 nm) from any coastline, including offshore islands or biologically important areas. The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve will not be affected by the SURTASS LFA sonar system operations.

6.7 The Northwestern Hawaiian Islands Marine National Monument

In June 2006, the Northwestern Hawaiian Islands Marine National Monument was created by Presidential proclamation. This national monument will encompass nearly 140,000 square miles of the Northwestern Hawaiian Islands. The national monument will:

- Preserve access for Native Hawaiian cultural activities;
- Provide for carefully regulated educational and scientific activities;
- Enhance visitation in a special area around Midway Island;
- Prohibit unauthorized access to the monument;
- Phase out commercial fishing over a five-year period; and
- Ban other types of resource extraction and dumping of waste.

It is more than 100 times larger than Yosemite National Park, larger than 46 of our 50 states, and more than seven times larger than all our National Marine Sanctuaries combined.

The monument will preserve access for native Hawaiian cultural activities. Within the boundaries of the monument, unauthorized passage of ships, unauthorized recreational or commercial activity, and any extraction of coral, wildlife, minerals, and other resources, or dumping of waste is prohibited.

7 UNAVOIDABLE ADVERSE IMPACTS

There have been no significant changes to the knowledge or understanding in adverse impacts. The information in Chapter 7 (Unavoidable Adverse Impacts) of the FOEIS/EIS remains valid, and its contents are incorporated by reference.

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8 RELATIONSHIP BETWEEN SHORT TERM USES OF MAN'S ENVIRONMENT AND THE ENHANCEMENT OF LONG-TERM PRODUCTIVITY

There have been no significant changes to the knowledge or understanding in the short term uses of the environment. The information in Chapter 8 (Relationship Between Short Term Uses of Man's Environment and the Enhancement of Long-Term Productivity) of the FOEIS/EIS remains valid, and its contents are incorporated by reference.

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9 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

There have been no significant changes to the knowledge or understanding in the commitments of resources. The information in Chapter 9 (Irreversible and Irretrievable Commitments of Resources) of the FOEIS/EIS remains valid, and its contents are incorporated by reference.

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10 PUBLIC REVIEW PROCESS AND RESPONSE TO COMMENTS

Public involvement in the review of draft supplemental environmental impact statements (Draft SEISs) is stipulated in 40 CFR Part 1503 of the Council on Environmental Quality's (CEQ) regulations implementing the National Environmental Policy Review Act (NEPA) and in OPNAVINST 5090.1B. These regulations and guidance provide for active solicitation of public comment via the public comment periods and public hearings. This chapter has been prepared to document the public involvement process in preparation of the EIS. This chapter also presents the response to questions and comments raised by individual commenters during the public comment period on the Draft SEIS.

10.1 Public Review Process

The Notice of Intent (NOI) for this project was published in the *Federal Register* on July 28, 2003 (FR Vol. 68 No. 144). It broadly described the decision to prepare a supplemental analysis to provide additional information regarding the environment that could be potentially affected by employment of SURTASS LFA sonar and additional information related to mitigation of the potential impacts of the system.

10.1.1 Filing and Distribution of the Draft SEIS

Commencing in November 2005, copies of the Draft SEIS were distributed to agencies and officials of federal, state, and local governments, citizen groups and associations, and other interested parties. Copies of the Draft SEIS were made available for review at seventeen public libraries located in many coastal states including Hawaii. Copies of the SURTASS LFA Sonar Draft SEIS were made available for review at seventeen public libraries located in many coastal states including Hawaii. Copies were also available via the SURTASS LFA Sonar Internet website (http://www.surtass-lfa-eis.com).

10.1.2 Public Review Period and Public Hearings

The public review period was originally scheduled to end on December 27, 2005, but due to numerous requests from both individuals and organizations was extended to receive written comments up to and including February 10, 2006 (FR Vol. 70 No. 248).

During this period, public hearings were held as follows:

- December 1st in Washington, DC;
- December 3rd in San Diego, CA; and
- December 5th in Honolulu, HI.

Notifications for the public hearings were published in the *Federal Register* on November 16, 2005 (FR Vol. 70 No. 220) and in local newspapers. The hearings were conducted in accordance with NEPA requirements and comments were recorded by a stenographer. Transcripts of the hearings are in Volume 2 of the Final SEIS.

10.2 Receipt of Comments

Comments on the Draft SEIS were received in the following forms: letters, written statements delivered at the public hearings, oral statements made at the public hearings, written statements received via facsimile and e-mail correspondence. Written and oral comments were received from 97 commenters, including federal, state, regional, and local agencies, groups and associations, and private individuals. Comments postmarked by February 10, 2005, or received via facsimile, voice mail, or e-mail on February 10, 2005, were reviewed and are considered in this chapter.

10.2.1 Identification of Comments

The Navy received 97 comments and no petitions during the public comment period, which ended on February 10, 2006. In addition, no statements were presented at the December 1, 2005, public hearing in Washington, DC; 3 statements were presented at the December 3, 2005, public hearing in San Diego, CA; and 11 statements were presented at the December 5, 2005, public hearing in Honolulu, HI.

Each comment or statement received was assigned one of the following letter codes:

G	State and Federal agencies and officials
C	Congresspersons
O	Organizations and associations
I	Individuals

These labels were assigned for the convenience of readers and to assist the organization of this document; priority or special treatment was neither intended nor given in the responses to comments. Within each of the categories, each comment or statement was then assigned a number, in the order it was received and processed (e.g., G-001).

All comments received were categorized into broad issues based on the organization of the SEIS. These issues were further subdivided into more specific comments/questions. Responses to these comments/questions were then drafted and reviewed for scientific and technical accuracy and completeness. The Navy’s responses also identify cases in which a specific comment generated a revision to the Draft SEIS (denoted by underlined text), or when the existing text of the SURTASS LFA Sonar Final SEIS and/or Final OEIS/EIS is deemed an adequate response to a comment, the appropriate chapter, subchapter, and/or appendix is identified.

10.2.2 Comments Submitted

Comment submissions have been included in Volume 2 to this Final SEIS. The alphanumeric code associated with each written submission is marked at the top of each page of the letter. Comment letters or statements are reprinted in numerical order.

Written hearing transcripts are provided in Volume 2.

Tables 10-1 thought 10-3 present lists of commenters. Subchapter 10.3 provides detailed responses to the comments received.

Table 10-1. Congresspersons and Federal/State/Local Agencies

Organization	Commenter Number
Fisheries and Oceans Canada	G-005
Marine Mammal Commission	G-002
Marine Mammal Commission	G-008
National Oceanic and Atmospheric Administration	G-003
State of California - California Coastal Commission	G-001
State of Maine - Maine State Planning Office	G-006
US Congress - Rep. Michael Michaud	C-001
US Department of Interior	G-007
US Environmental Protection Agency	G-004

Table 10-2. Organizations and Associations

Organization	Commenter Number
Animal Welfare Institute	O-004
Animal Welfare Institute	O-013
Citizens Opposing Active Sonar Threats	O-008
Earth Island Institute	O-005
Earth Island Institute	O-006
Earth Island Institute	O-011
Friends of Santa Clara River	O-007
Green Party of Hawai'i	O-002
The Hawaiian Kingdom	O-003
National Resources Defense Council (NRDC)	O-001
New York Whale and Dolphin Action League (Taffy Lee Williams)	O-015
NRDC (with CD attachment of works cited)	O-014
Ocean Mammal Institute/International Ocean Noise Coalition	O-010
Seattle Aquarium Society	O-009
Sierra Club	O-012

Table 10-3. Individual Commenters

Commenter Name	Commenter Number
Aaron (Manor School class)	I-050
Aila, Pansy	I-007
April (Manor School class)	I-035
Ari (Manor School class)	I-041
Botwin, Wendy	I-060
Boyle, Karen (RN)	I-003
Browe, Courtney	I-070
Charlotte (Manor School class)	I-042
Christian (Manor School class)	I-046
Crabill, Robert E.	I-074
Cronin, Marc	I-015
Dashu, Max	I-056
Diana (Manor School class)	I-047
Dziak, John	I-030
Eagle, Kathleen	I-066
Eagle, Wesley	I-063
Ellenby, John	I-022
Ellis, Dulanie	I-019
Emma (Manor School class)	I-040
Friedman, Debbie and Paul Kelby	I-016
Gibbs, Ashley Eagle	I-062
Gibbs, Thomas	I-067
Goodman, Janet	I-069
Gray, Sylvia Ruth	I-024
Grunther, Doug	I-059

Commenter Name	Commenter Number
Guzman, Piedad	I-012
Honda, Laura Dax (Manor School class)	I-033
Hubacker, Peggy Kala	I-010
Hurley, Gail	I-065
Husband, Ariana	I-052
Jack (Manor School class)	I-051
Jasper, Marilyn	I-025
Julia (Manor School class)	I-036
Klein, Wendy	I-053
Leonard, Gordana	I-028
Levine, Jodi	I-017
Louise (Manor School class)	I-043
Lundy, Dee	I-073
Maas, Mila	I-054
Magill, Cheryl	I-072
Mainland, Edward	I-027
Marcus, Lucy	I-023
Martin (Manor School class)	I-048
Max (Manor School class)	I-037
McMillan, Jeff	I-026
Murray, Jay	I-021
Olivia (Manor School class)	I-049
Parsons, Chris (PhD)	I-058
Petta, Janic	I-031
Plaster, Deane	I-057
Public, Jean	I-001
Rassmussen, Pat	I-018

Commenter Name	Commenter Number
Reed	I-071
Reinz, R. (PhD)	I-068
Salem (Manor School class)	I-044
Sara (Manor School class)	I-045
Schmidt, Robert	I-029
Selena (Manor School class)	I-038
Sinclair, Scott	I-020
Sinkin, Lanny	I-004
Stewart, Kay	I-002
Taylor (Manor School class)	I-039
Trent (Manor School class)	I-034
Wardell, Merrie B. (Rev)	I-055
Weilgart, Lindy (PhD)	I-011
Weintraub, Rona	I-064
Weis, Laura	I-061
Weiss, Valerie	I-008
Wheeler, Jeanne	I-014
White, Sean	I-032
Williams, Craig	I-013
Williams, Taffy Lee	I-009
Wray, Russel	I-006

10.3 Detailed Responses To Comments

This subchapter presents the detailed response to comments made by commenters on the Draft SEIS for SURTASS LFA Sonar (DON, 2005c). Detailed responses will be provided on comments directly relating to the continuing employment of SURTASS LFA sonar systems. Comments on other anthropogenic sound sources, such as tactical mid-frequency sonars and seismic surveys, will be responded to only as they relate to LFA. Underlined text represents changes made to the specific subchapters of the Final SEIS.

CHAPTER 1 PURPOSE AND NEED

ISSUE 1.1 Purpose and Need for Proposed Action

Comment 1.1.1: Does the U.S. play a role in the proliferation of subs? Has the U.S. Government ever been involved in supplying these submarines or the technology to produce them to other nations? O-008

Response: No, because nuclear submarines are larger, more expensive, and harder to operate and maintain, and because many countries do not have personnel able to operate a nuclear reactor, the majority of submarines being manufactured and sold are diesel-electric powered. The U.S. does not currently build diesel submarines. European countries such as France, Germany, Sweden, and Russia, as well as China and other non-European countries, produce diesel submarines and are currently working to produce quieter-running, more effective submarine models (Moltz, 2006). Two of the more popular models are the German-built Type 209 and 214, which have been sold to numerous southeast Asian and South American nations, as well as South Africa, Greece, Turkey, and others (Global Security Website, 2006; Naval Technology Website, 2006). Also, following the end of the Cold War, the Russian Navy sold off a large number of submarines in an effort to obtain much-needed funds. China also has sold a number of older submarines to countries, including North Korea. Many of these submarine sales involve not only the transfer of the vessel, but also of the production equipment and construction know-how (Revelle and Lumpe, 1994).

See Subchapter 1.1.1 of the SURTASS LFA Sonar FOEIS/EIS (DON, 2001) and Subchapter 1.1.1 and 1.1.2 of the SEIS.

Comment 1.1.2 Need for LFAS is not adequately discussed in the Draft SEIS. Under NEPA the Draft SEIS is required to explain the underlying need for the sonar and explore and evaluate reasonable alternatives. Navy must address need and offer safer alternatives to public. O-010

Response: The SEIS is not an independent document, but is a supplement to the FOEIS/EIS. As stated in the SEIS Preface (p. P-3), the information in the FOEIS/EIS remains valid, except as noted or modified in the SEIS. The contents of the FOEIS/EIS are incorporated into the SEIS by reference, except as noted or modified. See Subchapter 1.1 of FOEIS/EIS and Subchapter 1.1 of the SEIS for a discussion of the Navy need for LFA, and Subchapters 1.2.1 and 1.2.2 of the FOEIS/EIS for a discussion of non-acoustic detection alternatives.

Comment 1.1.3: Draft SEIS must go beyond identifying the need for LFA; it must meaningfully address the long-term potential of the proposed project to effectively address that need. O-014

Response: This need is adequately explained in the FOEIS/EIS and elaborated on in the SEIS. Due to improving submarine technology, these craft are becoming increasingly quiet, reducing the strategic effectiveness of passive sonar systems alone. Because LFA technology involves active sonar, it is the best technology available for the foreseeable future to adequately meet this threat. See Subchapter 1.1 of the FOEIS/EIS and SEIS Subchapter 1.1 for additional information.

Comment 1.1.4: The SEIS still does not address the use of SURTASS LFA during conditions in armed conflict or direct combat support operations, or during periods of heightened threat conditions. I-012, I-018, I-027, O-002, O-005

Response: Such potential threats are beyond the scope of this document.

Comment 1.1.5: During periods of “armed conflict etc….” the Navy will operate LFA sonar without any limitations or mitigation whatsoever. O-012

Response: See SEIS RTC 1.1.4 above.

Comment 1.1.6: Navy is proposing to increase the number of naval vessels with LFA from two to four and operate them on a world-wide basis. I-017, I-018, I-028, I-029, O-001, O-004, O-011, O-012, O-013

Response: The Navy is not proposing to increase the number of SURTASS LFA systems beyond what was analyzed in the January 2001 FOEIS/EIS. That document analyzed the potential impacts of up to four SURTASS LFA systems. As stated in the ROD (67 FR 48145), the decision-maker decided to employ two SURTASS LFA sonar systems with certain geographical restrictions and monitoring mitigation, because only two of the four systems would be operational during the timeframe of the initial five-year regulation authorizing the taking of marine mammals incidental to LFA testing and training. Moreover, NMFS authorized only two systems under the initial five-year Rule. Deliveries of the third and fourth systems were postponed until after FY 2007. Because of this delay, the decision in the ROD was for the employment of only two SURTASS LFA sonar systems. The use of SURTASS LFA sonar is not scheduled to increase past the originally analyzed four systems during the timeframe of the requested follow-on five-year regulation. Therefore, the number of systems has not increased over the number initially proposed and analyzed in the FOEIS/EIS (DON, 2001).

The proposal to deploy SURTASS LFA sonar in a number of oceans is not new either. As stated in the SEIS, these systems will be employed as required for security operations in the oceanic areas as presented in Figure 1-1 of the FOEIS/EIS. Potential operations could occur in the Pacific, Atlantic, and Indian Oceans, and the Mediterranean Sea. Large oceanic areas are restricted from operations, including the Arctic and Antarctic Ocean areas, all offshore areas within 12 nm (22 km) of land, and OBIAs (Table 2-4 of the SEIS).

Comment 1.1.7: Commenter concerned that for the first time this Draft SEIS states that LFA and compact LFA (CLFA) sonars will be used in "shallow littoral ocean regions" since the danger of impacts to humans increases with use in these areas. I-028, O-010, O-011, O-012

Response: Under any of the alternatives analyzed in the Draft SEIS, LFA would never operate inside of 22 km (12 nm) from any coastline, which is in accordance with the FOEIS/EIS. Subchapter 1.1.3 of the Draft SEIS provides a definition of the term "littoral" as used by the U.S. Navy and explains the ways in which the use of the term as a tactical designation differs from its use as a geographic term. The littoral operating environment does not necessarily include or exclude any waters because of depth; it can include both deep and shallow water. The use of SURTASS LFA sonar in coastal environments was discussed in FOEIS/EIS RTCs 1-1.4 and 3-2.8.

Comment 1.1.8: The UK, France, Germany, Canada, The Netherlands, and Norway are developing LFA systems, thus making the oceans even noisier and threat submarines even harder to find. The U.S. should rethink this "need" and come up with a better way to find these quiet submarines. O-013

Response: Research does suggest that the ambient noise levels of the world's oceans are growing louder, which is due to a number of factors, including commercial shipping, recreational boating, seafloor mapping, and to a lesser extent, active sonar (Hildebrand, 2004). The ICES AGISC (2nd edition) (2005) notes that, "[commercial] shipping accounts for more than 75 percent of all human sound in the sea, and sonar accounts for no more than 10 percent or so". The increase in ambient and continuous ocean noise affects the usage of passive sonar technology, making the development of reliable, effective active sonar capabilities all the more pressing.

Various countries are researching and developing low frequency active sonar technology. Among these are the United Kingdom, France, Germany, The Netherlands, and Norway. Even though listed as low frequency, the frequencies of these systems range from 500 Hz to 2.5 kHz with most above 1 kHz. These systems include:

- United Kingdom – Sonar 2087, a sonar system with both active and passive components developed by Thales Underwater Systems, is currently installed aboard 3 *Duke* class (Type 23) frigates, HMS *Westminster*, HMS *Northumberland* and HMS *Richmond*. The Royal Navy has contracted to purchase a total of 8 Sonar 2087 systems. (Naval Technology Website, 2006; Thales Underwater Systems, 2006; United Kingdom Defence Procurement Agency, 2006)
- France – SLASM (System de Lutte Anti-Sous Marine), described as a low frequency active sonar system currently installed aboard two *Tourville* class frigates, the D612 *De Grasse* and D610 *Tourville* (Thales Underwater Systems, 2006).
- Germany –ACTAS, a low frequency active sonar system, developed by ATLAS ELEKTRONIK, scheduled to be installed aboard each of Germanys 4 *Brandenburg* class

(Type 123) frigates (Atlas Elektronik Naval Systems, 2006; Naval Technology Website, 2006).

- Netherlands – Dutch Navy is planning to upgrade ASW suites of the 2 *Karel Doorman* class frigates in their fleet with LFA (Naval Technology Website, 2006).
- Norway – CAPTAS (Combined Active/Passive Towed Array sonar) Mk 2 V1, a low frequency active sonar system developed by Thales Underwater Systems, is set to be installed aboard the new *Fridtjof Nansen* class frigate. The F310 *Fridtjof Nansen* was commissioned April 5, 2006 and 4 others are scheduled for commission by 2009 (Naval Technology Website, 2006).

Canada does not currently have nor is testing an operational LFA sonar system. However, from 2003 – 2004, Defense Research and Development Canada (DRDC) conducted trials under the Towed Integrated Active-Passive Sonar (TIAPS) Projects to test LFA sonar technology to possibly replace the CANTASS (Canadian Towed Array Sonar Systems) currently installed aboard Canadian *Halifax* class frigates. There are no current plans for further research or deployment (DRDC, 2006). 12 *Halifax* class frigates are in active service with the Canadian Forces Maritime Command (Watt, 2003; Naval Technology Website, 2006).

See Subchapters 4.4.1, 4.4.2, and 4.4.3 of the FOEIS/EIS, and Subchapter 4.6.1 of the SEIS for a discussion of ocean noise. See subchapter 1.2.1 of the FOEIS/EIS for a discussion of non-acoustic detection alternatives. As discussed in SEIS RTCs 1.1.2 and 1.1.3 above, SURTASS LFA is the only available technology capable of meeting the U.S. need to detect quieter and harder to find submarines at long range.

ISSUE 1.2 Background (Court Opinion and Order, Military Readiness and Environmental Compliance System Upgrades)

Comment 1.2.1: NDAA drastically weakens the protections offered by the MMPA, and a clear undermining of the law's original intent. O-008

Response: Policy issues regarding the MMPA are beyond the scope of this document.

Comment 1.2.2: We understood the law (MMPA) as requiring that not only should the effect on the stock of any marine mammal from significant change in a biologically important behavior be minimal, but that natural behavior patterns cannot be disrupted to a point where patterns are abandoned or significantly altered in *individual* animals. This is not reflected in ES-18 under Alternative 1. O-010

Response: The Navy concurs. As presented in the FOEIS/EIS Subchapter 4.2.7.8 and the SEIS Subchapter 4.7.7, under Alternative 1, the potential impact on any stock of marine mammals from injury is considered negligible, and the effect on the stock of any marine mammal from significant change in a biologically important behavior is considered minimal. However, because there is some potential for harassment of individual marine mammals and listed species, the Navy is requesting a Letter of Authorization under the MMPA from NMFS for the taking of marine mammals incidental to the employment of SURTASS LFA sonar during military readiness operations, and is consulting with NMFS under Section 7 of the ESA.

<u>The SEIS Preface p. P-2, Executive Summary p. ES-3, and Subchapters 1.2.2 and 6.1 have been corrected to better reflect the NDAA 04 amendments.</u>

Comment 1.2.3: NMFS was found to have improperly issued LOAs to the Navy for LFA sonar in 2002, and in doing so violated the MMPA, ESA, and NEPA. O-008

Response: Under the Court's opinion NMFS was found to have improperly combined its negligible impact determinations with small numbers requirements and improperly applied the specific geographic region requirement. The FY04 NDAA eliminated both of these requirements for military readiness activities, which includes LFA employment. Subsequently, the trial court dismissed all claims under the MMPA. At no time did the trial court ever void the SURTASS LFA sonar Final Rule or subsequent LOAs. Court issues concerning NEPA are being addressed in this SEIS. Under the ESA, the Navy has reinitiated consultation.

Comment 1.2.4: Navy has failed to cure the deficiencies in the 2001 FEIS identified by the Court with respect to required alternatives and mitigation. O-014

Response: The deficiencies noted by the Court relating to the FOEIS/EIS alternatives analysis have been addressed in SEIS RTC Issue 4.7 below.

ISSUE 1.3 Environmental Impact Analysis Process

Comment 1.3.1: Project description and meaningful public disclosure should include source levels, frequency ranges, duty cycles, and other technical parameters relevant to impact analysis. O-014

Response: All technical parameters relevant to the impact analysis, including those listed by the commenter, were provided in the project descriptions for SURTASS LFA sonar in both the FOEIS/EIS (DON, 2001) Subchapters 2.1.1 and 2.3.2.2 and in RTCs 2-1.1 and 2-1.2a, which are incorporated by reference into this SEIS; and in the SEIS Subchapter 2.1.1.

Comment 1.3.2: The scope of the FEIS (2001) analysis is for the extraterritorial portion of the LFA program, that part which lies outside U.S. territorial waters, under EO 12114 rather than under NEPA. Draft SEIS at ES-2. Nothing in the Draft SEIS suggests that the Navy has altered this decision. NRDC urges Navy to reconsider and comply fully with NEPA. O-014.

Response: The FOEIS/EIS (2001) clearly states on page 1-1:

> "It (FOEIS/EIS) has been prepared by the Department of the Navy (DON) in accordance with the requirements of Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions) and the National Environmental Policy Act of 1969 (NEPA). The provisions of EO 12114 apply to

> major federal actions that occur or have effects outside of U.S. territories -- the United States, its territories, and possessions. The provisions of NEPA apply to major federal actions that occur or have effects in the United States, its territories, and possessions."

The Draft SEIS (pp. ES-2 and 1-1) clearly makes the same statement, as do the title pages from both documents.

Comment 1.3.3: The Navy's application for a new small take permit is a separate final agency action from the original application and, absent the sort of tiering that has not been conducted here; it requires its own EIS. O-014

Response: In accordance with 40 CFR §1502.9, agencies shall prepare a supplement to a draft/final EIS when the agency makes substantial changes to the proposed action that are relevant to environmental concerns, there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action and its impacts, or if the agency determines that the purposes of the act will be furthered. The Navy's proposed action is the employment of SURTASS LFA sonar, not the issuance of a permit. Moreover, the SEIS incorporates by reference the analysis contained in the FOEIS/EIS, except as noted or modified. The employment of up to four SURTASS LFA sonar systems is a continuing activity from the FOEIS/EIS. "Tiering" is not applicable.

Because the issuance of various permits by the NMFS is considered a major federal action, NMFS is a cooperating agency under NEPA for this action as recommended by CEQ regulations.

Comment 1.3.4: A new EIS is needed because the Navy is: 1) increasing the number of ships from two to four and is increasing the number of transmit hours; and 2) adding a different system called CLFA. An independent analysis of environmental impacts of CLFA is needed. O-014

Response: The Navy is not proposing to use more SURTASS LFA sonar systems, or to transmit with them more hours, than was analyzed in the FOEIS/EIS. The proposed action in the FOEIS/EIS is the U.S. Navy employment of up to four SURTASS LFA sonar systems, which is the same as the proposed action in the SEIS. As stated in the SEIS Subchapter 1.2.3 and 2.1, compact LFA is an upgrade and modification to the SURTASS LFA system necessary to install and operate on the smaller VICTORIOUS Class T-AGOS 19 Class ocean surveillance ships. The operational characteristics of the active system components installed, or to be installed, on the R/V *Cory Chouest*, USNS IMPECCABLE, and VICTORIOUS Class are given in SEIS Subchapter 2.1.1. The characteristics of LFA and the upgrade and modifications for the T-AGOS 19 installations are essentially the same. Therefore, because the FOEIS/EIS and the SEIS analyzed the impacts of up to four SURTASS LFA sonar systems and the operational characteristics of both LFA and compact LFA are essentially the same, a separate analysis for CLFA is not necessary. Therefore, a new EIS would not be required under NEPA regulations (See SEIS RTC 1.3.3 above of additional information).

Comment 1.3.5: Given the pace of research into acoustic impacts on marine life, significant new information is almost certain to arise between now and the Navy's application (MMPA). Therefore the Navy's analysis will simply be outdated and should not be relied upon to judge impacts of a small take permit that will run through 2012. This is why the Navy needs to complete a separate EIS for its application. O-014

Response: The Navy will prepare any additional NEPA analysis as the need arises.

Comment 1.3.6: Where is the Navy's evidence-based data of benefit? I-003

Response: Evidence-based data from real-world SURTASS LFA sonar operations remains classified. However, the fact that the Navy considers LFA its primary, long-range ASW system in the Pacific Fleet area of responsibility, where it has been operating since 2003, and the Navy's decision to have four operational LFA systems (the level analyzed in the FOEIS/EIS) before 2012 underscores the system's benefit to the U.S. National Security posture. Also, see RTCs 1.1.2 and 1.1.3 above for additional information on the need for SURTASS LFA sonar.

ISSUE 1.4 Analytical Contexts (Adequacy of Scientific Information of Marine Animals)

Comment 1.4.1: Baseline data on the distribution and behavior of marine mammals is not available, making it impossible to evaluate long term effects of LFA. Under NEPA, Navy must make it clear that this baseline information is not available and discuss how this lack of information affects their ability to evaluate adverse impacts on marine life. O-010

Response: Available baseline data on the distribution and behavior of marine animals are limited. The SEIS utilizes the best available data. The Navy sponsored independent research to fill pertinent data gaps, as discussed below. As stated in the SEIS Subchapter 1.4, there have been no substantial changes to the framework for the development of the analytical context since the FOEIS/EIS. This information in the FOEIS/EIS remains valid. Except as noted, the contents of Subchapter 1.4 of the FOEIS/EIS are incorporated by reference into the SEIS. This subchapter discussed the adequacy of scientific information on marine animals and the series of original scientific field research projects to address the most critical of the data gaps regarding the potential effects of LF sound on the behavior of marine mammals. That research effort was referred to as the Low Frequency Sound Scientific Research Program (LFS SRP).

Under the SEIS several additional topics are addressed. First, the specific scientific information for marine animals was updated to ensure that the best available data were utilized in the analysis. These data are presented in Final SEIS Chapter 3. For example, baseline data on the distribution and abundance of marine animals is detailed in SEIS Table 3.2-1 (Fish), Table 3.2-2 (Sea Turtles), Table 3.2-3 (Mysticetes), Table 3.2.4 (Odontocetes), Table 3-2.5 (Otariidae), and Table 3.2-6 (Phocidae).

Second, 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 CEE is a study being conducted by the University of Maryland designed to examine the effects of LFA signals on hearing, the structure of the ear, and selected non-auditory systems in a *salmonid* (rainbow trout) and channel catfish. See SEIS Subchapter 4.1 for additional information.

Finally, as stated in SEIS RTC 4.3.1 below, LFA has not been implicated in any known strandings. Although there is no evidence that LF sound can cause biologically significant behavioral responses in certain species of odontocetes, the Navy is presently planning 2007-2008 field research for deep-diving marine mammal behavioral response studies (BRS) to address this issue.

The conclusions in the FOEIS/EIS (Subchapter 1.4.4) concerning the relevance of incomplete information in the evaluation of reasonably foreseeable significant adverse impacts from the employment of SURTASS LFA sonar on the human environment remain valid. LFA has operated in the northwestern Pacific Ocean area since January 2003 with minimal effects. New peer-reviewed, published documents are consistent with the conclusion that LFA has not been causative in any marine mammal stranding events (ICES, 2005; Cox et al, 2006; D'Spain et al, 2006). Updated summaries of credible scientific evidence relevant to SURTASS LFA sonar impacts on the human environment are provided through the SEIS. The agency's evaluation of such impacts is based upon theoretical and research methods as noted above, which are generally accepted by the scientific community.

Therefore, under 50 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 LFA sonar in relationship to reasonably foreseeable significant impacts. The SEIS updated the information and data provided in the FOEIS/EIS and provided evaluations and summaries of existing credible scientific evidence.

Comment 1.4.2: Low levels of received sound have the potential to disrupt a large portion of a population, if the sound reduces hearing sensitivity enough to mask normal stimuli. The Draft SEIS should discuss, for studies used to predict marine life exposure to LFA sonar, the statistical power of each study to detect subtle changes in behavior, such as reduced prey capture per unit of effort, or reduced time spent feeding. Amount of uncertainly in EIS analysis should be stated explicitly. O-012

Response: Population-level effects of masking are addressed in SEIS RTC 4.3.23 below.

CHAPTER 2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

ISSUE 2.1 General System Descriptions

Comment 2.1.1 Why does the FOEIS/EIS state in Section 2.1.1 "The source frequency is between 100 and 500 Hz (The LFA system's physical design does not allow for transmissions below 100 Hz)?" This contradicts the article in *Sea Technology* and the transmissions from the HIFT. I-021

Response: The above statement in the FOEIS/EIS (and the Draft SEIS Subchapter 2.1.1) is correct. The *Sea Technology* article to which the commenter refers is assumed to be "Low-Frequency, High-Power-Density, Active Sonars" in the May 1995 issue (White, 1995). However, there are no frequencies specified in the article. The transmit array used during the Heard Island Feasibility Test (HIFT), which was described by Monk et al. (1994), was of a different configuration than that of the LFA transmit arrays. The HIFT sources were configured to resonate at 57 Hz with a bandwidth of 14 Hz and a source level of 204 dB re: 1 µPa @ 1 m, which differ from LFA characteristics and operating features presented in the FOEIS/EIS and the SEIS. For additional information, see FOEIS/EIS RTC 2-1.8.

Comment 2.1.2: Is the Navy calling transmissions below 100 Hz something else like Extreme Low Frequency Active sonar, and is the Navy using it? I-021

Response: The FOEIS/EIS (Subchapter 2.1 and Glossary) and SEIS (Subchapter 2.1) define LF sound as below 1,000 Hz. Chapters 1 and 2 of both the FOEIS/EIS and SEIS clearly state that the scope of the analysis is for SURTASS LFA sonar systems with frequency ranges of 100 to 500 Hz. Therefore, anything below 100 Hz is not within the scope of this NEPA/EO 12114 analysis.

Comment 2.1.3: Why does the Navy need 18 transmitters? I-021

Response: An array of 18 elements is required to meet the Navy's technical specifications and operational needs for the detection of submarines.

Comment 2.1.4: Would the received level of the LFA sonar array be the same at a range of 100 miles if there was only one transducer operating and not 18? I-021

Response: No.

Comment 2.1.5: The long wavelengths used by LFA mean that only larger targets can be detected. Small submarines, for instance, would escape detection. How would this deficiency be overcome or why is it not considered a deficiency? O-010

Response: The frequency band and wavelengths selected for LFA sonar operations meets the design criteria for the system to detect nuclear attack submarines, nuclear strategic ballistic missile submarines, conventional (diesel-electric) submarines, and advanced non-nuclear designs, such as AIP diesel-electric submarines.

Comment 2.1.6: The Draft SEIS states that the R/V *Cory Chouest* and the USNS IMPECCABLE are the only ships equipped with SURTASS LFA sonar systems. Jane's Warships, Page 844 states the sonar onboard as the"UQQ2 SURTASS and LFA; towed array; passive/active surveillance" and "The Low Frequency Active component produce both mono and bi-static performance against submerged diesel submarines in shallow water." Have any VICTORIOUS class SWATH vessels been built and already deployed with LFA sonar as Jane's suggests? I-021

Response: Four VICTORIOUS class Ocean Surveillance ships were built between 1991 and 1993. As stated in the SEIS Subchapter 2.1, there are no LFA sonar systems deployed on these vessels at this time. The projected LFA/CLFA sonar system availabilities are shown in the SEIS Figure 2-2, which includes future installations onboard the VICTORIOUS Class.

Comment 2.1.7: Does the Navy plan to develop any different LFA sonar transmit platforms such as deploying it on the new Sea Shadow SWATH vessels? I-021

Response: There are no current LF systems beyond LFA/CLFA planned for deployment during the timeframe of this SEIS and the requested regulations under the MMPA. The projected availability of LFA sonar systems/platforms through Fiscal Year 2012 was provided in Figure 2-2 of the SEIS.

ISSUE 2.4 Mitigation Measures

Comment 2.4.1: What is the full power of the HF/M3 sonar if it is ramped up starting at 180 dB? What is the SL? What is the indication of the error rates? How many animals escape detection? How many false positives? Why is HF/M3 ramped up, but LFA is not? What are the mitigation measures for the HF/M3 sonar? I-011

Response: The general operating characteristics of the HF/M3 sonar are given in the FOEIS/EIS (p. 2-17). The source level is 220 dB re 1 microPascal (μPa) at 1 meter. HF/M3 sonar testing and effectiveness are discussed in the FOEIS/EIS (pp. 2-19 through 2-22 and the SEIS RTC 5.2.20. As a mitigation measure, the HF/M3 sonar is ramped up from 180 dB SL to full power over 5 minutes in 10 dB increments (SEIS, Subchapter 5.2.3). LFA ramp-up is discussed in RTC 5.0.3a.

Comment 2.4.2: The principal means of actively monitoring for the presence of large marine animals is a device developed by the same company that produced the DEIS, FEIS, and SEIS for SURTASS LFA. This is a risk of biased reporting and a conflict of interest. An independent assessment of the use, applicability, and effectiveness of the equipment is called for. I-002

Response: Marine Acoustics, Inc. (MAI) was the prime contractor for the Draft OEIS/EIS, the Final OEIS/EIS, the Draft SEIS, and the Final SEIS. The HF/M3 sonar was designed by the Navy and Scientific Solutions, Inc., and thereupon developed and manufactured by Scientific Solutions, Inc. Although one individual from MAI was involved in the design, test, and development of the HF/M3 sonar, neither MAI nor any employee or officer of MAI has any financial interest in use of that sonar.

The SURTASS LFA FOEIS/EIS and the SEIS were developed by a scientific team with MAI as the lead integrator, document drafter and editor. Pursuant to the requirements of 40 CFR § 1506.5(c) of the Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, MAI signed a Disclosure Statement on 10 October 2003 stating that MAI has no financial or other interest in the outcome of the project.

ISSUE 2.5 Interim Operational Restrictions and Proposed Modifications to Mitigation

Comment 2.5.1: Navy rejects NMFS' 360-degree one-km buffer zone extending outside of the 180-dB isopleths. O-014

Response: The Navy has not rejected NMFS' requirement for the one-km buffer zone. This was an interim operational restriction added by NMFS in the Final Rule. This restriction was not included in Alternative 1 of the FOEIS/EIS. Because the analysis in the FOEIS/EIS did not indicate the need for the additional buffer, the Navy did not include it in the analysis for the SEIS. The one-km buffer zone is discussed in more detail in SEIS RTC 4.7.11. Analysis demonstrated that the removal of this restriction will not appreciably change the percentage of animals potentially affected. However, the decision on whether or not to include the one-km buffer zone in the next 5-year Rule will be made by NMFS, not the Navy.

Comment 2.5.2: Navy rejects the 330 Hz frequency restriction imposed by NMFS to protect marine mammals from resonance effects based on the argument that an expert group, convened in 2002 by NMFS, ruled out resonance effects as a likely problem (DOC, 2002). In fact, that group did not rule out resonance, though it considered lung resonance in particular less promising than other pathologies such as bubble growth and, in fact, called for further research on the subject—particularly on structures other than the lungs, which was the only structure considered. Meanwhile, an expert group convened more recently, by the Marine Mammal Commission (MMC), concluded that resonance remained as a potential cause for concern and made similar recommendations for further research. Under NEPA, damage from resonance remains a "reasonably foreseeable" impact that must be considered in the Navy's environmental review and mitigation. O-014

Response: The 330-Hz frequency restriction was an interim operational restriction added by NMFS in the Final Rule to preclude the potential for injury to marine mammals by resonance effects. That restriction was based on a statement made by Dr. Darlene Ketten, an expert on the functional morphology of marine mammal hearing, in her testimony before the Subcommittee on Fisheries Conservation, Wildlife and Oceans of the House Committee on Resources on October 11, 2001 (Ketten, 2001). Dr. Ketten's statement was "The consensus of data is that virtually all marine mammal species are potentially impacted by sound sources with a frequency of 300 Hz or higher." The topic of Dr. Ketten's testimony was Marine Mammal Auditory Systems: A Summary of Auditory and Anatomical Data and Its Implementations of Underwater Acoustics Impacts. The data presented related predominately to marine mammal hearing and not resonance.

The Navy did not state in the Draft SEIS that the NMFS acoustic resonance workshop ruled out resonance, but stated that the report provided part of the evidence required by NMFS that resonance and/or tissue damage from LFA transmissions were unlikely to occur in marine mammals at levels below 190 dB (SEIS Subchapter 2.5.1). As to the requirement for needed research, DOC (2002) stated that it seemed unlikely that acoustic resonance in air spaces played a primary role in tissue trauma in the Bahamas and other events. Nevertheless, they then suggested continued research. The MMC workshop did not discuss in detail the results of the NMFS acoustic resonance workshop, but endorsed three recommended areas of study: 1) beaked whale lung resonance throughout the dive profile; 2) potential for other organs and structures to be affected by resonance; and 3) possibility that animals experience tissue shear (Cox et al., 2006).

The commenter claimed that the above workshops provide data that damage from resonance remains a "reasonably foreseeable" impact that must be considered in the Navy's environmental review and mitigation. The Navy did consider this issue in its environmental review. In addition to its reference to DOC (2002), it also relied on the review of the potential for *in vivo* tissue damage from underwater sounds (Cudahy and Ellison, 2002). Regarding tissue effects, Cudahy and Ellison (2002) indicated that the potential for *in vivo* tissue damage to marine mammals from exposure to underwater LF sound (100 to 500 Hz) will occur at a damage threshold on the order of 180 to 190 dB. The paper noted that resonance does not necessarily equal damage and that damage is not always linked to resonance. Their review included both areas. They concluded the following: (1) transluminal (hydraulic) damage to tissues at intensities on the order of 190 dB or greater; (2) vascular damage thresholds from cavitation at intensities in the 240-dB regime; (3) tissue shear damage at intensities on the order of 190 dB or greater; and (4) tissue damage in air-filled spaces at intensities above 180 dB. The results are primarily based on the Gerth and Thalmann (1999) presentation at the Underwater Sound Conference of January 25, 1999, and summary test data (along with more recent analysis) on animal sound exposure from the SURTASS LFA EIS Technical Report Number 3 (Cudahy et al., 1999). It should be noted that Drs. Cudahy and Ellison were participants in the 2002 NMFS Acoustic Resonance Workshop.

The "reasonably foreseeable" impacts as discussed by the commenter are based on three recommended research topics, and untested hypotheses, not existing scientific data. The topics from the MMC workshop are listed above. The first concerned beaked whale lung resonance, which the MMC workshop concluded was "highly unlikely." The second concerned the potential for other organs and structures to be affected by resonance. Based on the NMFS workshop report, *if* resonance explained the Bahamas stranding, then sonar operating at a different frequency (like LFA at 100 to 500 Hz) would be unlikely to stimulate resonance in the same structures or species as a mid-frequency sonar would (DOC, 2002). The third area was tissue shear. Cudahy and Ellison (2002) reported tissue shear damage at intensities on the order of 190 dB or greater. Therefore, subject matter experts in the fields of marine biology/bioacoustics/ acoustics have stated that two of the three MMC proposed research areas are based on impacts that are unlikely and that the third will not occur below an exposure level of 190 dB, which is well within LFA's 180-dB safety zone. Finally, the Ocean Studies Board of the NRC in its report on Marine Mammal Populations and Ocean Noise stated that resonance from air spaces is not likely to lead to detrimental physiological effects on marine mammals (NRC, 2005). Therefore, analysis by the Navy (Cudahy and Ellison, 2002), reports on two workshops on acoustic impacts (DOC, 2002; Cox, et al. 2006), and the NRC Ocean Studies Board (NRC, 2005) support the conclusion that resonance from LFA operations is not a "reasonably foreseeable" impact.

Comment 2.5.3: Saying Cudahy and Ellison (2002) provides empirical and documentary evidence that resonance and/or tissue damage from LFA transmissions are unlikely to occur in marine mammals under 190 dB for the frequency range 330-500 Hz and thus the previous interim operational frequency restriction is not required is premature and overstating the certainty of science. I-011

Response: See SEIS RTC 2.5.2 above.

Comment 2.5.4: Commenter disagrees that it is difficult to identify areas particularly devoid of marine life. It is true that sometimes these areas have simply not been surveyed adequately, but a good first indication of primary productivity, and thus, often marine mammal abundance, can be obtained from color scanner satellite photographs of the ocean. These areas can subsequently be surveyed, visually and especially acoustically, to determine marine mammal abundance. I-011

Response: The Coastal Zone Color Scanner (CZCS) was a multi-spectral line scanner devoted principally to measurements of ocean color. The CZCS was developed by NASA and launched on the Nimbus-7 satellite in October 1978. During its 7 1/2 year lifetime (October 1978 - June 1986), CZCS acquired nearly 68,000 images, each covering up to 2 million square kilometers of ocean surface.

From these images of Ocean Color, oceanographers are able to map the chlorophyll concentrations of different parts of the world's oceans and study seasonal changes in chlorophyll. The chlorophyll concentrations indicate phytoplankton clusters throughout the euphotic zone (upper part of water column that sunlight penetrates) which, in turn, can help oceanographers study primary productivity in the ocean.

Assuming that areas of the oceans mapped by CZCS that indicate low chlorophyll concentrations are devoid of marine life would be irresponsible without confirming such a supposition through visual and/or acoustic surveys. The Navy reiterates that it is more realistic to identify areas of high marine life concentrations and avoid them when practicable. See SEIS Subchapter 2.5.2.1 for additional information.

Comment 2.5.5: Commenter is not aware of a situation where the Navy has willingly and of its own initiative changed its preferred mission area because of marine mammal impact concerns. I-011

Response: 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. This process has been detailed in the Subchapter 4.4 of the SEIS. In the second year LOA applications for the R/V *Cory Chouest* and the USNS IMPECCABLE, the Navy initially proposed mission areas that included two areas off Hawaii. For the area north of Hawaii, the Navy proposed that operations would be conducted at least 93 km (50 nm) offshore and limited to June to November due to humpback whale migration, breeding, and calving during the other months. For the area south of Hawaii, all LFA operations would be conducted at least 93 km (50 nm) offshore. Later in the permitting process and as a result of Court mediation between the Navy and NRDC et al., the Navy agreed not to operate in these areas.

ISSUE 2.6 Alternatives

Comment 2.6.1: Draft SEIS does not discuss many reasonable and accepted mitigation procedures which may be consistent with military training, such as those included in a recent notice issued by NMFS in 71 FR 3474-84 (Jan 23 06) for Eglin AFB gunnery exercises. O-010

Response: An Incidental Harassment Authorization (IHA) was issued by NMFS to Eglin AFB for air-to-surface gunnery missions on 3 May 06 (71 FR 27695-710). Mitigation measures included mission area aerial surveys by the AC-130 gunship itself; development of a test round utilizing only about 7 percent of the normal high explosive load; ramp up by starting each mission with the smallest gunnery rounds; Beaufort sea state of 3.5 or less; avoidance of sperm whale areas; pre-mission visual observations, radar, all-light TV and IR prior to mission; and mission will be cancelled or relocated if marine mammals, sea turtles, vessels, or Sargassum rafts are sighted.

As discussed in the SEIS Subchapter 5.4, aerial surveys for SURTASS LFA operations are not feasible. Similar to the AC-130 gunship, the Navy uses the best available technology to allow it to detect critical marine life during LFA sonar operations. The HF/M3 sonar is ramped up beginning 30 minutes prior to the commencement of the exercise. Sea state restrictions and visual monitoring devices designed for night use are not required because the active acoustic monitoring provides for 24-hour, all weather monitoring for marine mammals within the LFA safety and buffer zones, with a much higher probability of detection than visual and passive acoustic monitoring alone. Unlike the AC-130 gunship activity, areas of high marine animal concentrations are avoided to the extent practical in mission area planning during each LOA application process.

ISSUE 2.7 Additional Research

Comment 2.7.1: There are several problems with the characterization of the process on page 2-15 of the Draft SEIS. First, the process was agreed to be confidential at this stage, so that it is highly inappropriate to reference it in a public document. Second, the planning document is not detailed, as maintained, but is a general overview of potentially useful future research in this area. Third, the Oxford process has not restricted itself to experimental tests of, among other things, the effects of LFA sonar on deep-diving marine mammals, but rather takes a broader view of studies that may inform on this topic such as retrospective studies, modeling, necropsies, studies of the natural behavior of animals in the wild, etc. I-011, O-010

Response: The Oxford meeting produced a draft planning document that did include, among other options and recommendations, the notion of experimental acoustic playback tests on deep-diving marine mammals. Whether or not it is considered “confidential” is also open to interpretation, although it certainly is not confidential in the functional sense of the word. Moreover, the primary plan drafter considered that once the draft version had been promulgated to the participants and their comments had been applied, that revised version was releasable. The commenter is correct in that the Oxford meeting planning document was not restricted to experimental tests. <u>The comment refers to Draft SEIS Table 2-5. This table has been revised based on updated research status in the Final SEIS.</u>

Comment 2.7.2: The final proposed research topic (long-term cumulative effects on a stock of marine mammals regularly exposed to LFA) is very worthwhile and important. However, how are the studies going to separate out impacts from other noise or environmental threats or oceanographic and ecosystem changes? If the study is inconclusive because other factors could have caused a change in population, then not much will have been gained. I-011, O-010

Response: First, given the limitations of the schedule and locations of SURTASS LFA use, it is highly unlikely that any “stock” of marine mammals would be regularly exposed to LFA, especially any stock that is potentially at risk from LFA sounds. Given the best available evidence, odontocetes stocks, and this by definition includes beaked whales, are not at risk from LFA.

The commenters also stated that “*If the study is inconclusive because other factors could have caused a change in population, then not much will have been gained.*” Over the long-term, assessing cumulative impact from multiple stressors is of critical importance and recognized as an issue that must be planned for and addressed. There are some recent data (e.g., Evans, 2003) implicating synergistic effects from multiple stressors, including noise. The study proposed here should recognize that similar impacts might occur with marine mammals, while recognizing that the scientific understandings necessary to engage in such studies on marine mammals are still emerging. That said, detecting and scientifically validating a change in a marine mammal population (e.g, trend, demographics) is an extremely difficult and rare accomplishment (e.g., the Beaufort-Chukchi-Bering seas bowhead whale population, see George et al. 2004). Scientifically demonstrating that such a change is due to a single anthropogenic factor has never been attempted for a cetacean, and it is probably unreasonable to expect that a single factor would explain such a change. Therefore, saying that nothing would be gained by demonstrating a population change is not true as this is a necessary step for determining which combination of factors might have contributed to that change. Given that the research would be focused on populations of free-ranging marine mammals, it is illogical to suggest or require that all potential population factors be understood or measured prior to conducting the research. Science proceeds step-wise. We are learning that there are potential issues related to anthropogenic noise that might affect individual animal survival and reproductive success. Specifically for LFA, research results indicate that some whales will respond to LFA over relatively short temporal periods and over small spatial areas, and it is recognized that that research was only capable of testing for responses over short time periods and spatial scales. However, research on the appropriate temporal and spatial scales has not been conducted to address this level of potential impact, so questions concerning the level of impact at such scales remain unanswered. No research on this recommended research topic is presently planned.

Comment 2.7.3: The serious issue of ignoring the available evidence about numerous impacts of LFA on whales even at the low test levels used in the SRP needs to be addressed. The fact that the real, higher levels of LFA were never tested needs to be addressed. It is obvious that testing at actual deployment levels raises ethical issues. Indeed the potential severe consequences of testing LFA at actual deployment levels may be the reason why it hasn't been tested at those levels. If it is too dangerous to test at actual deployment levels, then it is obviously too dangerous to use at those levels. O-010

Response: First, the commenter did not specify the "*available evidence about numerous impacts of LFA on whales*" to which he/she was referring, so that comment cannot be addressed directly. Second, comments on the levels of the LFS SRP testing were addressed in the FOEIS/EIS (RTCs 4-5.1, 4-5.10, 4-5.21, 4-6.2, and 4-6.5). It is reiterated that during Phase I of the LFS SRP research, there were times when the test source level was at the higher, operational level. During such test periods received levels at the subject animals were within the range as specified in the research permit and responses were no different than those observed when using lower source levels. Furthermore based on the onboard LFA monitoring program, there is no evidence that LFA has caused *severe consequences* to marine mammals since it commenced operations in 2003, and at present the only observed behavioral effects are considered short-term, small scale and minor. Because of the general lack of significant biological behavioral changes during the LFS SRP and the conservative nature of the risk continuum, the Navy does not plan at this time to do any additional controlled exposure experiments on baleen whales. The Navy does agree with the recommendation of the Marine Mammal Commission's workshop on understanding the impacts of anthropogenic sound on beaked whales and agrees that CEEs on beaked whales' responses to sound should be a top research priority (Cox et al., 2006). As such, Navy research funds are being programmed to support this research in 2007 and 2008.

Comment 2.7.4: Passive acoustic monitoring using bottom-mounted hydrophones is worthwhile, but how much of this research has been published or made available to the public?

Response: The following is a partial listing of recent research on passive acoustic monitoring of marine mammals:

Clark, C.W. and N.S. Altman. 2006. Acoustic detections of blue whale (*Balaenoptera musculus*) and fin whale (*B. physalus*) sounds during a SURTASS LFA exercise. JASA 31: 120-128.

Clark, C.W. and P.J. Clapham. 2004. Acoustic monitoring on a humpback whale (*Megaptera novaeangliae*) feeding ground shows continual singing into late Spring. Proceedings Roy. Soc. Lond., B. 271: 1051-1057.

Clark, C.W., J.F. Borsani, and G. Notarbartolo-di-Sciara. 2002. Vocal activity of fin whales, Balaenoptera physalus, in the Ligurian Sea. Mar. Mamm. Science 18(1): 281-285.

Clark, C.W. 1995. Application of US Navy underwater hydrophone arrays for scientific research on whales. Annex M, Rep. Int. Whal. Commn. 45:210-212

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

Charif, R.A., P.J. Clapham, and C.W. Clark. 2001. Acoustic detections of singing humpback whales in deep waters off the British Isles. Mar. Mamm. Science 17(4):751-768.

McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. Journal of the Acoustical Society of America 109(4):1728-1735.

McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. J. Accoust. Soc. Am. 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. The Journal of the Acoustical Society of America 118(6):3941-3945.

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.

Mellinger, D. K., and C. W. Clark. 2003. Blue whale (*Balaenoptera musculus*) sounds from the North Atlantic. The Journal of the Acoustical Society of America 114(2):1108-1119.

Mellinger, D. K., K. M. Stafford, and C. G. Fox. 2004. Seasonal occurrence of sperm whale (*Physeter macrocephalus*) sounds in the Gulf of Alaska, 1999-2001. Marine Mammal Science 20(1):48-62.

Moore, S. E., M. Stafford Kathleen, D. K. Mellinger, and J. A. Hildebrand. 2006. Listening for Large Whales in the Offshore Waters of Alaska. BioScience 56(1):49-55.

Stafford, K. M. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. Marine Mammal Science 19(4):682-693.

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. Journal of the Acoustical Society of America 104(6):3616-3625.

Stafford, K. M., and S. E. Moore. 2005. Atypical calling by a blue whale in the Gulf of Alaska (L). Journal of the Acoustical Society of America 117(5):2724-2727.

Stafford, K. M., S. E. Moore, and C. G. Fox. 2005. Diel variation in blue whale calls recorded in the eastern tropical Pacific. Animal Behaviour 69(4):951-958.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 1999. 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. 1999. Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. 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.

Watkins, W. A., M. A. Daher, J. E. George, and D. Rodriguez. 2004. Twelve years of tracking 52-Hz whale calls from a unique source in the North Pacific. Deep Sea Research Part I: Oceanographic Research Papers 51(12):1889-1901.

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio, and D. P. Gannon. 2000. Seasonality and Distribution of Whale Calls in the North Pacific. Oceanography 13(1):62-67.

Watkins, W. A., M. A. Daher, J. George, V. Ronquille, and A. Stanley. 1993. Unusual whale sounds tracked by Navy SOSUS. none (draft):1-17+.

CHAPTER 3 AFFECTED ENVIRONMENT

ISSUE 3.1 Marine Environment

Comment 3.1.1: At peak power, the LFA Sonar system sends out pulses of sound underwater the equivalent of standing five feet away from a Saturn rocket on liftoff. O-011, O-015

Response: Were an accurate source level of the Saturn V known, the comparison of this, or any other rocket, to LFA would be inappropriate. The sound generated by a Saturn V rocket, or any rocket in general, is broadband and generates a different frequency spectrum than that of LFA, and travels in a significantly different transmission pattern. The Saturn C-1 rocket (a predecessor to the Saturn I rocket, which had about 1,600,000 lbs of thrust) was projected to have produced acoustic levels as high as 205 dB (in air) from a distance of 305 meters. Some sources suggest that the sound levels produced by the Saturn V (during the launch of Apollo 15, the first stage of the Saturn V generated 7,823,000 lbs of liftoff thrust) may have been as high as 220 dB (in air) (Benson and Faherty, 1978). As sound is perceived differently underwater than it is in air, sound propagation and transmission losses in each case are subject to differing factors, including terrain and temperature, and in the case of LFA, water salinity, temperature and depth. Therefore, when corrected to the equivalent sound levels in water, the above acoustic levels of 205 dB in air and 220 dB in air would be 266.5 and 281.5 dB in water, respectively (See FOEIS/EIS Appendix B, Subchapter B.3.2). These sound levels are over 100 to 10,000 times louder than the LFA source; thus the commenter’s statement is incorrect.

For additional information, see FOEIS/EIS Subchapter 2.1.1 and SEIS Subchapter 2.1.1 for a technical description of the LFA system. FOEIS/EIS Subchapter 3.1.2 discusses the factors affecting sound propagation in water. FOEIS/EIS Subchapter 4.4.3 and SEIS Subchapter 4.6.1. compare LFA to other sources of anthropogenic noise.

ISSUE 3.2 Marine Organisms

Comment 3.2.1: Draft SEIS reveals an extraordinary lack of any real concern….when it comes to endangered and threatened species and their importance to the ecosystem. O-008

Response: All threatened and endangered species, whose ranges are expected to overlap that of potential LFA operations, are evaluated in the SEIS Subchapter 3.2 and Chapter 4. The Navy’s analyses of listed species in the SEIS built upon and updated its analyses in the FOEIS/EIS by incorporating new and updated scientific references from all species and their ecosystems. The Navy has initiated consultation with NMFS under Section 7 of the ESA. The Navy has and intends to continue to fully comply with all environmental regulations due to its concerns for threatened and endangered species.

Species Screening

Comment 3.2.2: Draft SEIS conclusion that there would be no impacts on sea birds is not reasonable. Just because there is no evidence that they use underwater sound, does not mean that they cannot be impacted by the noise. O-008, O-013, O-015

Response: Both the FOEIS/EIS and Draft SEIS clearly stated that seabirds likely can hear underwater LF sounds. The conclusion in the SEIS that seabirds are unlikely to be affected by LFA sonar is not based solely on a lack of evidence that the birds use underwater sound as the commenter suggests. 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. <u>The SEIS Subchapter 3.2.1.2 has been updated to clarify that seabirds were not excluded from further evaluation only because there is no evidence that the use underwater sound.</u>

Ballance et al. (2001) state that seabirds spend 90 percent of their life at sea foraging over hundreds to thousands of kilometers. Some dive from the sea surface to several hundred meters. Ballance et al. (2001) further state 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 (see FOEIS/EIS Subchapter 4.3.2.1). 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 below the water surface at least 2 meters (6.6 ft) during the 7.5 to 10 percent of the time (active transmission duty cycle based on actual operations) that the LFA source would be transmitting. The determinations in the FOEIS/EIS (Subchapter 3.2.1.2) and the SEIS (Subchapter 3.2.1.2) that seabirds would not 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) remain valid. 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.

Comment 3.2.3: Rationale that seabirds can rapidly disperse if disturbed is potentially an impact especially for T&E species. Birds may not always be able to disperse, depending on their energy reserve levels. The need to feed may outweigh any disturbance from sound. I-011, O-010, O-013

Response: As noted above, most offshore seabirds are generally shallow divers and spend a small fraction of their time at water depths where LFA would be above background noise levels (Ballance et al., 2001; Brierley, 2001). The probability that they will be exposed to LFA signals is minimal and the probability that they will disperse if exposed to LFA signals is considered very low. Therefore, the combined probability of dispersal due to LFA sound exposure is expected to be extremely rare, and the potential impact should be considered negligible. Even if they are dispersed, since the LFA vessel is moving, they could return to the area fairly quickly. The Navy is consulting with NMFS on the potential effects of LFA sonar on listed threatened and endangered species.

Comment 3.2.4: Draft SEIS exclusion of sea snakes from further evaluation is unreasonable. Just because there is no evidence that they use underwater sound, does not mean that they cannot be impacted by the noise. O-008, O-013

Response: 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 internal 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, SEIS Subchapter 3.2.1.2 concerning sea snakes is considered reasonable and is supported by the best available data. <u>The SEIS Subchapter 3.2.1.2 has been updated to reflect the information in this response.</u>

Comment 3.2.5: We strongly question the assumption that invertebrates are not considered because they have no delicate organs or tissues whose acoustic impedance is significantly different from water and because there is no evidence of auditory capability in the frequency range used by LFA. Given the recent research and observations concerning squid and snow crabs, we find such statements unsupportable. Not much is known about hearing in most invertebrates but our knowledge is evolving rapidly. For instance, not too long ago squid were thought to be deaf. Fish and some invertebrates have a lateral line (or equivalent) system which detects water movement and could also conceivably detect sound or particle motion. Both squid (McCauley et al. 2000; MacKenzie 2004; Guerra et al. 2004) and snow crabs (DFO, 2004) appear to show reactions to seismic noise which is predominantly low in frequency. While it is unknown which characteristics of the noise they are reacting to, it seems irresponsibly premature to conclude that these characteristics are ones not shared by LFA sonar. I-011, O-010, O-013, O-014

Response: There are a number of issues here. While it is possible that marine invertebrates detect sound, the data in the literature are very limited. A recent comprehensive review suggests that the majority of invertebrates studied to date have not shown the ability to detect sounds, nor do most species have what could be construed as hearing organs (Popper et al., 2003). The commenter is correct in pointing out that some cephalopods have a lateral line-like organ, but this is not widely found among invertebrates, and it is likely, based on what we know of the teleost lateral line, that this end organ in invertebrates would only respond to signals of very low frequencies (well below any sonar) from sources that are within a few body lengths from the animal.

The reviewer suggests several citations that indicate invertebrates can detect sound (McCauley et al. 2000; DFO, 2004; MacKenzie 2004; Guerra et al. 2004). In each case the study was related to seismic air guns, whose underwater sound transmission characteristics do not resemble those of sonar. Seismic air guns differ from SURTASS LFA sonar in that they generally transmit in the 5-20 Hz frequency band, but they do have considerable bandwidth energy at higher frequencies. Close to the surface, Madsen et al. (2006) found that air gun pulses contain most energy between 0.3 and 3 kHz. Typical air gun array firing rate is once every 9-14 seconds, but for very deep-water surveys could be as high as 42 seconds. Broadband source levels of 248-255 dB are typical for a full-scale array, but can be as high as 260 dB. Because LFA sonar signals are usually 60 seconds (maximum 100 seconds) in length with a duty cycle of nominally 7.5 to 10 percent and the variability in tone, it is inappropriate to attempt to extrapolate animal responses between the different sound sources.

While it is hard to explain the squid results in McCauley et al. (2000), it must be remembered that these animals were in cages with other species, and it is possible that the squid, which are highly visually oriented (with excellent eyes) were responding to visual cues from other animals in or just outside the cage. More studies are clearly needed, but the most important point is that using current air gun data to attempt to extrapolate results to sonar is scientifically improper.

The Canadian Department of Fisheries and Oceans (DFO) study is problematical (DFO, 2004). Besides using air guns for the study, which makes extrapolation to sonar erroneous to begin with, there are inherent issues with the study. The DFO (2004) report indicates that the experimental results were inconclusive. The DFO (2004) report states, “There were several significant differences between the experimental results of the test and control groups, even after five months. It was not known if these differences were due to environmental differences between the test and control sites. As a consequence, nothing definitive could be said about the results until further work is done.” Also no sound exposure levels or other required details of the experiment were given, so further evaluation of this report is infeasible. When it was reviewed and discussed at a recent meeting in Halifax, Nova Scotia, it was subject to criticisms that questioned whether the results were valid. This was a well-designed study but due to technical issues during execution, the results are not compelling, and there were far too few controlled data to reach any valid conclusions about the effects of air guns on the species studied. The consensus of the reviewing scientists at the Halifax meeting was that the study is a design of some use, but it needs replication to get any useful data.

In an internet news article, MacKenzie (2004) reported that an unusually large number of dead giant squid have washed up on the Spanish shores of the Bay of Biscay coincident with seismic surveys. Guerra et al. (2004), based on examinations of the squid caucuses, claimed that the giant squid turned up around the time of seismic operations, and that the damage to the squid was unusual when compared to other dead squid found at other times. The paper presented the conclusion (unsubstantiated with any data) that the damage was related to the seismic operations.

Understanding and interpreting the results presented by the authors was very difficult since the article provided no actual data. Instead, there are broad statements made about damage in the animals including the mantle, organ systems, and the organ of equilibrium (or statocyst). From the brief descriptions given in the article, it does appear that the squid examined had some damage to them. However, it is impossible to state with any certainty the source or extent of the damage since much of the damage could have been a result of poor tissue preservation (fixation). Preservation was primarily by freezing, and this significantly damages tissue since as water in the cells freeze it expands and damages cell membranes. Moreover, normal, and often massive, tissue changes can occur quickly on the death of an animal as the animal dies and tissues no longer get blood circulated to them. In other words, without knowing more about the tissue, the time between death and preparation of the tissue, it is impossible to know the cause of the tissue condition that is reported to be due to the seismic devices. However, without knowing how the tissue was examined, or seeing images that show the actual damage, no further evaluation of the science or the findings could be completed.

The author seems to imply that the statocysts of all specimens had damage. Of course, no images were provided and there was no way to know if the investigator(s) have any experience with statocyst tissue in cephalopds and could differentiate between normal tissue, tissue that was damaged due to trauma, or tissue that was damaged due to poor preparation, freezing, or tissue decay on death. Keeping in mind that the statocysts in cephalopods are very different in terms of cells than the vertebrate ear, it is of interest to note that the sensory cells of the ears of vertebrates are very sensitive to any changes, and decays very quickly upon death, and this may be the case in cephalopods as well. Thus, one cannot realistically speculate as to the source of the damage seen in the statocyst without far more data, without seeing the tissue at the light microscopic and electron microscopic levels, and without having controls for changes in this tissue post-death.

Most importantly, the association with the seismic survey as suggested by the author is purely circumstantial and speculative. There is no substantive evidence for death by seismic exposure other than there being seismic vessels in the general area at the time of the squid death. Moreover, there are no data on the effects of seismic exposure on cephalopods (the group that includes squid). The only other work involving cephalopods was on octopus by McCauley et al. (2000) in which there were 100 percent survival of (smaller) animals even though the animals showed temporary behavioral response to the sounds.

It should be noted that Guerra et al. (2004) stated that the source level for the seismic device was 200 dB at the source (no information as to RMS or peak, or as to how this number was obtained), which suggests that the sound levels at the depth of squid was likely to be much lower. While comparing any exposure levels and effects of the squid to the octopus work of McCauley and his colleagues is *highly speculative* at best, one can suggest that the sound levels used by McCauley, and to which octopus were not damaged, were likely much higher than any levels to which these squid were exposed. Thus, either squid are more sensitive to the seismic sounds than are octopus, or the sounds did not affect squid. While it may be possible that exposure to seismic sounds potentially harmed the squid, one is not prevented from speculating that the increased number of damaged animals in a short period of time could easily have resulted from some other factors; but the association is just too weak to speculate on what that might be.

In summary, the reported damage to the tissue could have easily have been due to artifacts reflecting poor tissue preservation, and/or the effects could have been due to the tissue degrading between the time of death and the investigators getting it. Because of the lack of detailed and controlled scientific data and the apparent poor condition of the specimens when they were gotten, the article by Guerra et al. (2004) does not provide any supportable evidence that these giant squid were injured by seismic surveys.

Comment 3.2.6: Marine mammal echolocation has been shown to directly injure invertebrates, raising the question whether LF sources can do the same (Norris and Mohl, 1983). O-014

Response: The paper cited by the commenter is self-stated as being a discussion of a hypothesis entitled, “Can Odontocetes Debilitate Prey with Sound?” (Norris and Mohl, 1983). It did not show directly, or otherwise, that invertebrates can be injured by marine mammal echolocation. Benoit-Bird et al. (2006) examined this hypothesis by exposing three species of fish commonly preyed upon by odontocetes to pulsed signals at 18 kHz, 55 kHz, and 120 kHz with exposure levels of 193 dB, 208 dB, and 213 dB, respectively. They observed: 1) no measurable changes in the behavior of any of the species during the exposures; 2) no noticeable change in swimming activity; 3) no apparent loss of buoyancy; 4) no movement away from the transducer; and 5) no mortality. Despite the use of signals at the maximum source levels recorded for odontocete clicks, they could not induce stunning or even disorientation in the fish tested. Benoit-Bird et al. (2006) results do not support the hypothesis that odontocetes use their clicks alone to induce stunning in prey (fish). Because invertebrates (cephalopods) do not have swim bladders, they should be less susceptible to the above frequencies and energy levels than fish.

As stated in the SEIS (Subchapter 3.2.4.2), odontocetes echolocate in the MF and HF frequency range, not LF. Therefore, based on this fact and Benoit-Bird et al. (2006) analysis results, the Norris and Mohl (1983) hypothesis does not provide any evidence that LFA will cause injury to marine animals.

Comment 3.2.7: The audiogram for the American lobster shows sound sensitivity below several hundred Hz (Offutt, 1970). Cephalopods and decapods should not be dismissed from consideration as potentially affected organisms. I-011, O-014

Response: Cephalopods and decapods were eliminated from further consideration because: 1) they do not have delicate organs or tissues whose acoustic impedance is significantly different from water; and 2) their high LF hearing threshold. They were not eliminated from further study because they cannot sense LF sounds, but because of their high thresholds to LF sound of approximately 146 dB SEL for cephalopods and 150 dB SEL for decapods. As stated in the SEIS Subchapter 3.2.1.2:

> "While data are still very limited, they do suggest that some of the major cephalopods and decapods may not hear well, if they hear at all. We may cautiously suggest that given these high levels of hearing thresholds, 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 vessel 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."

Comment 3.2.8: The Draft SEIS exclusion of sea otters, chungungo, manatees, and dugongs is unreasonable. O-008

Response: The operation of SURTASS LFA sonar is generally restricted to water depths of greater than 200 m (656 ft). Proposed SURTASS LFA system operational restrictions and monitoring/mitigation measures require that received levels are less than 180 dB (SPL) within at least 22 km (12 nm) of any coastlines, dependent on alternative. Sea otters and chungungo are coastal, near-shore species that occupy soft- and hard-sediment marine habitats. Though little is known about the secretive chungungo, the sea otter has been studied extensively (Reeves et al. 2002). While most sea otters inhabit the area between the shore and the 20-m (65-ft) depth contour, they are occasionally observed in waters as deep as 100 m (330 ft) (U.S. Fish and Wildlife Service, 2003; Bodkin et al., 2004). Similarly, manatees and dugongs inhabit coastal, near-shore waters. The dugong displays a deep-water limit of approximately 23 m (75 ft) (Reeves et al., 2002) and, in a series of surveys in Mexico, the density of manatees dropped to 17-32 percent at distances of greater than 1 km (0.54 nm) from the coastline (Olivera-Gomez and Mellink, 2002). Given these preferences for water depths that are 100 m (330 ft) in depth or less, the geographic sphere of the acoustic influence of the SURTASS LFA sonar does not overlap with the coastal, near-shore habitats of the sea otter, chungungo, manatee or dugong; and thus they are excluded from the analysis of potential effects.

Fish and Sharks

Comment 3.2.9: Has sonar noise caused sharks to come near shore and attack swimmers and surfers? I-007

Response: There is no evidence that sonar-generated noise has caused sharks to move closer to shore and attack swimmers and surfers. Additionally LFA sonar use is restricted from operating in coastal waters within 12 nm (22 km) of shore, in offshore biologically important areas, and in known recreational or commercial dive sites. These are the areas of the greatest levels of human activity and therefore the areas of the majority of shark attack incidents.

See FOEIS/EIS Subchapters 3.2.2.3 and 4.1.1.2 for further information on the potential effects of LFA on sharks. This information is elaborated upon in SEIS Subchapters 3.2.2.3 and 4.1.2.

Sea Turtles

Comment 3.2.10: Are there migratory corridors for leatherback turtles in the Atlantic as well as the Pacific Ocean? I-011

Response: Satellite tracking of leatherback turtles in the North Atlantic Ocean shows that female and male turtles disperse over the entire ocean basin and do not exhibit the relatively narrow migration corridors that have been documented in the Pacific Ocean (Ferraroli et al., 2004; James et al., 2005).

Cetaceans

Comment 3.2.11: The southern resident orca population has been recently listed as endangered. Although these orcas frequent coastal waters inshore of proposed LFA operations, during many times of the year, they (and other orca populations) also swim in ocean waters that may potentially have LFA operations. O-009

Response: The Southern Resident Stock of killer whales was listed as endangered under the ESA on November 15, 2005 (70 FR 69903). This information was included in the Biological Assessment and LOA Application that were submitted to NOAA Fisheries in May 2006. This information has now been added to the killer whale species description in SEIS Subchapter 3.2.4.2. It should be noted that killer whales are considered in the analysis of potential effects at mission sites where their presence has been documented (e.g., SEIS Mission Site #2, Table 4.4-3).

Comment 3.2.12: The latest worldwide sperm whale estimates have not been cited (Whitehead, 2002a). Whitehead (2002a) is not the first person to have realized that the sperm whale is the largest odontocete. Estimates of worldwide sperm whale numbers over 1 million are invalid. I-011, O-010

Response: As Whitehead (2002a) states, there are several existing hypotheses about the current estimate of sperm whale numbers worldwide. The recent work by Whitehead (2002a) has been incorporated into the SEIS Subchapter 3.2.4.2, with the following edit: There is much uncertainty associated with global population estimates of sperm whales. Estimates vary from 300,000 (Whitehead, 2002a) to almost 2 million (Rice, 1989; Reeves and Whitehead, 1997). The best abundance estimates for the sperm whale in the western north Pacific Ocean is 102,112 individuals (CV=0.155) (Angliss and Lodge, 2005).

Comment 3.2.13: When first introducing beaked whales, the Draft SEIS should state that the reason Ziphiidae are not listed under MMPA, ESA, or IUCN, is because they are data-deficient. Thus, they may be endangered, but not enough is known to say. I-011, O-010

Response: Ziphiidae are protected under the MMPA and the CITES. In the IUCN Redlist (www.iucnredlist.org), Arnoux's beaked whale, Baird's beaked whale, northern bottlenose whale, and southern bottlenose whale are listed as LR/cd (Lower Risk/conservation dependent) indicating that they are not critically endangered, endangered, or vulnerable, but that they are the target of a conservation program that if ended, would result in the taxon qualifying for one of the threatened categories within five years. The *Mesoplodon* spp., Shepherd's beaked whale, and Cuvier's beaked whale are listed as Data Deficient under the IUCN Redlist, indicating there is insufficient information to assess the taxon's risk of extinction and acknowledges that future research may show that threatened classification is appropriate. This information has been added to SEIS Subchapter 3.2.4.2.

Comment 3.2.14: The Gully population of northern bottlenose whales has been assessed by COSEWIC (the official Canadian independent panel of scientific experts) as endangered. It is not mentioned in the Draft SEIS that the Gully population is resident year-round. Instead, there is reference to migrations in the Draft SEIS, which is inaccurate for this discrete, non-migratory population. Winn et al. (1970) is based on one encounter and is not considered well-documented. It has been largely superseded by the research mentioned subsequently and thus should be deleted. I-011, O-010

Response: The Scotian Shelf population of northern bottlenose whale was listed as endangered under Canada's SARA and designated as endangered by the COSEWIC in November 2002. The Scotian Shelf population appears to be non-migratory, unlike other northern bottlenose whale populations. For example, the Labrador population migrates to the southern portion of their range, between New York and the Mediterranean, for winter months. This information has been added to Final SEIS Subchapter 3.2.4.2 to clarify the unique nature of the Scotian Shelf population. The sentence referencing the Winn et al. (1970) paper has been deleted.

Comment 3.2.15: Our general impression of Section 3 is that it is often inaccurate and not well-referenced (not the most appropriate references are used). Ex.: p. 3.2-73 "Audiograms for Risso's dolphins indicate their hearing SLs equal to or less than approximately 125 dB in frequencies ranging from 1.6-110 kHz." We assume RLs are meant here? I-011, O-010

Response: The Navy updated the species analyses in Chapter 3 of the FOEIS/EIS by reviewing and incorporating newer references for all species, as well as their ecosystems. The Navy will review and incorporate, where appropriate, any recommended references to improve SEIS Chapter 3. The reference to audiograms for Risso's dolphin should be RL, not SL. This correction has been made in the SEIS.

ISSUE 3.3 Socioeconomics

Comment 3.3.1: Why are costs (trash, ship strikes, pollution from boats) to only whale watching listed in section 3.3.2? What about tourism in general? I-011, O-010

Response: The Navy analyzed the costs to whale watching and not tourism as a whole because, aside from whale watching, scuba diving, and snorkeling, the Navy does not expect any other tourism activities to have the potential to be affected by SURTASS LFA sonar.

Comment 3.3.2: Why are whale watching's impacts on whales being evaluated here? The Draft SEIS is supposed to address the impact of LFA sonar. I-011, O-010

Response: The potential effects to whale watching are evaluated because there are requirements to analyze the potential for social, economic and cumulative impacts from SURTASS LFA operations. SEIS Subchapter 3.3.2 discusses recreational activities that may be affected by SURTASS LFA. SEIS Subchapter 4.5 analyzes the potential socioeconomic effects on commercial and recreational fishing, recreational activities (including whale watching), and research and exploration activities. SEIS Subchapter 4.6 then discusses potential cumulative impacts, including changes in ocean noise, commercial shipping, oil and gas industry, and military and commercial sonar. Whale watching impacts are presented due to the requirement to evaluate cumulative impacts, or the impacts caused by both whale watching and other recreational activities in relation to potential effects from SURTASS LFA sonar.

Comment 3.3.3: How can it be concluded that LFA has not harmed whale watching when LFA operations to date have been restricted to around Taiwan, an area not known for its whale watching industry? O-010

Response: The conclusion in the FOEIS/EIS that SURTASS LFA sonar is not expected to have significant impacts on whale watching is based on the operational restrictions in coastal waters and OBIAs. These are also areas of prime whale watching activities. (See FOEIS/EIS p. 4.3-5.) According to the *Taipei Times* (23 September 2004), the growing whale watching industry in Taiwan numbers over 33 boats taking out an estimated 220,000 tourists per year.

Comment 3.3.4: I disagree with the contention that LFA would not affect whale watching unless LFA were nearby. What if whale stocks suffer a slow decline or vacate certain areas due to intermittent or persistent, moderate noise levels from LFA? I-011

Response: There is no evidence that LFA operations have caused any decline (slow or otherwise) in whale stocks or have ever caused whales to vacate an area. It should be noted that because LFA sonar operations are short duration exercises in limited areas and mitigation eliminated injurious effects, it is unlikely that LFA sonar would result in population declines, especially when compared to whaling and bycatch causes of mortality.

Comment 3.3.5: Canada is not mentioned in the Draft SEIS text (p. 3.3-9) as allowing aboriginal whaling, though it does. It is stated in tables, however. O-010

Response: Under the current IWC regulations, aboriginal hunting is only permitted for Denmark, the Russian Federation, St. Vincent and the Grenadines, and the U.S. (IWC, 2006). Canada was not listed in the Table 3.3-6 because it is not a member of the IWC. Table 3.3-6 has been updated in the SEIS to show subsistence hunting from 2001 through 2005.

Comment 3.3.6: Why is bycatch listed under socioeconomic impacts of LFA? LFA can certainly potentially affect the health of fish populations, and thus fisheries, but how does LFA impact bycatch specifically? Masking from LFA could prevent or hinder marine mammals from detecting fishing gear and thus contribute to bycatch, but this argument is not made in the Draft SEIS and the rationale should be made more explicit. Otherwise, the bycatch section can be misread as a ploy to downplay the impacts LFA could cause, by pointing the finger at bycatch instead. Again, this logic would entirely miss the point of cumulative or synergistic impacts. I-011, O-010

Response: Bycatch was discussed to provide necessary information for analysis of the potential for cumulative impacts in SEIS Subchapter 4.6. SURTASS LFA sonar is not expected to affect the amount of bycatch from fisheries. However, it is appropriate to examine bycatch relative to other anthropogenic impacts to marine mammals and other marine resources. Since SURTASS LFA sonar is not expected to cause lethal takes of marine animals, it will not increase the total number of marine animal deaths.

The masking effect of the SURTASS LFA signal will be limited for a number of reasons. First, the bandwidth of the system is limited (30 Hz). Second, the instantaneous bandwidth at any given time of the signal is small, on the order of 10 Hz. Therefore, within the area in which masking is possible, the effect will be limited because animals that use this frequency region typically use broader bandwidth signals. The potential for a marine animal's signals to be entirely masked by an LFA transmission will only rarely occur. Finally, the low duty cycle of 7.5 to 10 percent (based on historical LFA operational parameters) means that at least 90 to 92.5 percent of animal signals cannot be affected by LFA transmissions. Therefore, masking from LFA would not be expected to prevent or hinder marine mammals from detecting fishing gear and would not contribute to bycatch. See SEIS Subchapters 4.1.1.5, 4.1.2.6, 4.2.5, and 4.3.5 for further discussions on masking.

Comment 3.3.7: Commenter doesn't understand the logic that many recreational activities would not be affected by LFA because they do not involve the creation of underwater sound. So only serious consideration needs to be extended to other noise producers, so that LFA does not interfere with their noise? Recreational boaters, divers, swimmers, and snorkelers will likely have a different opinion. I-011

Response: SEIS Subchapter 3.3.2 stated, "Many of these activities would not be affected by SURTASS LFA 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." Serious consideration is not extended only to noise-producers. All marine recreational activities, including swimming, snorkeling, recreational diving, and whale watching are considered, both for the effects SURTASS LFA sonar may have on the activities, and if there may be cumulative effects. Recreational boaters, divers, swimmers, and snorkelers are considered and discussed in SEIS Subchapter 3.3.2. It is determined that since boaters are above the surface of the water, they would not be affected by SURTASS LFA sonar. Since most swimming and snorkeling sites are located within 5.6 km (3 nm) of the coast and recreational diving sites are generally located between the shoreline and the 40 m (130 ft) depth contour, and since SURTASS LFA sonar cannot operate within 12 nm (22 km) of the coastline and sound fields must not exceed 145 dB RL inside of the 40-m (130-ft) isobath, divers, swimmers and snorkelers are not expected to be affected by SURTASS LFA sonar, and no cumulative effects are anticipated.

CHAPTER 4 IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

ISSUE 4.0 General Comments

Comment 4.0.1: Draft SEIS assumption of no potential for injury below 180 dB is unjustified. O-008

Response: The 180-dB injury criterion is based on scientific documents and research, which are provided in the FOEIS/EIS Subchapter 1.4.2.1, and Chapter 10 RTCs 4-4.9, 4-5.1, 4-6.1, 4-6.13, and 5-2.1. In its Final Rule for the operation of SURTASS LFA sonar (67 FR 46721-89), NMFS discussed the 180-dB criterion in its responses to comments SIC44 through SIC49.

Since the FOEIS/EIS was published in early 2001, there has been additional research published in a peer-reviewed journal that supports the 180-dB criterion for injury as being a conservative level for assessing potential injury to marine mammals. Laurer et al. (2002) from the Department of Neurosurgery, University of Pennsylvania School of Medicine, exposed rats to 5 minutes of continuous high intensity, low frequency (underwater) sound (HI-LFS) either at 180 dB SPL re 1 µPa at 150 Hz or 194 dB SPL re 1 µPa at 250 Hz, and found no overt histological damage in brains of any group. Also, blood gases, heart rate, and main arterial blood pressure were not significantly influenced by HI-LFS suggesting that there was no pulmonary dysfunction due to exposure. This published paper was based on work performed in support of Technical Report #3 of the SURTASS LFA Sonar FOEIS/EIS.

From 2003 to 2006, the University of Maryland conducted a series of studies to test the effects of high intensity LFA sonar on fishes. These studies, which tested the effects of an actual LFA sonar transducer, examined the changes in hearing capabilities, changes in the mechanical structures of the ear, and the effects on other organ systems, including the swim bladder and brain. Detailed information on the experiment is provided in the Final SEIS Subchapter 4.1.1.3. The results of the study are still being analyzed and will be submitted for scientific publication. Preliminary examination of the data show that there is no permanent hearing loss in either species studied (the rainbow trout [*Onchorynchus mykiss*]—a close relative of endangered and listed salmonid species, and the channel catfish [*Ictalurus punctatus*]—an example of a hearing specialist). Both species showed some temporary hearing loss. This was not of great magnitude, and hearing returned to normal within a day or so after exposure. Results suggest no effect on other organ systems; for example, the swim bladder in fish exposed to the LF sonar signal was completely intact. Moreover, all animals survived the experiments and none died, even several days after exposure. The sound levels (up to 193 dB rms RL) used in these experiments approached those that fish would encounter very close to an active LFA source array (within 200 m [656 ft]). However, the exposure during 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 the successive emissions from the source would decrease in intensity as the ship moved away from exposed fish.

Comment 4.0.2: Draft SEIS is flawed because it centers its entire analysis on a questionable premise—a sound pressure level threshold of 180 dB RL for marine animal impact. O-013

Response: The SPL threshold of 180 dB RL was only for potential injury impacts and not for other impacts, such as significant behavioral modifications. See SEIS RTC 4.0.1 above.

Comment 4.0.3: Non-auditory injury can conceivably occur below 180 dB RL, in contrast to what is implied on Draft SEIS p. 4-2. Moreover, not only resonance, but effects such as static diffusion fall under this category. I-011, O-010

Response: Cox et al. (2006) stated that gas-bubble disease, induced in supersaturated tissues by a behavioral response to acoustic exposure, is a plausible pathologic mechanism for the morbidity and mortality seen in cetaceans associated with sonar exposure. They also stated that it is premature to judge acoustically mediated bubble growth as a potential mechanism and recommended further studies to investigate the possibility.

The theory that naval sonar activity in Greece, Bahamas, Madeira, and Canaries caused the strandings by inducing behavioral reactions in the beaked whales which then led to direct stranding or possible injury from bubble growth from rapid ascents is partially based on the transmission characteristics, including pulses with rapid onset and decay times, at depths shallower than 10 m (32.8 ft) (Cox et al., 2006). The LFA transmit array is at a depth well below 10 m (32.8 ft). While it is true that there was a low-frequency component to the sonar employed in the Greek stranding in 1996, only mid-frequency sonar components were utilized in the strandings in the Bahamas in 2000, Madeira 2002, and Canaries in 2002. This supports the logical conclusion that the LF sonar component in the Greek stranding was not causative (ICES, 2005; Cox et al., 2006). In its discussion of the Bahamas stranding, Cox et al. (2006) stated, “The event raised the question of whether the mid-frequency component of the sonar in Greece in 1996 was implicated in the stranding, rather than the low-frequency component proposed by Frantzis (1998).” The ICES in its “Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish” raised the same issue as Cox et al. stating that the consistent association of MF sonar in the Bahamas, Madeira, and Canary Island strandings suggest that it was the MF component, not the LF component, in the NATO sonar that triggered the Greek stranding of 1996 (ICES, 2005).

Also, most odontocetes have relatively sharply decreasing hearing sensitivity below 2 kHz. If a cetacean cannot hear a sound or hears it poorly, it is unlikely to have a significant behavioral impact (Ketten, 2001). Therefore, it is unlikely that LF transmissions from LFA would induce behavioral reactions from animals that have poor LF hearing, such as beaked whales. While it is highly unlikely, the sounds could damage tissues even if the animal does not hear the sound, but this would have to be occur within the 180-dB sound field (within 1,000 m [3,280 ft] of the transmit array.

The issue of resonance is addressed in SEIS RTC 2.5.2 above. This response concluded that the analysis by the Navy (Cudahy and Ellison, 2002), reports on two workshops on acoustic impacts

(DOC, 2002; Cox et al., 2006), and the NRC Ocean Studies Board (NRC, 2005) support the conclusion that resonance from LFA operations is not a "reasonably foreseeable" impact.

Comment 4.0.4: If trained, informed Navy qualified divers can't stand LF sonar for even 15 minutes at 160 dB, why does the Navy feel they can expose marine life to a level hundreds or thousands of times more powerful than that? I-021

Response: As stated in the FOEIS/EIS RTC 4.6-21 (p. 10-122), these values represent different criteria: psychological aversion (a behavioral reaction) from direct measurements with human divers (Technical Report #3), and the exposure level at or above which all marine mammals are evaluated as if they are injured (FOEIS/EIS Subchapter 1.4). Also, as stated in the FOEIS/EIS RTC 4-9.5, the divers involved in the study were recreational divers, not Navy qualified divers.

Critical variables in the response to sound are intensity, duration and duty cycle. The 15 minute exposure was continuous (100 percent duty cycle) at 160 dB SPL. The LFA sonar source does not operate in that fashion. The pulses are less than 2 minutes and occur at least 10 minutes apart (< 20 percent duty cycle). Due to this difference, the psychological impact is less for the LFA system than for the continuous 15 minute exposure. The continuous exposure was used in the research studies to generate a conservative estimate of the impact with a correspondingly conservative guidance. Furthermore, the movement of the ship relative to any marine life means that the exposure intensity will not be maintained at the highest levels for the entire duration of the signal. This will also reduce the impact.

Comment 4.0.5: Draft SEIS vastly underestimates the effects (sonar-related injuries) of LFA sonar on marine life, such as fish and threatened and endangered sea turtles, because not all organisms that are affected are likely to strand or wash ashore. O-012

Response: The Navy's analysis was not restricted to the issue of whether or not potentially affected organisms strand or wash ashore. Instead, the Navy examined the larger issue is whether these organisms could possibly be exposed to LFA sonar at levels that have the potential to cause injury. As stated in the SEIS, all marine animals exposed to ≥ 180 dB RL are evaluated as if they are injured. SEIS RTCs 4.0.1 and 4.0.3 above discuss the continued validity of the 180-dB injury criterion. Analyses in both the FOEIS/EIS and Draft SEIS determined that with mitigation the potential impacts on any stock of marine mammals from injury is considered negligible and the effects on the stocks of any marine mammal from significant changes in biologically significant behavior is considered minimal. This is supported by the research results of the LFS SRP, which found minimal behavioral responses to LFA signals, and the fact that current LFA sonar operations have not been associated with any known stranding events.

Comment 4.0.6: Throughout the document, the Navy states that the SURTASS LFA ships move in two dimensions whereas marine animals move in three dimensions. It uses this logic to state that the amount of time that an animal will be in the sonar transmit beam is very low. However, sound propagates in three dimensions so this logic is flawed. I-011, O-013

Response: The Navy agrees that this statement in the Draft SEIS (Subchapters 4.1 and 4.2) needs clarification. It has been rewritten in the Final SEIS as follows:

> “Slowly moving ship, coupled with low system duty cycle, would mean that fish and sea turtles would spend less time in the LFA mitigation zone (180-dB sound field); therefore, with a ship speed of less than 5 knots, the potential for animals being in the sonar transmit beam during the estimated 7.5 to 10 percent of the time the sonar is actually transmitting is very low.”

Comment 4.0.7: Draft SEIS minimizes impacts by emphasizing the small number of SURTASS LFA systems to be employed and the narrow bandwidth of the active sonar signal. It is the intensity and pervasiveness of the LFA sonar that is important in the discussion of impacts. O-013

Response: Even though the source level of SURTASS LFA sonar is similar intensity to many anthropogenic underwater sound sources, such as air gun arrays and other military sonars, there are significant differences in their operational characteristics (See SEIS RTC 4.3.1 for more details). In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (U.S.) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. He reported that the most energetic regularly-operated sound sources are seismic air gun arrays from approximately 90 vessels with typically 12 to 48 individual guns per array, firing about every 10 seconds There are approximately 11,000 super tankers worldwide, each operating 300 days per year, producing constant LF noise at source levels of 198 dB (Hildebrand, 2004). Conversely, LFA signals are transmitted for a maximum of 432 hours (18 days) per vessel per year. The signal length is between 6 to 100 seconds with 6 to 15 minutes between transmissions with individual elements sources levels of 215 dB. Therefore, LFA contributes less acoustic energy to the oceans than other sources. For more detailed discussions of Hildebrand (2004), see SEIS RTCs 4.6.4 and 4.6.5. Pervasive means to permeate or be present throughout. Even though LFA signals are long range, LFA sonar cannot be considered to be pervasive because of the nominal 7.5 to 10 percent duty cycle—meaning that during any given mission LFA it is not transmitting 90 to 92.5 percent of the time.

Comment 4.0.8: The Draft SEIS states that for fish exposed to intense noise there was no damage to tissues either at the gross or cellular level. But there was for snow crabs and several tissues were affected both at the gross and cellular levels (DFO, 2004). Research on the effects of seismic air guns on snow crabs (DFO, 2004) also showed that some organs and ovaries of animals exposed were bruised and hemorrhaging compared to controls, ovaries were abnormal, there were changes in some organs consistent with a response to stress, embryo development appeared delayed, larvae were slightly smaller, and there were indications of greater leg loss. I-011

Response: The DFO (2004) results were inconclusive. The report states, “There were several significant differences between the experimental results of the test and control groups, even after five months. It was not known if these differences were due to environmental differences between the test and control sites. As a consequence, nothing definitive could be said about the results until further work is done.” Also no sound exposure levels or other required details of the experiment were given, so further evaluation of this report is infeasible. For additional information, see SEIS RTC 3.2.5.

Comment 4.0.9: Are sonar buoys themselves toxic when left on the ocean floor? I-019

Response: Routine SURTASS LFA sonar operations do not include the deployment of sonobuoys. Therefore, this issue is outside the scope of both the FOEIS/EIS and the SEIS.

ISSUE 4.1 Potential Impacts on Fish

Comment 4.1.1: Are the recent studies on fish undertaken by the Navy peer-reviewed? I-011, O-010

Response: They are now being written up for submission to peer-reviewed scientific journals. They have been presented at national and international meetings, including Acoustical Society of America (ASA) 2004 and 2005 (Popper, et al., 2005a: Halvorsen et al., 2006). A manuscript has been accepted for publication in JASA.

Comment 4.1.2: A significant amount of research discussed in the Draft SEIS shows fish respond to sound in the low frequency range which also shows a paucity of research on impacts of very high dB sound, the SEIS proposes no monitoring or mitigation for protecting oceanic fish stocks. This monitoring and mitigation would provide valuable data with which to evaluate impacts of other very loud sounds. I-002

Response: The Draft SEIS (Subchapters 4.1.1.3, 4.1.1.4, 4.1.1.5 and 4.1.1.6) and SEIS RTC 4.0.1 above discuss the fish controlled exposure experiments being conducted by the University of Maryland. The sound levels (up to 193 dB RL) used in these experiments approached those that fish would encounter very close to an active LFA source (approximately 200 m [656 ft]). Results from these experiments provide evidence that SURTASS LFA sonar sounds at relatively high levels have minimal impacts on the reference species of fish studied (the rainbow trout [*Onchorynchus mykiss*]—a close relative of endangered and listed salmonid species, and the channel catfish [*Ictalurus punctatus*]—an example of a hearing specialist). The use of these two species as reference species to determine the potential effects of LFA on other fish species is discussed in SEIS RTC 4.1.11. The exposure during 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 intensity as the ship moved away from exposed fish. While the proposed mitigation monitoring requirements (SEIS Subchapter 5.2) do not have the fidelity required to provide scientific data on the potential effects of transmissions on individual fish or fish stocks, the HF/M3 sonar is likely to detect large fish or fish schools through swim bladder reflections and thereby result in termination protocols preventing injury to fish.

Comment 4.1.3: By focusing on two freshwater species under experimental laboratory conditions, the Navy continues to trivialize the science of biological impacts of underwater noise and ignore recent studies *in situ* suggesting severe impacts on fisheries from sources of ocean noise, including low frequency sources. I-012, O-005, O-012

Response: The Navy did not ignore recent studies on potential impacts on fisheries. The SEIS, Subchapter 4.1, discusses numerous studies concerning injury, hearing loss, behavioral changes, and masking. This comment cannot be addressed further because the commenter did not specify which studies he/she considers the Navy ignored.

Two species indigenous to Seneca Lake were chosen for study. Rainbow trout (*Onchorynchus mykiss*), a hearing generalist, was selected as a surrogate for several species of salmonids that are listed under the ESA because they are all members of the same genus. The second species used was the channel catfish (*Ictalurus punctatus*). In contrast to the rainbow trout, the channel catfish is a hearing specialist. More details on fish species studied and the rationale for their choice are provided in the SEIS (Subchapter 4.1.1.3).

Comment 4.1.4: Sound can do great harm to fish stocks. Earth Island suspects the adverse impacts of military sonars on fish may be greater than the impacts on whales and dolphins. Commenters have noticed that our fish supplies have been affected. But the Navy's Draft SEIS dismisses such concerns and provides no mitigation. The Navy claims that mitigating the LFA Sonar system for fish is "impractical." Given the importance of fish resources for the world's hungry and the wide impacts of LFA Sonar on such resources, we find the overall SEIS inadequate in addressing this important issue. Many fish species could be disturbed as a result to LFA sonar and fisheries could be affected. I-018, I-052, I-054, I-055, I-056, O-011, O-012

Response: There is no evidence that "sound can do great harm to fish stocks." The SEIS discussed several studies which examined fish catch rates before and after presentations of sounds from seismic air guns (SEIS Subchapter 4.1.1.4). These studies noted a temporary decline in catch rate for trawls and longlines. The real point here is that the exposure to seismic air guns was over a much longer time frame than those projected for LFA sonar. Moreover, there are significant acoustic differences between the impulsive sounds of air guns and the coherent sounds of LFA sonar. Thus, it is scientifically improper to extrapolate from these studies to LFA. Since exposure times to LFA is so much shorter than to seismic air guns, it is reasonable to suggest that any behavioral effects from LFA signals will be minor and transitory.

In the LFA fish exposure studies (SEIS Subchapters 4.1.1.3 and 4.1.1.4), fish were exposed to 324 seconds of sonar at levels (193 dB RL) that would only occur within 200 m (656 ft) of the LFA source array. This was done to give a worst-case situation. In "real life," the sonar is on a moving platform and so fish would only be exposed to maximum signal levels (perhaps similar to that used in the LFA fish experiments, but probably of lower sound level unless the fish were within 200 m [656 ft] of the LFA source array) for only a few seconds at a time, not for the over 5 minutes in the experiment. The likelihood of a fish school (or even a few fish) being exposed at the sound levels and for the durations of sound exposure given in the LFA studies must be considered negligible.

In the SEIS, Subchapter 2.5.2.2, it was stated that the implementation of fish mitigation procedures was impractical, given that visual monitoring cannot be relied upon to detect fish schools, passive acoustic detection is infeasible, and active acoustics would give so many false alarms that the impact on the effectiveness of the military readiness activity (and, hence impact on National Security) would be very high. Moreover, the potential for a fish or school of fish to be harmed (thus impacting fish stocks) by exposure to LFA signals (within 200 m [656 ft] of the LFA source array) based on recent field research results is negligible. See Final SEIS Subchapter 4.1.1 and SEIS RTC 5.2.16.

Comment 4.1.5: The sound use in the fish CEE was considerably lower than peak LFA sonar noise. I-018

Response: In the LFA studies, fish were exposed to 324 seconds of sonar at 193 dB RL. This level would only occur within 200 m (656 ft) of the LFA source array. See SEIS RTC 4.1.6 below for more information.

Comment 4.1.6: 24 hours of compromised hearing in catfish and some rainbow trout is not trivial and could have survival consequences. There is a logical leap made when a study that examined only obvious physical effects from LFA on two fish species is used to conclude that LFA will not impact fish populations and thus not recreational or commercial fishing. If a concentrated fish school were to suffer temporary hearing loss for 24 hours, it is quite possible population effects would result. The fish school would be vulnerable to predation, would perhaps be unable to communicate, and thus not mate or stay in contact with each other. I-011

Response: While it is theoretically possible that a concentrated school of fish could experience TTS over a 24-hour period, the likelihood of a fish school (or even a few fish) being exposed at the sound levels and for the durations of sound exposure given in the LFA studies must be considered very unlikely. In the LFA studies, fish were exposed to 324 seconds of sonar at levels that would only occur within 200 m (656 ft) of the operational LFA source array. This was done to give a worst-case situation. In "real life," the sonar is on a moving platform and so fish would only be exposed to maximum signal levels (perhaps similar to that used in the LFA fish experiments, but probably of lower sound level unless the fish were within 200 m of the source) for a few seconds. Based on other research experiments (Scholik and Yan, 2001; Smith et al., 2004 a, b; Wysocki and Ladich, 2005), it is unlikely that such a signal would result in any TTS. See SEIS RTC 4.1.11 for additional information.

Comment 4.1.7: The apparent "freezing" response of the catfish during exposure to LFA noise is a behavior that could affect their survivability in the wild. It is difficult to conclude that lower exposure levels would have produced less of a response—they might have produced the same behavior pattern. Results often turn out to be counter-intuitive, such as when longer duration exposures produced less hearing loss in the rainbow trout or the fact that there was more hair cell damage with increasing time after the acoustic insult (as in the McCauley et al. [2003] study). The seasonal variation in hearing loss is also reason for caution. Would the same results of the recent LFA exposure study apply at other water temperatures? Could there be more hearing loss? Was stress measured, particularly in light of the recent study by Wysocki et al. (2005) on ship noise? I-011

Response: The catfish did not freeze. They were moving but facing the source, just as if a person heard a sound and faced it to try to determine what it was.

There are no data to show that longer duration sounds produced less hearing loss in trout. Indeed, the trout data are very interesting in that we have new evidence to suggest that developmental issues or even genetic differences between fish may affect how much hearing loss is seen. But, hearing loss was never more than 10 or 15 dB at 400 Hz, and to date, the majority of trout show no hearing loss at all.

The greater hair cell loss over time reported in McCauley et al. (2003) is understood in terms of length of time that cells take to die, or dying cells cause other cells to die. This is not atypical of other pathological conditions.

The question of water temperature is more difficult to address; but since both the experimental and control animal groups were all at the same temperature, this would negate any temperature effects.

Hormonal effects were not addressed per Wysocki et al. (2005), but these effects seen by Wysocki et al. were very small and cleared up quickly (as they did in Smith et al., 2004a), suggesting that fish acclimatize quickly. It should be noted that both the Wysocki and Smith studies had long-duration exposures on the order of weeks), whereas the LFA sonar studies had far shorter-duration exposures (max a little over 5 minutes).

Comment 4.1.8: Why are resonance effects in fish not addressed here, if marine mammal air spaces are thought too large? Low frequency sounds certainly caused swim bladder rupture in fish studies by Turnpenny et al. (1994). Even though there is some criticism of the study, it is impossible to rule out these effects entirely, especially for all species, at all depths, at all life stages, in all water temperatures, etc. I-011, O-010

Response: Resonance of fish swim bladders is discussed in the FOEIS/EIS Subchapter 4.1.1.1 and RTC 3-2.5. A subsequent analysis by Cudahy and Ellison (2002) of the potential for resonance from SURTASS LFA signals to cause injury supports this conclusion that tissue damage will not occur at SPLs below 180 dB.

As to Turnpenny et al. (1994), the research was comprised of a series of experimental trials to determine the effects on selected fish species of pure-tone burst signals similar to sonar systems. SPL was the issue, not resonance. The results reported by Turnpenny et al. (1994) were evaluated by experts in the fields of acoustics and bioacoustics and found to be seriously lacking in several areas due to poor protocols. Thus, the actual SPL to which the fish were exposed was not known. But more importantly, the results reported are not supported by recent studies on both seismic airguns (Popper et al., 2005b) and the SURTASS LFA sonar fish controlled exposure experiments (Popper et al., 2005a; Halvorsen et al., 2006) (see SEIS Subchapter 4.1.1) where the sound fields were highly calibrated by expert underwater acousticians and where the sound fields were, potentially, much higher than those used by Turnpenny et al. (1994).

Comment 4.1.9: The Gausland (2003) document should be ignored. Its statistics are entirely invalid. It uses the same data as Engås et al. (1996) yet splits them up for no valid reason, and then notes they are no longer statistically significant. Anytime you split the data up, you will lose statistical power, so it is no surprise that this sort of manipulation will result in insignificant results. This in no way invalidates the Engås et al. (1996) study, and moreover, is an incorrect use of the data. To say that the variation Engås et al. (1996) noted is within normal fishing season variation is neither here nor there. The fact is that the variation occurred under a systematic study and was related to when seismic exposure was present compared with when not. The results were dramatic, obvious, and large scale. That there is variation in catch rates over several fishing seasons is well-known (however, the Engås et al (1996) study occurred over one fishing season, not over many). What happens when there are low catch rates due to oceanographic factors and then seismic exposure reduces them even further? These are the sorts of synergistic or cumulative impacts that can cause tremendous damage to fish populations. This argument offers no valid rationale for criticizing the Engås et al. (1996) study. Quite the contrary, it provides more reason for caution. I-011, O-010

Response: The exposure to seismic air guns in the Engås study was over a much longer time frame than any LFA sonar exposure. Moreover, as stated several times in the SEIS and SEIS RTCs, there are significant acoustic differences between the impulsive sounds of air guns and the coherent sounds of LFA sonar. Thus, it is not possible to extrapolate from the Engås study to LFA. And, since the time between signals (potential exposures to LFA) is much shorter for seismic air guns (9 to14 seconds) than to LFA (6 to 15 minutes), it is reasonable to infer that any behavioral effects from LFA will be transitory. The Gausland study is not ignored because it raises a realistic alternative explanation for the observed data; that there was a systematic change in fish numbers in the areas over the course of the study (Gausland, 2003).

Comment 4.1.10: The Wardle et al. (2001) study did show some indications of change in the long-term day-to-night movements of Pollock. A clear and repeated C-start reaction was also present in some fish, which could cause stress and otherwise affect survivability. The fact that fish did not seem to leave with exposure to seismic noise is hardly surprising. These are reef fish tied to their territory and there are many documented cases of animals staying near damaging noise, even to the point of injury. I-011

Response: This comment is a misinterpretation of the Wardle et al. data. The field research was done on a reef off Scotland in cold waters. The authors indicate that two pollock did move away a bit, but it is likely that this was a result of the air gun and the camera being in their territory. The authors point out that the primary reaction of the fish on the reef took place when the fish could *see* the airgun explosion and not when they could not see it. When fish could not see the air gun explosion they did sometimes show a c-start[1], but then continued to swim to the airgun, which was the path they were swimming in. Nothing in Wardle et al. (2001) suggests that the fish were bothered or disturbed more than transiently by the airgun.

Comment 4.1.11: On the one hand, the Draft SEIS urges caution in extrapolating between species, yet summarily concludes that there will be negligible impact on fish from LFA exposure. Again, behavioral changes or stress are all but ignored. I-011, O-010, O-012

[1] C-start is a twist of the body of the fish at the onset of a stimuli and then rapid movement away from the stimuli.

Response: The commenter is right in that one must be very cautious in extrapolation between fish species due to their very broad diversity, and the very large number (25,000+) of extant species. It would, of course, be impossible to test even all of the species most likely to be exposed to LFA to determine effects. The Fish CEE therefore concentrated on the fish species with the potential to be most effected by LFA—listed salmonid from the order *Salmoniformes*. Because the rainbow trout (a hearing generalist) is of the same toxemic genus, they have similar, if not identical, ears and hearing sensitivity, they can be used as "reference species" to determine the potential effects on other salmonid and, more generally, on other hearing generalist. Channel catfish were selected for the CEE to be reference species for hearing specialist. Thus, one must examine select species and use them as "reference species." From the perspective of the University of Maryland studies, the rainbow trout and the channel catfish are excellent reference species for fish that do not hear well (trout) and those that do hear well (Catfish). At the same time, more recent studies at the same site on black perch and large mouth bass, which are still being written up and analyzed, suggest even less of an effect (and no mortality or physical damage) to these additional two species.

It is assumed that the commenter is looking for field behavioral responses – something that are not available for LFA sonar. At the same time, work by Wardle et al. (2001) using seismic airguns (again, very different sources than LFA sonar) and watching fish on a reef showed no responses during exposure to loud sounds. In the LFA fish studies conducted by the University of Maryland, there was no mortality whatsoever, and the fish behavior (albeit in cages) did not differ between animals before or after exposure or from control animals. Stress, and particularly behavioral stress, is very hard to study in fish. The only data suggesting stress responses to sound in fish come from long-term exposures with physiological, not behavioral, responses to stress (Smith et al., 2004a). This would be a good future topic to address, but there are tremendous complexities in studying stress hormones that are hard to overcome.

There are scientific data gaps regarding the potential for LFA to cause stress in fish. Even though exposure to LFA may be more than one time, the intermittent nature of the LFA signal, its low duty cycle, and the fact that both the vessel and animal are moving, provide a very small chance that LFA exposure for individual animals and stocks would be repeated over extended periods of time, such as those caused in the above studies. Therefore, impacts from stress are not a reasonable foreseeable significant adverse impact on fish and fish stocks from exposure to LFA.

Comment 4.1.12: This Draft SEIS repeatedly urges caution when extrapolating between fish species or between fish and sharks, for instance, but then goes on to do just that. O-010

Response: The SEIS did not directly extrapolate between species, but compiled the results of several studies to determine the potential for LFA signals to affect fish. See SEIS Subchapter 4.1.1 and SEIS RTCs 4.1.3 and 4.1.11 above for additional information. The determination that the effects of SURTASS LFA transmissions on fish and sharks would be minimal to negligible is based on the best available science.

Comment 4.1.13: The Draft SEIS argues that the LFA signal is too different from LF sounds made by struggling fish to be attractive to sharks, yet has no problem with equating natural sounds, even marine mammal vocalizations, to man-made noise. For instance, in its discussion of the potential cumulative effects of several LFA systems operating simultaneously, “whale vocalizations” are considered an additive impact together with LFA noise! The Draft SEIS makes the assumption that it is the pulsed nature of the playback sounds that caused sharks to withdraw. Since LFA is not pulsed, it argues, sharks would not withdraw from LFA. Yet these pulsed sounds were usually attractive and only caused withdrawal at higher, but still very modest, received levels of 111 dB. Thus, one could just as easily conclude that it may be the higher sound level, not the pulsed nature that causes shark withdrawal. O-010

Response: There are two parts to this comment. First, the discussion of cumulative effects in the SEIS Subchapter 4.6 is correct. To analyses potential cumulative effects of LFA, it must be measured against all sounds, which include both anthropogenic and natural sources.

The second part of the comment relates to shark attraction/withdrawal in response to pulsing LF sounds. The Navy agrees that the statement in the SEIS, Subchapter 4.1.2.4 concerning LFA not generating a pulsed signal is unclear. The “pulsed” signal to which it referred was the signal used by the researchers (Nelson and Johnson, 1972). In their study, lemon sharks withdrew from artificial sounds which included 10 pulses/second (continuous), 10 pulses/second (intermittent, and 15 to 7.5 decreasing pulses/second (intermittent). Myrberg et al. (1978) utilized sounds that simulated orca screams and a pure tone. In a more recent study, Myrberg (2001) stated that sharks have demonstrated highest sensitivity to LF sound (40 to 800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity thus resembling a struggling fish. These signals, some “pulsed,” are substantially different from the LFA signals. <u>The statement in the SEIS has been modified accordingly.</u>

Comment 4.1.14: It is false that there has been no evidence of hearing loss associated with sensory hair cell loss in fish and that such a connection is “only conjecture”. The very reason why McCauley et al. (2003) examined pink snapper hair cells in the ears is because the fish were not showing the stereotypical reaction to seismic noise that they had previously. They “fed and appeared to behave normally” because they were *captive*. Whether they would have survived in the wild is another question. I don’t know that the ability to “depart the immediate sound field” would have helped the pink snapper avoid ear damage. In the case of LFA, they would have been presented with a fairly complex sound field and may have had difficulty finding a way to escape. Further, they may not be able to swim fast enough, especially if there is some confusion as to where they should swim to lessen the noise exposure. I disagree that the exposures from LFA would necessarily be shorter than what the pink snapper experienced. There were very few seismic “shots” at high intensity in this study—the vast majorities were much lower exposure levels. A key question is how the LFA-equipped ship would move. Would it be in a straight line, with a consistent heading? Or rather in a non-transiting mode, circling an area, or doubling back over its track at some times? I-011

Response: The statement made by the commenter in the first sentence was taken out of context. The SEIS Subchapter 4.1.1.2 concerning permanent hearing loss states,

> "Thus, it is likely that comparable damage to sensory hair cells in fish could also result in hearing loss. However, while there are studies, as discussed below, indicating some damage to sensory hair cells in fish resulting from exposure to very intense and relatively long signals, there has yet to be any study that has examined fish hearing before and after such damage. Thus, while it may be speculated that fish with damaged and destroyed sensory hair cells would also have hearing loss, to date this is only conjecture."

McCauley et al. (2003) did not test the fish's hearing before or after the tests, only post-exposure damage. In addition, because of the approach-departure nature of the trials, the precise airgun exposure required to produce the damage was not obtained.

The LFA ships travel in a straight line at 5.6 kph (3 knots). Thus, most, if not all, fish would only be exposed at one pass of the ship. This exposure would be for just a few seconds, as LFA transmissions are 6 to 100 seconds long with 6 to 15 minutes time between transmissions. In contrast, the fish in the McCauley et al. (2003) research were exposed to almost continuous seismic air gun sound for 1 hr 5 min, with a 1 hr 12 min break, followed by a 36 min exposure at a rate of 6 pulses per minute. This was clearly far more exposure than any animal could possibly receive from LFA. Moreover, as pointed out previously, the seismic air gun is an impulsive source and has acoustic characteristics very different from that of coherent LFA sonar.

In the LFA studies conducted by the University of Maryland, fish were exposed to 324 seconds of sonar at levels (193 dB RL) that would only occur within 200 m (656 ft) of the LFA source array. This was done to give a worst-case situation. In "real life," the sonar is on a moving platform and so fish would only be exposed to maximum signal levels (perhaps similar to that used in the LFA fish experiments, but probably of lower sound level unless the fish were within 200 m of the LFA source array) for a few seconds at a time. The likelihood of a fish school (or even a few fish) being exposed at the sound levels and for the durations of sound exposure given in the LFA studies must be considered negligible. Based on other research experiments, it is reasonable to suggest that it would be unlikely that such a signal would result in any TTS.

Of course, we do not know if the pink snapper would have left the area of exposure or not. But this is not relevant since we are not discussing seismic airguns but LFA sonar. In the case of sonar the fish can stay where they are or move away. Fish swim speeds are for the most part in excess of the 5.6 kph (3 knots) of the LFA vessel. For example, herring, pike, carp, cod, and mackerel have swim speeds of 5.9 to 10.9 kph (3.2 to 5.9 knots) with salmon, bonito, tuna, and swordfish swimming much faster at 44.4 to 96.3 kph (24 to 52 knots) (Hirata, 1999). Unless they moved along with the ship, and at the same speed, their exposure to sound would be, at most, for a few seconds. It should be noted that injury would only occur within 200 m (656 ft) of the LFA source array. Because of the slow speed of an approaching LFA vessel, fish would perceive the sound as originating from the direction of the vessel—essentially as a point source, not as a "complex sound field." Assuming the fish are basically stationary, or milling around, the LFA signal would get louder as the vessel approached. If, or when, the LFA signal began to affect (i.e., annoy, vex, bother) the fish, they could easily swim away from the 5.6-kph (3-knot) LFA vessel.

Comment 4.1.15: Mortality rates of 20-30 percent in herring exposed to sonar signals are not inconsiderable (Draft SEIS p. 4-17). There is no RL indicated but rather SL of 189 dB. Is this a typo? Was stress measured? I-011

Response: The commenter is referring to the Jorgensen et al. (2005) study on herring larvae and juveniles. As pointed out in the SEIS exposures in this study were between 4 and 100 pulses per second of 1-second duration at 1.5, 4, and 6.5 kHz with estimated RL of 150 to 189 dB. Mortality rates of 20-30 percent occurred in only two out of a total of 42 exposure groups (none of the other 40 exposure groups showed close to this mortality). There was no repeat test at the test signals that caused these levels of mortality. While the authors made an issue of the level of mortality, careful analysis suggests strongly that this could have been a spurious result. Since most other exposures showed no losses greater than in controls, these results must be discounted unless they are replicated carefully, as in any good study. This study did not include stress.

The 189 dB discussed in the Draft SEIS on page 4-17 should be SPL, vice SL. <u>The correction has been made in the Final SEIS.</u>

Comment 4.1.16: Why is there no discussion of recent work on fish larvae showing they use noise for the selection of, and orientation to, suitable settlement sites (Simpson et al., 2005)? I-011

Response: The Simpson et al. (2005) work is not relevant. The argument for those studies is that masking of reef sounds would hinder larvae finding reefs. However, the masking would have to be long term and probably continuous. LFA does not meet these criteria, given that it is on a moving ship and which would, at best, expose larvae for a few seconds. After which, even if masked from hearing reef sounds for a few seconds, the larvae would no doubt continue on their way to the reef.

Comment 4.1.17: It is not possible to conclude that LFA impacts on fish would be negligible because only an inconsequential portion of any fish stock would be present within the 180 dB sound field at any given time. First, there is no evidence that makes a compelling case for 180 dB being a "highly conservative" figure. Mortality rates of 20-30 percent at 189 dB have been reported for fish. Allowances must be made for sub-lethal, more subtle, or long-term effects. Delayed development hasn't been adequately studied, nor non-immediate mortality through injury or over-stimulation of neuroendocrine systems. Second, what is the support for the conclusion that only inconsequential portions of a fish stock would be affected? Fish are clumped and would be concentrated around areas of productivity. As such, one broadcast could affect large numbers of several species of fish at once. And what about the effects on fish eggs, larvae, or fry? Studies such as Kostyuchenko (1973), Dalen and Knutsen (1987), and Booman et al. (1996) show increased mortality with seismic air gun exposure of fish eggs, larvae, and fry compared with controls. One spawning aggregation ensonified could have population consequences. Even a 5 percent loss at critical stages of development and metamorphosis could impact recruitment into a fishery and thus affect the population. I-011

Response: First, the University of Maryland conducted a study to examine the effects of LFA on hearing, the structure of the ear, and selected non-auditory systems of rainbow trout and channel catfish. Fish were exposed to 324 seconds of LFA sonar sound at 193 dB RL. This level would only occur within 200 m (656 ft) of the LFA source array. No fish died as a result of exposure during the research; there were no pathological effects from the sound on any major body tissues; and no short- or long-term effects on ear tissue. The results of no injury/damage to fish at 193 dB RL strongly support the use of the "conservative" 180-dB injury criterion for fish. The commenter is using a tiny part of one study (Jorgensen et al., 2005) using mid-frequency sonar (1.5, 4, and 6.5 kHz) on captive larval fish to suggest that there is a high mortality. Objective examination of the Jorgensen et al. data show that this mortality, as discussed earlier, only occurred in two of 42 tests, and there were no replicates. In the LFA studies, fish were exposed to 324 seconds of sonar at 193 dB RL—a level that would only occur within 200 m (656 ft) of the LFA source array.

Second, the SEIS concluded that "only an inconsequential portion of any fish stock would be present within the 180-dB sound field at any given time" (SEIS Subchapter 4.1.1.6). This statement refers to injury. As stated above, this LFA fish study (SEIS Subchapter 4.1.1.3) provide evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB RL, which would be within 200 m (656 ft) of the actual LFA sonar array) will have minimal impact on the reference species of fish that have been studied.

As to the other studies mentioned; Kostyuchenko (1973), Dalen and Knutsen (1987), and Booman et al. (1996) concern seismic air gun exposure of fish eggs, larvae, and fry.

In the Kostyuchenko (1973) study, fish eggs were exposed to either explosions of TNT or to seismic air guns. The author found some effects on eggs and larvae when they were within 5 m (16.4 ft) of a seismic air gun and 20 m (65.6 ft) of a TNT blast. However, the results of this study of effects of "elastic waves" must be questioned since there was no replication of tests to confirm if the damage was replicatable.

Dalen and Knutsen (1987) examined fish distribution associated with a seismic survey. While they reported there was some fish dispersal, presumably related to the seismic exposure, data were limited and there were no controls to demonstrate if the changes in dispersal could have been related to presence of the vessel or other factors.

They also exposed eggs, larvae, and fry of Atlantic cod (*Gadus morhua*) to two types of air guns and a water gun. There was no effect at any distance (as close as 1 m) to the small air gun in terms of survival or developmental morphology as compared to controls. Experiments with the larger air gun could only be done on fry (110 days old) and there were no effects but minor balance issues from which the fish "…recovered within a few minutes." (Note, the same was reported for the small air gun). There were significant effects to 110 day old fry from the water gun (only age animal tested) including a high mortality. The authors suggest that this was due to swim bladder rupture which resulted from the high negative pressure from the water gun as opposed to the initial positive pressure of the air gun. However, there were no experiments to test whether this could have actually been the case, and no information was provided about other aspects of the relative signals between the air guns and the water gun (e.g., sound pressure).

Booman et al. (1996) did what appears to be a reasonably comprehensive investigation of the effect of exposure to seismic air guns within 6 m (19.7 ft) of different early life stages of several fish species (note that this discussion is based on an English-language summary and not from reading the original paper which is in Norwegian). The estimated sound exposure levels were 242 dB re 1 μPa (no indication if peak or RMS) at 0.75 m (2.5 ft) from the source to 220 dB re 1 μPa at 6 m. The extent of effects ranged from none in some species to extensive in others, and even within a single species there were differences in effects at different developmental stages. For example, in saithe (*Pollachius virens*), there were no effects on eggs at 0.75 m (2.5 ft), but the same species at early gastrulation (embryonic) stage of development showed considerable mortality. In contrast, there were no such effects on Atlantic cod of the same age. In contrast, yolk sac stage cod showed a higher mortality than controls at sound levels up to 224 dB re 1 μPa, but later stages showed no effect. There were no effects at all of statistical significance at any stage for a herring (species not specified). It is clear that there were considerable differences in effects between the species mentioned and other species as well. There were also differences in effects depending on life stage of the young fish and the distance of the fish during specific stages to the source. Accordingly, the authors concluded for all species that “highest mortality rates and most frequent injuries were observed out to 1.4m distance, while low and no mortality rate and more infrequent injuries were observed out to 5m distance.”

In the three studies there are several factors that should be noted. In all cases the only effects seen on eggs and larva were to animals that were extremely close (1 to 20 m [3.3 to 65.6 ft]) to the source of energy. There is considerable variability in the effects at different life stages. Seismic sources are impulsive and have acoustic characteristics very different from that of coherent LFA sonar. Therefore, these three studies do not detract from the conclusions of the Fish CEE and the SEIS that LFA sonar sounds at relatively high received levels (up to 193 dB RL, which would be within 200 m (656 ft) of the actual LFA sonar array) will have minimal impact on the reference species of fish that have been studied.

Comment 4.1.18: Conjectures about the potential disruption of shark migration are made that are wholly unsubstantiated. Basically, we have no idea what the impact of LFA would be on shark migration, and this fact must be honestly acknowledged. I-011, O-010

Response: The discussions in SEIS Subchapter 4.1.2.5 of the potential for LFA to affect shark migrations are based on the best available information and have been reviewed by scientific experts in marine biology, with emphasis on the elasmobranch class of fishes (sharks).

Comment 4.1.19: To say that the percent of fish catch potentially affected by LFA would be negligible compared to fish harvested commercially and recreationally in the region is a bizarre comparison. I-011

Response: The conclusions in the SEIS Subchapter 4.1.1.6 are valid. The comment is noted.

Comment 4.1.20: Commenter is surprised that there should be less definitive data on fish and shark stock distributions in the open ocean than on some cetacean stock distributions. This is given as the reason why it is not feasible to estimate the proportion of stock that could be co-located with an LFA transmission. I-011

Response: Data on fish are not usually given in terms of populations or stock sizes, but in terms of annual, reported catch data. However, as stated in the SEIS Subchapter 3.3.1.1, in 2002 combined zones of the Pacific Ocean catches were over 51 million metric tons. The SEIS concluded that only an inconsequential portion of any fish stock would be present within the 180-dB sound field (injury zone) at any given time (SEIS Subchapter 4.1.1.6). The LFA fish study (SEIS Subchapter 4.1.1.3) provides evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB RL, which would be within 200 m [656 ft] of the actual LFA sonar array) will have minimal impact on the reference species of fish that have been studied.

Using the SURTASS LFA sonar deployment data provided in SEIS Table 2-1, the following calculations are presented to compare the volume of the Pacific Ocean that two LFA equipped vessels could ensonify at 180 dB and greater for a one year period:

Vessel speed:	5.6 kph (3 kt)
Transmit hours per day	1.8 hr/day
Distance traveled per day while transmitting	10,080 m (33,071 ft)
Width of track (2 x radius of 180-dB sound field): Note—this is conservative because research shows it should be 200 m (100x2).	2,000 m (6,562 ft)
Vertical extent of affected area:	160 m (525 ft)
Days of transmission per mission (max.):	40
Missions per year in the region (max.):	6
Total volume affected annually (max.):	7.74×10^{11} m^3 (2.73×10^{13} ft^3)

The comparable volume of water in the Pacific Ocean was calculated as follows:

Area of Pacific Ocean	1.695×10^{13} m^2 (1.82×10^{14} ft^2)
Minimum vertical extent of region expected to contain pelagic fish:	160 m (525 ft)
Total volume Pacific Ocean:	2.72×10^{16} m^3 (2.93×10^{17} ft^3)

From the above calculations, the ratio of the total volume of the Pacific Ocean ensonified at or above 180 dB during a year would be 0.00003 (or 0.003 percent) for one vessel or 0.00006 for two or 0.00011 for four. Applying this to the 51 million metric tons annual catch would be 0.003

million metric tons. This supports the conclusion that as compared to annual catch rates, the potential effects of LFA sonar on pelagic fish are very small.

ISSUE 4.2 Potential Impacts on Sea Turtle Stocks

Comment 4.2.1: Navy has not shown that LFA will not cause widespread mortality to sea turtles. O-015

Response: Based on the analysis in the SEIS Subchapter 4.2.6, the potential for SURTASS LFA sonar operations to impact leatherback sea turtle stocks is negligible. Although there are few studies of the impact of underwater sound on sea turtles, a number of factors limit the potential contact of LFA sonar with sea turtle populations (SEIS Subchapter 4.2). As reported by NMFS in the 2002 SURTASS LFA Biological Opinion (and reasserted in 2003 - 2006), "the Navy's proposed employment of SURTASS LFA sonar in the Atlantic, Indian, and Pacific Oceans and Mediterranean Sea . . . is not likely to jeopardize the continued existence of threatened or endangered species". They additionally state that, "because of their ecology [sea turtles lay their eggs on the beach], only the juvenile and adult stages of sea turtles could be potentially exposed to SURTASS LFA transmissions . . . the probability of an interaction between SURTASS LFA sonar and individuals of any one of these species is statistically small". Further, there has been no reported sea turtles strandings in SURTASS LFA operational areas. Hence, there is no evidence, and there is no reason to believe, that SURTASS LFA could cause widespread mortality in sea turtles.

Comment 4.2.2: Commenter is surprised that there should be less definitive data on turtle stock distributions in the open ocean than on some cetacean stock distributions. This is given as the reason why it is not feasible to estimate the proportion of stock that could be co-located with an LFA transmission. I-011

Response: Data are admittedly limited on open ocean sea turtle distribution, but what data there are were considered. A number of factors related to the deployment of LFA sonar limit its potential impact on sea turtle stocks. This sentiment is supported by a 2002 Biological Opinion provided to the Navy by NMFS, which states that, "the probability of an interaction between SURTASS LFA sonar and individuals of any one of these species is statistically small". Sea turtle distribution in ocean areas is seasonal, ranging between 40°N and 35°S in the winter and expanding in the summer. Leatherbacks can be found between 71°N and 65°S. Sea turtles, other than leatherbacks, generally inhabit coastal areas and are not often found in great numbers or concentrations in water depths greater than 200 m (656 ft).

See SEIS Subchapter 4.2.6, which uses the best available data to calculate SURTASS LFA impacts on sea turtles.

Comment 4.2.3: Why is the lack of data on sea turtle PTS a valid rationale for concluding LFA will not cause PTS in sea turtles? I-011

Response: The Navy agrees that a lack of data is not a rationale for concluding that SURTASS LFA will not cause PTS in sea turtles. The intention was to state that there are limited data available relating to whether or not LF sound causes PTS and that there is only a small amount of available information concerning hearing in sea turtles. <u>The Final SEIS text has been modified accordingly.</u> See FOEIS/EIS Subchapters 3.2.3.2 and 4.1.2 and SEIS Subchapters 3.2.3.2 and 4.2 for further information on sea turtle hearing capabilities.

Comment 4.2.4: Ducting, or SOFAR channels, does/do exist in temperate regions and are usually at a depth of about 1,000 m, within leatherback turtle diving range. In cold water regions, SOFAR channels are closer to the surface. This discussion of transmission distances due to temperature zones is misleading. I-011

Response: Leatherback sea turtles have been recorded to dive deeper than 1,000 m (3,281 ft); but, as stated in SEIS Subchapter 3.2.3.1, they typically dive to depths of 250 m (820 ft) (Hays et al., 2004). This comment proposes an unlikely scenario by combining worst-case acoustic propagation conditions in the deep sound channel with the extreme diving limit of the leatherback turtle—one that is far deeper than its usual diving depth. Regardless, a sea turtle would have to be within the LFA mitigation zone (180-dB sound field) when the sonar was transmitting to be at risk of injury.

The Navy concurs that the statements in the Draft SEIS Subchapter 4.2.2 is unclear. <u>It has been rewritten as follows:</u>

> <u>“Moreover, the majority of sea turtle species inhabit the earth’s oceanic tropical, subtropical, and temperature zones (generally, 40 deg N to 35 deg S longitude, except for the leatherback which is found from 71 deg N to 47 deg S). These are areas where sound propagation is usually characterized by downward refraction (higher transmission loss, shorter range), rather than ducting (lower transmission loss, longer range) which is usually found in colder-water regimes. Hence, transmission ranges within the principal water-column habitat for most sea turtles—the near-surface region—are relatively shorter in the warmer-water regimes versus ranges in colder-water regimes.”</u>

Comment 4.2.5: Until we know which characteristics of noise turtles are reacting to, I do not believe it is valid to dismiss impacts on turtles from seismic exposure simply because the signals differ. I-011

Response: Air guns are impulsive, broadband sources, typically producing sound repetitively every 9-14 seconds over a span of days to weeks with only occasional interruptions. Broadband source levels can be from 248 to 255 dB (peak-to-peak pressure) with most energy emitted between 5 and 20 Hz. This differs substantially from LFA transmissions, which are coherent, narrow bandwidth signals of 6 to 100 seconds in length followed by a quiet period of 6 to 15 minutes. The SURTASS LFA sonar bandwidth is very limited (approximately 30 Hz) with a constant frequency for 10 seconds and an average duty cycle of 7.5 to 10 percent (thus the system is off at least 90 percent of the time). See FOEIS/EIS Subchapter 4.1.2 and SEIS RTC 4.3.1 below for additional information. The only information on behavioral responses of sea turtles to human activity is in response to seismic air guns. Because this is the best available information, it was presented in the SEIS Subchapter 4.2.4 with the statement that air guns and LFA signals should not be directly compared since their signal characteristics are very different and the likelihood of effects on living tissue is dissimilar as well.

Therefore, the conclusions in SEIS Subchapter 4.2 are considered valid.

Comment 4.2.6: The calculation of the area ensonified should state which RL is being used. I don't believe visual or active acoustic monitoring will produce a high detection rate for sea turtles. I-011

Response: The analysis presented in Draft SEIS Subchapter 4.2.6 is an update to the similar analysis in the FOEIS/EIS Subchapters 4.1.2.1 and 4.3.1.1 based on more current information. The calculation of the area ensonified is based on a received level of 180 dB at estimated radius of 1000 m (3281 ft). <u>This information has been added to SEIS Subchapter 4.2.6.</u> The calculation in Draft SEIS Subchapter 4.2.6 did not take the effectiveness of visual or active acoustic mitigation into account. Therefore, the determination in the analysis that a very small probability, if any, that a sea turtle would be found within the 180-dB mitigation zone, is not based on visual or active acoustic monitoring. The SEIS Subchapter 4.2.6 further states that if in the unlikely event that sonar operations coincide with a sea turtle "hot spot" that the sonar operational characteristics coupled with the mitigation measures would minimize the probability of impacts on the animals in the vicinity.

Comment 4.2.7: The Draft SEIS points out the lack of knowledge about impacts of loud low-frequency sound on sea turtles but claims that the monitoring and mitigation program, which uses 180 dB RL as the critical threshold to protect marine animals from harm, will achieve the objective desired. I-002

Response: It is true that there are few data on the impact of sound on sea turtles and the Navy recognizes that the effectiveness rate of monitoring for sea turtles is similar to that of small cetaceans. However, according to the findings of a 2006 Biological Opinion by NMFS, sea turtles have an insensitive ear. Additionally, the Biological Opinion published in 2002 by NMFS explains that, "the probability of an interaction between SURTASS LFA sonar and individuals of any one of these species is statistically small". This is supported by the analyses in the FOEIS/EIS Subsection 4.1.2.1 and SEIS Subchapter 4.2.6. In addition there is no reason to believe that sea turtles would be at higher risk of potential injury from SURTASS LFA sonar signals than cetaceans or fish.

ISSUE 4.3 Potential Impacts on Marine Mammal Stocks

Comment 4.3.1: Navy stated in the Draft SEIS (p 4-30) "there are no new data that contradict any of the assumptions or conclusions in the FOEIS/EIS." To the contrary, following new data exist: 1) linking whale strandings to naval sonar; 2) linking non-stranding injuries in marine mammals to naval sonar; 3) describing mechanisms of harm to marine mammals from sonar; 4) showing unexpectedly high propagation of noise in shallow water; 5) finding that intense noise sources can mask whale calls over vast distances, thousands of sq km; and 6) revealing difficulties for mitigating noise impacts over thousands of square miles. O-014 p. 26

Response: First, in order to address the comment, it must be pointed out that there are different types of anthropogenic sounds potentially associated with possible impacts to and strandings of marine mammals. These are naval sonar and seismic airgun arrays, each with different characteristics and purposes. Many comments lump these types under one heading, loud naval sonars or military sonars; or loud anthropogenic noise sources including sonars and seismic survey airguns. Thus, when there is a stranding that may be associated with the use of one type of sonar or sound source, it gets blamed on all types—a premise that is not true and one that does not stand up to scientific scrutiny from the marine bio-acoustics community. A wide range of naval sonars are used to detect, localize and classify underwater targets. For the purposes of the SURTASS LFA SEIS analysis, these systems are categorized as LFA (< 1000 Hz) and MFA (1 to 10 kHz). Table 10-1 provides pertinent information on different types of LFA and MFA sonar. General information is also provided on airgun arrays. Sonar signals are generally coherent while air guns are impulsive.

Table 10-1. Comparison of Underwater Acoustic Source Properties

	SURTASS LFA	**AN/SQS 53C**	**AN/SQS 56**	**Air Gun Array**
Source Level	215 dB per element	235 dB	223 dB	260 dB
Pulse Duration	Variable 6 to 100 s Average 60 s Never longer than 10 s at single freq	1-2 s	1-2 s	0.02 s
Inter-pulse Time	6 to 15 min	24 s	24 s	9-14 s
Center Frequency	100-500 Hz	2.6 & 3.3 kHz	6.8, 7.5, & 8.2 kHz	Broadband
Bandwidth	30 Hz	100 Hz	100 Hz	Wideband
Source Depth	Array 87 to 157 m Center 122 m	8 m	6 m	6-10 m
Beamwidth	Omni-directional in horizontal	40 degrees	30 degrees	Function of freq
Beam Direction	Horizontal	3 degrees down from horizontal	Horizontal	Vertical

Source: D'Spain et al. (2006); DON (2001)

Cox et al. (2006) provided a summary of common features shared by the strandings events in Greece (1996), Bahamas (2000), and Canary Islands (2002). These included deep water close to land (such as offshore canyons), presence of an acoustic waveguide (surface duct conditions), and periodic sequences of transient pulses (i.e., rapid onset and decay times) generated at depths less than 10 m (32.8 ft) by sound sources moving at speeds of 2.6 m/s (5.1 knots) or more during sonar operations (D'Spain et al., 2006). A number of these features do not relate to LFA operations. First, the SURTASS LFA vessel operates with a horizontal line array (SURTASS: a passive listening system) of 1,500 m (4,921 ft) length at depths below 150 m (492 ft) and a vertical line array (LFA sonar source) at depths greater than 100 m. Second, operations are limited by mitigation protocols to at least 22 km (12 nm) offshore. Therefore, for these reasons SURTASS LFA sonar cannot be operated in deep water that is close to land. Finally, the LFA signal is transmitted at depths well below 10 m (32.8 ft), and the vessel has a slow speed of advance of 1.5 m/s (3 knots).

While it is true that there was a LF component of the sonar potentially related to the Greek stranding in 1996, only mid-frequency components were present in the strandings in the Bahamas in 2000, Madeira 2002, and Canaries in 2002. This supports the logical conclusion that the LF component in the Greek stranding was not causative (ICES, 2005; Cox et al., 2006). In its discussion of the Bahamas stranding, Cox et al. (2006) stated, “The event raised the question of whether the mid-frequency component of the sonar in Greece in 1996 was implicated in the stranding, rather than the low-frequency component proposed by Frantzis (1998).” The ICES in its “Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish” raised the same issue as Cox et al., stating that the consistent association of MF sonar in the Bahamas, Madeira, and Canary Islands strandings suggest that it was the MF component, not the LF component, in the NATO sonar that triggered the Greek stranding of 1996 (ICES, 2005).

Most odontocetes, such as beaked whales, have relatively sharply decreasing hearing sensitivity below 2 kHz. If a cetacean cannot hear a sound of a particular frequency or hears it poorly, then it is unlikely to have a significant behavioral impact (Ketten, 2001). Therefore, it is unlikely that LF transmissions from LFA would induce behavioral reactions from animals that have poor LF hearing, e.g. beaked whales, bottlenose dolphins, striped dolphins, harbor porpoise, belugas, and orcas (summarized in: Nedwell et al., 2004).

New data describing potential mechanisms of harm to marine mammals from sonar are concerned with acoustically mediated bubble growth and resonance. Cox et al. (2006) stated that it is premature to judge acoustically mediated bubble growth as a potential mechanism and recommended further studies to investigate the possibility. The analysis by the Navy (Cudahy and Ellison, 2002) and reports from two workshops on acoustic impacts (DOC, 2002; Cox et al., 2006) support the conclusion that resonance from LFA operations is not a “reasonably foreseeable” impact. See SEIS RTCs 2.5.2 and 4.0.3 above for additional discussions.

The ICES (2005) report concluded that no strandings, injury, or major behavioral change has yet to be associated with the exclusive use of LF sonar.

Therefore, the numerous scientists, who participated in the 2004 Workshop convened by the U.S. Marine Mammal Commission (Cox et al., 2006), and the ICES AGISC (2005), support the logical conclusion that LFA sonar is not related to marine mammal strandings.

For additional discussion on resonance, non-auditory injury, strandings, and stress see SEIS RTCs 2.5.2, 4.0.3, and 4.3.12.

Based on the above discussions, there are no “new” data: 1) linking LFA sonar to whale strandings, 2) linking LFA sonar to non-stranding related injuries, or 3) describing mechanisms of harm to marine mammals from LFA sonar.

The comment regarding unexpectedly high propagation of noise in shallow water is in reference to Tolstoy et al. (2004) concerning the measurement of propagation of broadband noise from air gun arrays in both deep and shallow water. As noted in Table 10-1 above, there are substantial differences between the impulsive sounds of air guns and the coherent signals from LFA, so that one must be careful in how they are compared. First, Tolstoy et al. (2004) found that in deep water, the predicted and measured distances to the received level of 160 dB from the air gun arrays suggested that the predicted radii tended to overestimate actual 160 dB RL ranges. This implied that the 180 dB radii for all arrays should be less than the predicted 1 km (0.54 nm), likely significantly less. Second, they found that actual measurements for shallow water were underestimated when compared to the same predicted values used for the deep water comparison. If a source level of 240 dB is used, then the calculated ranges using only a spherical spreading model agrees with the values presented in Tolstoy et al. (2004) for deep water calculations. In deep, homogenous water, sound initially spreads spherically (spherical spreading) and its intensity decreases in proportion to the square of the range. Once sound has propagated to a distance approximately equal to the water depth, it is physically constrained in a duct and propagates cylindrically (cylindrical spreading). When this occurs, its intensity decreases in direct proportion to the range (see FOEIS/EIS, Appendix B). It is not appropriate for the commenter to use the Tolstoy et al. (2004) paper as evidence to show unexpectedly high propagation of noise in shallow water, because the estimates of shallow water propagation were apparently made based on a deep water propagation model. Utilization of a shallow water model is more appropriate and would have predicted greater propagation ranges of noise in shallow water. Most importantly, this comment is not applicable to the SURTASS LFA analysis because the propagation models utilized for LFA are empirically validated and correctly account for critical variables, such as water depth (FOEIS/EIS Subchapters 4.2, 4.2.1 and 4.2.2; and Technical Report #2).

The masking effect of the SURTASS LFA signal will be limited for a number of reasons. First, the bandwidth of the system 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 bandwidth. Thus, only a portion of the animal's signal would be masked by the LFA. Furthermore, when LFA is in operation, the LFA source is active only 7.5 to 10 percent of the time (based on historical LFA operational parameters), which means that at least 92.5 percent of the time there is no risk of animal signals being masked by the LFA signal when LFA is operating. Therefore, within the area in which masking is possible, the effect will be limited because animals that use this frequency region typically use broader bandwidth signals.

Finally, LFA has not experienced difficulties in executing its mitigation procedures required by NMFS, which is based on protecting marine animals from injury. Because it is impractical and infeasible for mitigation to cover vast oceanic areas where the received levels do not cause physical injury to marine animals or jeopardize threatened or endangered species, the laws provide methods for authorizations for limited non-injurious impacts to marine mammals and listed species.. SURTASS LFA sonar has met all of these requirements and has been operating successfully since 2003—without any known physical injuries to marine animals. Potential non-injurious impacts are estimated based on location and times of operations and best available abundance and density data for the areas and seasons of the operations. These are reported to NMFS both quarterly and annually as required by regulation (50 CFR § 216 Subpart Q).

Comment 4.3.2: The association between anthropogenic ocean noise and its impacts on marine mammals is well documented although there is still scientific uncertainty over the actual causal mechanisms of impacts. It is generally accepted that impacts can range from altered behavior through temporary injury to mortality. Altered reactions can include startle response and can affect feeding, mating, migrating, care of young, and avoiding predators. Mortality can result directly from exposure to sound or indirectly as a consequence of altered behavior or temporary injury. Evidence obtained from actual mortality incidents associated with anthropogenic noise suggests that the mechanisms by which animals are impacted by noise are far less straightforward than the Draft SEIS suggests. O-013

Response: Generally accepted ideas of an impact do not provide valid support for the conclusion of impact. The commenter appears to be raising the issue of beaked whale strandings in response to naval mid-frequency sonar operations. This is the only situation where it has been proposed that behavioral responses to sound ultimately lead to mortality. Indications are that one scenario is that a behavioral response to mid-frequency sonar leads to a change in diving behavior, which in turn has physiological consequences. This seems to occur only when the following factors are present a) mid-frequency sonar, b) beaked whales, c) sharp bottom bathymetry (e.g., proximity to shore) and d) a surface duct (D'Spain et al., 2006). While SURTASS LFA can operate where there are beaked whales and a surface duct, it must remain farther offshore than a mid-frequency sonar ship, reducing the potential influence of bathymetry. D’Spain et al. (2006) also cited the sound source being located in the surface acoustic duct. The LFA source array depth ranges from approximately 87 to 157 m (285 to 515 ft), below most, if not all surface ducts.

Furthermore, there has been no direct link between LF sound and beaked whale strandings. Both LF and MF sonars were operating during the Greek strandings. However, based on more recent review of the data, scientists support the logical conclusion that the MF sonars, not the LF sonars were responsible for triggering a sequence of events that led to the Greek beaked whale strandings (ICES, 2005; Cox et al., 2006).

Comment 4.3.3: No studies have been conducted on marine mammals using the full operational sonar. O-010

Response: It is reiterated (see SEIS RTC 2.7.3 above) that during Phase I of the LFA SRP research, there were times when the test source level was at the operational level. During such test periods received levels at the subject animals were within the range as specified in the research permit and animal responses were no different than those observed when using lower source levels.

While no studies have been conducted on whether LFA sonar caused injury, there is recent support to scientific evidence that the LFA 180-dB mitigation zone will protect animals from injury (Laurer et al., 2002; Popper et al., 2005; Halvorsen et al., 2006). Injury cannot be studied in the wild. Any such experiments should be undertaken under controlled laboratory conditions, with animals in a more controlled setting. Furthermore, the Navy believes it has adequate data to assess what the potential for impacts would be at RLs $\geq$ 180 dB for the LF sounds from SURTASS LFA sonar, without the need to try to actually expose animals to that RL. Such high levels of exposure would occur only for animals in close proximity to the LFA vessel, and for this reason mitigation protocols are in place such that the LFA does not operate if animals are within that high exposure zone. See also FOEIS/EIS RTC 4-5.21.

In its response to Comment SIC9 in the Final Rule (67 FR 46785), NMFS addressed this issue. Specifically, NMFS and the Navy do not believe it desirable nor necessary for this action, let alone humane, to test animals at or above levels that might result in injury simply to develop an injury risk continuum (at or above 180 dB). All marine mammals exposed to RL at or above 180 dB are considered for the analysis and for monitoring/reporting purposes to be injured and activities are mitigated to protect marine mammals from ever being exposed to RLs at or above that level.

Comment 4.3.4: The Draft SEIS implies that human-produced underwater sounds and natural sounds have similar impacts on marine mammals. It is not scientifically defensible to imply that the vocalizations made by whales have impacts similar to loud human-produced noises. O-010

Response: The Draft SEIS did not imply that human-produced underwater sounds and natural sounds have similar impacts on marine mammals. Because the commenter did not state where in the Draft SEIS this was implied, it is assumed that the commenter is referring to the frequent comparisons drawn between the decibel level of LFA sonar at the source and whale vocalizations, earthquakes, and lightening strikes. The point here is that LFA sonar is not likely to be the loudest sound that a marine mammal will hear in its lifetime, nor is the decibel level of LFA sonar extraordinary in the evolutionary history of cetaceans.

Comment 4.3.5: 145 dB for diving and recreational sites acknowledges a risk to humans. It is unreasonable to conclude that humans are more sensitive than marine mammals to underwater noise. It would make sense to use this level for marine mammals as well. NATO uses a 145 dB impact level to denote harassment of marine mammals. I-011, O-010

Response: This comment was partially responded to in the FOEIS/EIS in RTC 4.6-21. These values represent different criteria: psychological aversion (a behavioral reaction) from direct measurements with human divers (Technical Report #3 of the FOEIS/EIS), and the exposure level at or above 180 dB RL, for which all marine mammals are evaluated as if they are injured (FOEIS/EIS Subchapter 1.4 [Analytical Context]). Behavioral responses for marine mammals utilizing the risk continuum (see FOEIS/EIS Subchapter 4.2.3) demonstrate the potential for significant biologically impart behavioral reactions from 119 to 179 dB RL are minimal. Therefore the 145-dB criterion for divers is consistent with the estimates of behavioral reactions to marine mammals.

The published data regarding human sensitivity to sound underwater (Parvin and Nedwell, 1995) indicates that human hearing sensitivity is comparable to marine mammals in the frequency region of interest. However, humans are performing in a foreign medium compared to marine mammals. This suggests that the risk to marine mammals for a psychological response would be less than for humans. Furthermore, data cited in the FOEIS/EIS suggests that when operating in the presence of a biological imperative such as feeding, migrating or mating such sound levels are insufficient to make the marine mammal discontinue their behavior (Technical Report #1 LFS SRP).

A review of the NATO regulations could not confirm the use of 145-dB impacts for harassment of marine mammals. The commenters did not provide citations, so this comment cannot be further addressed. The Navy's use of LFA sonar is regulated under United States law, in particular the MMPA, ESA, NEPA, and NMFS's regulations interpreting and administering those statutes.

Lethality

Comment 4.3.6: Commenter stated that sonar has the potential to harm and kill marine mammals.

Response: The potential for SURTASS LFA sonar to cause harm to marine mammals and the validity of the 180-dB injury threshold for SURTASS LFA are discussed in SEIS RTCs 4.0.1, 4.0.2, 4.0.3, 4.3.1, 4.3.2, 4.3.7, 4.3.8, 4.3.9, 4.3.10, and 4.3.12. LFA will not cause physical harm to marine mammals below 180 dB RL. Moreover, mitigation within the 180-dB mitigation zone is highly effective (See FOEIS/EIS Subchapter 2.3.2.2).

Comment 4.3.7: A number of whale strandings and deaths around the world have been linked to military sonar. Scientists believe that LFA sonar may have more lethal impacts than other types of sonar due to the ability of LF sound to transmit greater distances. O-012

Response: **S**ee SEIS RTC 4.3.1 above.

Comment 4.3.8: The statement that LFA sonar will cause no lethal takes of marine mammals rests entirely on invalid assumptions and conclusions reached in the Draft SEIS. These assumptions are that marine mammals will not be injured below 180 dB RL and second being that these animals would be protected within the 180-dB zone by mitigation measures. O-008

Response: Discussions on whether injuries can occur at SPLs below 180 dB (RL) have been addressed in SEIS RTCs 4.0.3, 4.3.1, 4.3.2, and 4.3.12. LFA sonar has been operating since 2003 in a restricted area in the western Pacific Ocean, with approximately 470 hours of transmit time under the first four years of the LOAs. These extensive operations, with mitigation, have produced no known Level A takes on marine mammals. As noted before, LFA is not the same as MFA (see SEIS RTC 4.0.3 and 4.3.1 above). There is no evidence that SURTASS LFA sonar has caused injuries below or within the 180-dB mitigation zone as verified by mitigation monitoring requirements of the LFA safety zone. Therefore, the 180-dB injury threshold remains valid, as does the effectiveness of the mitigation measures within the 180-dB injury zone.

180-dB Criterion

Comment 4.3.9: Commenter states that they have found no new scientific research to support the contention that 180 dB received level is the threshold of permanent threshold shift or behavioral shifts or other kinds of damage to cetaceans or sea turtles, yet it continues to be used as the basis for all the models for monitoring and mitigation. The range to the 180-dB isopleth is also, not necessarily coincidentally, the limits of the capability of a human being with binoculars to observe most large marine mammals. I-002

Response: An explanation on the development of the 180-dB criterion by NMFS and the Navy has been provided previously (see SEIS RTCs 4.0.1 and 4.3.1). The NMFS believes that this level is conservative as it is set where scientists estimate TTS (Level B harassment), not PTS (Level A harassment), which would be somewhat higher. As related to LFA, there has been no new evidence that contradicts the conservative nature of the 180-dB injury criterion to protect marine mammals and sea turtles. As stated on SEIS RTC 4.3.3, there is recent support to scientific evidence that the LFA 180-dB mitigation zone will protect marine animals from injury (Laurer et al., 2002; Popper et al., 2005; Halvorsen et al., 2006). The ICES (2005) report concluded that no strandings, injury, or major behavioral change has yet to be associated with the exclusive use of LF sonar. As stated in the FOEIS/EIS (p. 2-14), the LFA mitigation zone covers a volume ensonified to a level of ≥ 180 dB (RL). This zone will between 0.75 and 1.0 km (0.40 to 0.54 nm). A visual observer at a height of 12.2 m (40 ft) above the water under reasonable weather conditions utilizing 7x binoculars should be able to see a whale at 1.8 km (0.97 nm).

Comment 4.3.10: The determination of the 180 dB impact level is not supported by field research. Gray whales avoided much lower LFA levels (around 130 dB) while migrating (SRP results). The fact that offshore gray whales did not avoid such lower levels can mean that less sensitive or more marginal (sub-optimal) animals migrate offshore. This scenario is supported by the fact that mothers and calves tend to migrate inshore. Downplaying this impact because offshore animals behaved differently would be only one way to interpret these results and would be scientifically invalid. Is this result a consequence of the inshore vs. offshore environment or because of the different age/sex classes or sensitivity levels of animals in either environment or some other interpretation? I-011, O-010

Response: The 180-dB criterion is for injury, not behavioral response. The risk continuum, which is based on the results of the LFS SRP, is discussed in detail in the FOEIS/EIS Subchapter 4.2.3. The 180-dB criterion is not based on this research.

Comment 4.3.11: Determination of the 180-dB threshold (injury) impact level for marine mammals is not supported by research (namely, LFS SRP). O-010

Response: As stated in the FOEIS/EIS the LFS SRP supported the risk continuum, which was for significant behavior response, not injury. Neither the Navy nor NMFS believe that a controlled exposure experiment to determine injury levels in marine mammals is necessary, or for that matter humane. See RTC 4.3.3 above.

Comment 4.3.12: Navy's threshold for injury at 180 dB RL discounts growing literature on acoustic injuries and mortality in marine mammals, namely: 1) fails to properly account for bubble growth in marine mammals which indicates potential for injury and death at levels below 180 dB, 2) ignores evidence that mass strandings have been caused by levels lower than 180 dB, 3) Navy unaccountably rules out potential for resonance other than those affecting the lungs, and

4) does not reflect potential for other non-auditory physiological impacts, as stress. O-008, O-014

Response: The literature that the commenter refers to does not relate SURTASS LFA sonar. The specific four areas are discussed below.

Bubble Growth

Cox et al. (2006) stated that gas-bubble disease, induced in supersaturated tissues by a behavioral response to acoustic exposure, is a plausible pathologic mechanism for the morbidity and mortality seen in cetaceans associated with MF sonar exposure. They also stated that it is premature to judge acoustically mediated bubble growth as a potential mechanism and recommended further studies to investigate the possibility.

Strandings

See SEIS RTC 4.3.1 above.

Resonance

The issue of resonance is addressed in SEIS RTC 2.5.2. This response concluded that the analysis by the Navy (Cudahy and Ellison, 2002), reports on two workshops on acoustic impacts (DOC, 2002: Cox, et al. 2006), and the NRC Ocean Studies Board (NRC, 2005) support the conclusion that resonance from LFA operations is not a “reasonably foreseeable” impact.

Stress

NRC (2003) discusses 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 also cited controlled laboratory investigations of the response of cetaceans to noise that have shown cardiac responses (Miksis et al., 2001 in: NRC, 2003) but have not shown any evidence of physiological effects in the blood chemistry parameters measured. Belugas (white whales) exposed for 30 min to 134-153 dB RL playbacks of noise with a synthesized spectrum matching that of a semisubmersible oil platform (Thomas et al., 1990b in: NRC, 2003) showed no short-term behavioral responses and no changes in standard blood chemistry parameters or in catecholamines. Preliminary results from exposure of a beluga whale and bottlenose dolphin to a seismic watergun with peak pressure of 226 dB SL showed no changes in catecholamines, neuroendocrine hormones, serum chemistries, lymphoid cell subsets, or immune function (Romano et al., 2001 in: NRC, 2003).

NRC (2003) stated that although techniques are being developed to identify indicators of stress in natural populations, determining the contribution of noise exposure to those stress indicators will be very difficult, but important, to pursue in the future when the techniques are fully refined. There are scientific data gaps regarding the potential for LFA to cause stress in marine animals. Even though an animal’s exposure to LFA may be more than one time, the intermittent nature of the LFA signal, its low duty cycle, and the fact that both the vessel and animal are moving, means that there is a very small chance that LFA exposure for individual animals and stocks would be repeated over extended periods of time, such as those caused by shipping noise. There is sufficient information available to permit analysis and decision making. Therefore, impacts from stress are not a reasonable foreseeable significant adverse impact on marine mammals from exposure to LFA.

Comment 4.3.13: A 180 dB level should never be considered highly conservative, even for fish. I-011

Response: The University of Maryland conducted a study to examine the effects of LFA on hearing, the structure of the ear, and selected non-auditory systems of rainbow trout and channel catfish. Fish were exposed to 324 seconds of sonar at 193 dB RL. This level would only occur within 200 m (656 ft) of the actual LFA source array. No fish died as a result of exposure; there were no pathological effects from the sound on any major body tissues; and no short- or long-term effects on ear tissue. The results of no injury/damage to fish at 193 dB RL strongly support the use of the "conservative" 180-dB injury criterion for fish. Therefore, the 180-dB criterion is maintained for the analyses presented in the SEIS, with emphasis that this value is *highly conservative* and protective of fish.

The term *highly conservative* was only used in relation to potential impacts to fish.

Comment 4.3.14: Acknowledge the uncertainties of the effectiveness of the 180-dB impact threshold to mitigate impacts on marine mammals. Provide description of research being done and planned to address this uncertainty. G-008)

Response: See SEIS RTC 4.7.8.

Comment 4.3.15: Is the 180 dB isopleth distance given anywhere in this Draft SEIS? We didn't see it anywhere and it seems like it would be very important for the reader to know how far from the source 180 dB can be heard. This distance should be included. I-011, O-010, O-013

Response: The distance to the 180-dB isopleth is given in the FOEIS/EIS on pages 2-14, 2-18, and 5-1, which were incorporated by reference into the SEIS. Under normal operating conditions, this zone will vary from 0.75 to 1.00 km (0.4 to 0.54 nm) from the source array, ranging over a depth of approximately 87 to 157 m (285 to 515 ft). <u>For clarity, this information has been added to the appropriate section in SEIS Chapter 2.</u>

Comment 4.3.16: Competent specialists in ocean acoustics criticized the DEIS models of attenuation and distribution of the sound, in particular, noting that a much louder received level of sound was likely to be dispersed over a much larger area than modeled. The Draft SEIS still suggests the impacts described do not assume anything other than the model of sound spreading that finds, under certain oceanic conditions, a source level of 230-220 dB will attenuate to 180 dB at a distance of 1-2 km. I-002

Response: Subchapter 4.4 of the Draft SEIS presented the methodology utilized to provide NMFS with reasonable and realistic estimates of the potential effects to marine mammals. The distance to the 180-dB isopleth, as noted above, is between 0.75 and 1 km (0.40 and 0.54 ft) from the source array. This is based on the spherical spreading model, which is valid for LFA at least out to 1 km (0.54 ft).

To determine sound propagation specific to a given location and environmental conditions, the modeling techniques utilized for the Draft SEIS included the ETOPO5, ETOPO2 and DBDB-V (version 1.0) bathymetry databases and GDEM (version 2.5) sound velocity profile database. The FOEIS/EIS utilized the Parabolic Equation (PE) Model (version 3.4) to determine transmission loss verses range from the source array. These were provided in Technical Report #2 of the FOEIS/EIS. These databases and models have been assembled and verified by various federal agencies, including the National Oceanographic Data Center (NODC), the Oceanographic and Atmospheric Master Library (OAML) and the NOAA National Geophysical Data Center (NGDC).

Comment 4.3.17: There is no evidence to support the claim that marine mammals will not be injured by RLs below 180 dB. There is documented evidence of mass strandings where animals were exposed to 160-165 dB and stranded (Bahamas). Navy dismisses evidence suggesting behavioral reaction to sound can produce Level A harassment. O-008, O-012, O-013

Response: Scientific evidence supporting the claim that marine mammals will not be injured at received levels ≥ 180 dB is provided in SEIS RTCs 4.0.3, 4.3.1, and 4.3.7 through 4.3.15. LFA has not been implicated in any known marine mammal strandings as discussed in SEIS RTC 4.4.9 through 4.4.26. The Navy has determined that the potential injury to marine mammals by exposure to LFA signals at received levels below 180 dB is considered negligible and therefore not a reasonably foreseeable significant adverse impact.

Even though there is the potential for LFA signal to injure marine mammals at ≥ 180 dB (RL), the Navy does not dismiss the possibility that behavioral reactions to sound can possibly produce Level A harassment. Although there is no evidence that LF sound can cause biologically significant behavioral responses in certain species of odontocetes, the Navy is presently planning 2007-2008 field research for deep-diving marine mammal behavioral response studies in an attempt to scientifically address this issue for LFA, MFA, and seismic sources.

Comment 4.3.18: Navy admits in TR3 that sound levels above 160 dB are damaging to mice, rats and humans in water, but Draft SEIS says anything below 180 dB is almost harmless to cetaceans. Clarify and provide evidence. O-010

Response: The data in TR3 indicates that the damage risk threshold for humans is estimated to be over 180 dB at the resonance frequency of the lung. At other frequencies, the damage risk threshold is at least 15 dB higher. These frequencies are well below the frequency region of LFA. Furthermore, the lung resonance frequency is dependent on the size of the animal. As the animal gets larger the lung resonance frequency goes down, moving the lung resonance frequency even further from the frequency region of the sonar. This is just part of the evidence supporting the 180 dB criterion that was described in the FOEIS/EIS.

Since the FOEIS/EIS was published in early 2001, there has been additional research published in a peer-reviewed journal. Laurer et al. (2002) from the Department of Neurosurgery, University of Pennsylvania School of Medicine, exposed rats to 5 minutes of continuous high intensity, low frequency (underwater) sound (HI-LFS) either at 180 dB SPL re 1 µPa at 150 Hz or 194 dB SPL re 1 µPa at 250 Hz, and found no overt histological damage in brains of any group. Also, blood gases, heart rate, and main arterial blood pressure were not significantly influenced by HI-LFS suggesting that there was no pulmonary dysfunction due to exposure. This paper is based on work performed in support of Technical Report #3 of the SURTASS LFA Sonar FOEIS/EIS.

140 dB

Comment 4.3.19: Medical journals show human pain at 140 dB. I-003

Response: The 140 dB SPL sound cited in medical journals for auditory pain is for sound in air. Sound in water does not use the same units as sound in air and the sound is not handled by the auditory system in the same manner in air as in water. Appendix B (B.3.2) of the FOEIS/EIS provides a description of the comparison of sound intensity measurements in air versus water. The sound intensity in water equivalent to a 140 dB SPL sound intensity in air is approximately 200 dB SPL. This is above the injury criteria of 180 dB, and the diver would have to be well within the LFA mitigation zone to receive this exposure level.

Comment 4.3.20: Broadcasts in 1998 (LFA tests) resulted in exposure levels of 135-140 dB and whales fled the area.

Response: There is no evidence that whales "fled" the area during the LFS SRP. See FOEIS/EIS RTCs 4-5.10 and 4-6.37.

Comment 4.3.21: Bahamas stranding received levels were less than 140 dB.

Response: Received level values in the Bahamas have been estimated by numerous sources. The IWC (2004) and ICES (2005) reported estimates to be 160 to 170 dB (RL). SURTASS LFA sonar was not utilized in the exercises in the Bahamas (DOC and DON, 2001).

120 dB

Comment 4.3.22: Show area of impact at 120 dB RL, since many marine mammals react to noise at this average RL. Why is the area of impact at the 120 dB RL not given? I-011

Response: The potential for LFA to impact marine mammals was evaluated during the initial NEPA analysis, and included conducting independent field research in the form of controlled exposure experiments on baleen whale responses to LFA signals. This was known as the LFS SRP (see FOEIS/EIS Subchapter 4.2.4 and RTC 4-4.18). Specifically, marine mammal reactions to sounds at 120 dB RL are discussed in the FOEIS/EIS Subchapter 4.2.4.1. The LFS SRP detected only minor, short-term behavioral responses to RLs ranging from 120 to 155 dB. The ranges from the source to various sound field contours were discussed in the FOEIS/EIS RTC 2-1.5.

Comment 4.3.23: There is no consideration of the potentially dire nature of behavioral effects at lower sound levels. Population-level effects of masking or stress are ignored, for instance. If only one LFA system is operating in the Pacific at one time and marine life is behaviorally impacted at levels of 120 dB or so (as indicated by previous research on gray whales and LFA or other noise sources) (e.g., Richardson et al., 1995), then the area impacted is around 3.9 million sq km. (Johnson, 2003)…………… So, yes, many animals would indeed be impacted over a large amount of time, not the <0.2 animals per year per vessel as estimated for leatherbacks, for instance. Also, it is misleading to use low numbers impacted like this when we are talking about a highly endangered population. Because of the myriad of previous threats to leatherbacks, their numbers are dwindling. This should mean we treat the few remaining animals with more caution, not less, and not downplay the severity that only a few individuals may be impacted. Moreover, there is an assumption that LFA would be the only noise or other threat to these animals, rather than a serious analysis of the cumulative and synergistic effects. Using such figures as 0.2 animals per year per vessel also ignores the fact that animals are generally clumped in distribution, so that if a concentration of animals is impacted, the population could suffer. (I-011)

Response: The commenter is raising the two potential issues of population-level effects of masking and stress. Each of these will be addressed separately.

Masking

The commenter is confusing the avoidance response of migrating gray whales and bowhead whales with masking. There was no evidence of masking in any of the research on these two species. Certainly in the gray whale case, the interpretation by the scientists who conducted the research was that the whales responded but responses were not interpreted as having a behavioral impact. Furthermore, received level of 120 dB for LFA would not mask the species specific sounds of any low frequency mysticete, although under certain, rare circumstances it might interfere with species recognition. The masking effects of the SURTASS LFA signal are expected to be limited for a number of reasons. First, the frequency range (bandwidth) of the system is limited to about 30 Hz, and the instantaneous bandwidth at any given time of the signal is small, on the order of 10 Hz. Second, the LFA signal is active, or on, only about 7.5 to 10 percent of the time (i.e., low duty cycle based on historical LFA operations) during actual missions. Therefore, the effect of masking will be limited because animals that use this frequency region typically use broader bandwidth signals. As a result, the chances of an LFA sound actually overlapping whale calls at levels that would interfere with their detection and recognition would be extremely low.

Stress

Stress can be defined as a threat to homeostasis[2] (Fair and Becker, 2000) and is frequently measured with changes in blood chemistry (Romano et al., 2004; Smith et al., 2004a). These two last studies examined changes in blood chemistry in response to acoustic stimuli. Smith et al. (2004a) exposed goldfish (a hearing-specialist fish) to continuous background noise of 160-170 dB RL. There was a “transient spike” in blood cortisol levels within 10 minutes of the onset of noise that was loud enough to cause TTS. However, this cortisol spike did not persist and there was no long-term physiological stress reaction in the animals.

[2] Homeostasis is the property of an open system, especially living organisms, to regulate its internal environment to maintain a stable, constant condition, by means of multiple dynamic equilibrium adjustments, controlled by interrelated regulation mechanisms.

Thomas et al. (1990) exposed captive belugas to recorded industrial noise for 30 minutes at a time, with a total exposure of 4.5 hours over 13 days with a source level of 153 dB. Catecholamine blood levels were checked both before and after noise exposure; however, no significant differences in blood chemistry were observed. Another experiment that measured blood chemistry, but also varied the sound level is described in Romano et al. (2004). In this experiment, a beluga whale was exposed to varying levels of an impulsive signal produced by a watergun. The levels of three stress-related blood hormones (norepinephrine, epinephrine and dopamine) were measured after control, low-level sound (171-181 dB SEL) exposure and high-level (184–187 dB SEL) sound exposure. There were no significant differences between low-level sound exposure and control, while the high-level sound exposure did produce elevated levels for all three hormones. Furthermore, regression analysis demonstrated a linear trend for increased hormone level with sound level.

These data support a linear dose-response function (like the LFA risk continuum) for sound exposure and the onset of stress, with only high levels of sound leading to a stress reaction. The extrapolation of the response thresholds from the Romano et al. (2004) experiment to the LFA situation is tenuous because of the differences in the signals, but the relationship between sound level and stress is supported by several studies. As mentioned above (2.7.2), there are some recent data (e.g., Evans, 2003) implicating synergistic effects from multiple stressors, including noise. Although there are no data to support synergistic effects, similar impacts might occur with marine mammals, given the multiple stressors that often occur in their environment. In conclusion, this indicates that while stress in marine animals could possibly be caused by operation of the LFA source, it is likely to be constrained to an area much smaller than the zone of audibility, more similar in size to the mitigation zone around the vessel.

The potential effects of SURTASS LFA sonar operations on sea turtles and sea turtle populations are addressed in SEIS RTCs 4.2.1, 4.2.2, 4.2.6, and 4.2.7. The Navy has and will continue consultations with NMFS under the ESA on listed species, including sea turtles.

TTS/PTS

Comment 4.3.24: One important indictment against the appropriateness of the 180dB safe level comes from the UK military. In the EIS for the Royal Navy's SONAR 2087 low frequency sonar system (which has a source level approximately 10 dB quieter than the U.S. LFA SURTASS system), PTS was predicted to occur 6.6 km from the source.[3] The UK EIS predicted, moreover, that TTS could occur up to 71 km away.[4] Thus, the current safety radius of the louder and potentially more injurious LFA SURTASS system is clearly inappropriate. I-058

Response: According to the commenter the EIS by QinetiQ (2002) predicted PTS to occur 6.6 km from the source. In a more current Environmental Impact Assessment in Support of a S2087 Trial in the Northwest Approaches to the UK, August/September 2005 (QinetiQ, 2005), the thresholds for marine mammal acoustic impact criteria were: 1) PTS at 180 to 184 dB; 2) TTS 144 to 147 dB. Based on these values and acoustic calculations for the S2087 transmission, the stand-off ranges (SOR) for this test were 150 m (492 ft) for PTS and 43.8 to 56.8 km (23.7 to

[3] QinetiQ (2002).
[4] *Ibid.*

30.7 nm) for TTS (QinetiQ, 2005). Therefore, the more recent QinetiQ environmental impact assessment supports the conclusion that the SURTASS LFA 180-dB injury criterion (which includes PTS) of 1 km (0.54 nm) for LFA is appropriate and conservative. Additionally, SEIS RTC 4.3.26 provides a discussion of NMFS' thresholds for TTS and PTS.

Comment 4.3.25: There are many flaws in current methods of estimating potential source levels that could cause TTS and PTS in cetaceans. The "safe" level sound exposure for cetaceans appears to be primarily based upon extrapolations of responses by trained marine mammals, in particular, reported hearing sensitivities and observed onset of TTS, to exposures of man-made sounds, conducted in a captive, experimental environment. The applicability of these captive studies to cetaceans in the wild is highly debatable, with other studies so far showing a significant discontinuity between predicted sensitivities to sound and actual observed reactions by animal. The studies demonstrate the differences between conditioned, captive animals and wild animals. Also, sensitivity tests used pure tones, which animals would not encounter in the wild. It is possible that cetaceans have greater sensitivity to sounds which are biologically relevant, or sounds they are adapted to hear. This may have implications for some sound types, such as LFA, that sound very similar to the sounds produced by cetaceans. Finally, for cetacean species whose hearing sensitivities are unknown, extrapolations are made using other species, perhaps adjusted according to the known frequencies of vocalizations produced by particular species of concern. Extrapolations are problematic as animals may have excellent hearing capabilities outside the ranges in which they produce vocalizations. The 180 dB zone of impact is based on models extrapolating hearing abilities and thresholds of captive animals and the 180 dB zones were calculated based on the likelihood of producing temporary or permanent hearing damage in captive cetaceans. Using captive animal data is inappropriate for predicting behavioral responses in wild animals to noise disturbances. Zones of disturbance based on published, peer-reviewed, empirical observation of reactions by wild animals would be preferred. I-058

Response: The commenter presumes that the thresholds used in the FOEIS/EIS and SEIS were derived only from the captive TTS studies (e.g., Schlundt et al., 2000; Finneran et al., 2005). The initial selection of the 180-dB criterion for potential injury to marine animals was based on the best available data. This included:

- Extrapolation from equivalent human exposure results and comparison to fish hearing studies (See FOEIS/EIS pp. 1-24 to 1-26);
- Several scientific and technical workshops and meetings (See FOEIS/EIS p. 1-28); and
- TTS studies on bottlenose dolphins, white whales, harbor seals, sea lions, and elephant seals (See FOEIS/EIS pp. 1-26 to 1.27).

Further details concerning the LFA 180-dB criterion are provided in the SEIS Subchapter 4.3 and SEIS RTC 4.3.26.

Comment 4.3.26: Navy sets its threshold for hearing loss, or "threshold shift", at 180 dB re 1 micro Pa for a single, 100-second "ping" of exposure. Its contention, completely unchanged since the FEIS, is based on two flawed arguments—one, extrapolating from human and other terrestrial animals, and the other relying on limited data sets. O-014

- Navy disregarded new data on critical ratios and fails to account for expert criticism of Navy's approach made during first take authorization process.
- Navy misapplied hearing loss data taken from marine mammals, given its broad extrapolation from two species whose auditory sensitivity at test frequencies is poorer than that of other cetaceans, and its mistaken substitution in the Final EIS of 1-sec exposure thresholds for the 100-sec LFA signal. (FEIS p 1-27 and USWTR DEIS at 4.3-14).

Response: Misapplication of hearing loss data: As stated in the FOEIS/EIS, the 180-dB criterion for the purpose of SURTASS LFA sonar analysis is that all marine animals exposed to RLs $\geq$ 180 dB are evaluated as if they are injured. In its Final Rule for SURTASS LFA, 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 has adopted the standard that 20 dB of TTS defines the onset of PTS (i.e., a temporary shift of 20 dB in hearing threshold) (67 FR 46712, p. 46721). As noted in Schlundt et al. (2000) bottlenose dolphins and white whales (belugas) exposed to 1-sec signals at 400 Hz did not exhibit TTS after exposures to maximum RLs of 193 dB SEL. The point must be made while dolphins and belugas responses at 400 Hz are valid for those species, these results probably do not generalize to great whales (baleen whales). In this research, dolphins and white whales did not have TTS in response to 400 Hz at RLs of 193 dB SEL, but they did have TTS in response to higher frequencies at the same level. Therefore, it is reasonable to presume that the TTS threshold value from odontocetes at their frequency of highest sensitivity is applicable to larger animals' lower frequencies that are in the range of their best hearing sensitivity. This extrapolation is based the fundamental similarity of cochlear structure between odontocetes and mysticetes.

As a result, if it were assumed that 193 dB was the onset of TTS (conservative assumption because TTS was not observed at an RL of 193 dB SEL), then onset of PTS would be 20 dB above that, at 213 dB RL (SEL). This number is based on a signal of one second in duration. Using a 10 Log (T/Ti) where Ti is 1 second, then for a maximum 100-sec LFA signal, a 20-dB adjustment must be made, meaning that the onset of PTS would be 193 dB RL (SEL). This value is above the conservative LFA criterion for injury. Further detailed discussions are provided in the FOEIS/EIS RTCs 4-6.13 and 4-6.38 and the Final Rule RTCs MMIC8, MMIC9, SIC40, SIC58, and SIC59.

New data on critical ratios: Recent data on critical ratios (CR) in pinnipeds is discussed in the SEIS Subchapter 4.3.5. These data indicate that the CR for pinnipeds are lower in magnitude than for terrestrial animals (Southall et al. 2003). Southall et al. (2003), in describing their CR results, state that "It is reasonable to speculate that acoustic signal production and reception in typically noisy marine environments have led to selection for enhanced ability to detect signals in noise". Therefore these new CR data indicate that pinnipeds may be pre-adapted for detecting biologically important signals in high noise environments. Furthermore, the lower critical bandwidths of the pinniped auditory filters has the effect of decreasing the probability of masking of signals by noise at a different frequency (Southall et al. 2000). Nevertheless, pinnipeds remain as susceptible as any species to masking of signals by noise in the same frequency band.

Comment 4.3.27: Because LFA sonar will ensonify large ocean areas with RLs high enough to cause TTS, it is very likely that impacts to marine mammals will be far greater than the Draft SEIS states. O-008

Response: As discussed above in SEIS RTC 4.3.6, the LFA signal is not expected to cause TTS at RLs below 180 dB, or about 1 km (0.54 nm) from the vessel. Because of the high effectiveness of the monitoring and mitigation procedures, no animals are expected to be ensonified above 180 dB (RL) within the LFA mitigation zone. Thus no animals are anticipated to be exposed to levels necessary to induce TTS. See NMFS Final Rule (67 FR 46712) RTC MMIC9 for further discussion.

Comment 4.3.28: Why isn't TTS considered injury? O-011

Response: This issue was addressed by NMFS in the SURTASS LFA Final Rule (67 FR 46712) in RTC MMIC8, which concluded that NMFS does not believe the evidence warrants that TTS be considered as an injury. For more detail, see SEIS RTC 4.3.26.

Biological significance/behavior/stress

Comment 4.3.29: The Navy has not conducted any study to determine whether exposure to sound causes biologically significant effects. Exposure studies conducted have only looked at short term responses, during a short exposure at levels (on average 120 dB RLs) much lower than LFA source levels. Also, although cetaceans may not produce an observable reaction, or may exhibit only minor behavioral changes, this does not mean that there is no biologically significant impact. I-058

Response: The risk continuum explicitly represents the potential for significant change in a biologically important behavior within the 119 to 180 dB RL range. For additional information, see FOEIS/EIS RTCs 4-5.2, 4-5.6, 4-5.10, 4-5.22, 4-6.2, 4-6.3, and Appendix D.

Comment 4.3.30: There is no justification for concluding that the potential effects on the stock of any marine mammal from behavioral change or auditory masking would be minimal. The SRP was limited in scope and even then, significant results of avoidance or behavioral or vocal change were noted. No studies have been conducted on marine mammals using the full operational SL. You should mention the Miller et al. (2000) study on humpbacks that noted lengthening their song due to LFA broadcasts. I-011

Response: The justification for the conclusion that the potential effects on the stocks of marine mammals from behavioral changes would be minimal is discussed in SEIS RTC 4.3.29 above. The potential effects of masking are discussed in SEIS RTCs 4.3.1 and 4.3.23 above. The use of operational SLs is addressed in FOEIS/EIS RTC 4-5.21 and SEIS RTC 4.3.3 above. It is reiterated that during Phase I of the LFS SRP research, there were times when the test source level was at the higher, operational level. During such test periods received levels at the subject animals were within the range as specified in the research permit and responses were no different than those observed when using lower source levels.

The Miller et al. (2000) article "Whale songs lengthen in response to sonar" concerning observations of male humpback whales during Phase III of the LFS SRP was addressed in the Final OEIS/EIS RTC 4-5.19 and in NMFS Final Rule RTC SIC16 and SIC17. Fristrup et al. (2003) used a larger data set from Phase III to describe song length variability and to explain song length variation in relation to LF 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 tend to lengthen their songs in response to LF broadcasts.

The Fristrup et al. (2003) results provide 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 salient to the acoustic observers on the scene, but were revealed by careful statistical analyses (Fristrup et al., 2003). Aside from the delayed responses, other measures failed to indicate cumulative effects from LF broadcasts, with song-length response being dependent solely on the most recent LF 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 LF transmissions, and the fraction of variation in song length that could be attributed to LF broadcast was low. Fristrup et al. (2003) found high levels of natural variability in humpback song length and interpreted the whales' responses to LF broadcasts to indicate that exposure to LFA would not impose a risk of dramatic changes in humpback whale singing behavior that would have demographic consequences.

Comment 4.3.31: Reserved.

Comment 4.3.32: Behavioral changes of marine mammals caused by sonar must be seriously addressed as they may have substantial consequences that cannot be easily observed. “The status of any population is the consequence of the accumulation of many effects; resulting in marginal changes in survival and reproduction over time…the end result is often so far removed in time from the proximate causal events that they cannot simply be traced post hoc” (NRC, 2005). O-012

Response: The following response is a summary of the information provided in the FOEIS/EIS.

Given that the LFA sound source can be detected at moderate to low levels over large areas of the ocean, there was concern at the initiation of the NEPA process in 1996 that there was the potential for large percentages of species stocks to be exposed to moderate-to-low received levels. If animals are disturbed at these moderate-to-low exposure levels such that they experience a significant change in a biologically important behavior, then such exposures could potentially have an impact on rates of reproduction or survival. Knowing that cetacean responses to LF sound signals needed to be better defined using controlled experiments, the Navy helped develop and supported the three-year LFS SRP beginning in 1997. This field research program was designed to address three important behavioral contexts for baleen whales: 1) blue and fin whales feeding in the southern California Bight, 2) gray whales migrating past the central California coast, and 3) humpback whales breeding off Hawaii. Taken together, the results from the three phases of the LFS SRP do not support the hypothesis that most baleen whales exposed to RLs near 140 dB would exhibit disturbance behavior and avoid the area. These experiments, which exposed baleen whales to RLs ranging from 120 to about 155 dB, detected only minor, short-term behavioral responses. Short-term behavioral responses do not necessarily constitute significant changes in biologically important behaviors.

These results have been supported by recent, peer reviewed papers. Croll et al. (2001a) studied the effects of anthropogenic LF noise (SURTASS LFA sonar) on the foraging ecology of blue and fin whales off San Nicolas Island, California. Overall, the whale encounter rates and diving behavior appeared to be more strongly linked to changes in prey abundance associated with ocean parameters than to LFA transmissions. In some cases, whale vocal behavior was significantly different between experimental and non-experimental periods. However, these differences were not consistent and did not appear to be related to LF sound transmissions. At the spatial and temporal scales examined, Croll et al. stated that they found no obvious responses of whales to a loud, anthropogenic, LF sound.

Both Miller et al. (2000) and Fristrup et al. (2003) published on the results of tests conducted with male humpback singers off Hawaii in which they evaluated variation in song length as a function of exposure to LF sounds. In spite of methodological differences, the results of both studies indicated that humpback whales slightly increased their songs in response to LF broadcasts. Fristrup et al. (2003) found that the fraction of variation in song length that could be attributed to LF broadcast was low and concluded that the effects of LF broadcast did not impose a risk of dramatic changes in humpback whale singing behavior that would have demographic consequences. Slso see SEIS RTC 4.3.30 above.

Comment 4.3.33: Navy does not consider the possibility that injuries could result at sea from behavioral changes such as rapid surfacing or premature diving, whether or not the whale strands. O-014

Response: As related to LFA, the Navy performed extensive research to determine the potential for LF transmissions to cause significant behavioral effects in whales (LFS SRP). There is no indication during these tests that whales surfaced rapidly or dove prematurely in response to LFA source transmissions. The mechanisms to cause such events are based on the theory that mid-frequency naval sonar can cause rapid surfacing and diving, thus resulting in acoustically mediated bubble growth. See discussion in SEIS RTCs 4.0.3, 4.3.7, and 4.3.12 above.

Comment 4.3.34: Why is no threshold given for behavioral impacts (Level B harassment)? O-010

Response: Behavioral harassment is assumed to be a significant change in a biologically important behavior. This is defined by the risk function, which is discussed in detail in the FOEIS/EIS Subchapter 4.2.3.

Comment 4.3.35: The Draft SEIS ignores other important negative effects the sonar had even at the low levels used in Hawaii (during LFS SRP). It does not address the fact that two separated cetacean calves were observed in the relatively small test area in Hawaii during and shortly after testing. Separated cetacean calves are rare. Do sonar signals disrupt the mother-calf bond? O-010, O-012

Response: The issue of potential calf strandings during the LFS SRP in Hawaii was addressed in the Final OEIS/EIS RTC 4-5.25 where it was concluded that these events were not related to LFA testing. Masking of communications could potentially affect the mother-calf bond; however, masking effects from the SURTASS LFA signal are extremely unlikely and are expected to be negligible. The rationale for this is discussed in SEIS RTCs 4.3.23 above and 4.3.36 through 4.3.40 below. Thus, LFA signals are not expected to disrupt the mother-calf bond.

Masking

Comment 4.3.36: The Navy's statement that there has been no change in knowledge on masking since its last EIS is incorrect. A study published in 2004 noted significant masking of whale calls as the result of noise produced by seismic surveys as much as 3000 miles or more from their source (Nieukirk et al., 2004). I-058

Response: The above comment is a misinterpretation of Nieukirk et al. (2004). The paper states that sounds from seismic air guns were recorded frequently from locations over 3000 kilometers (not 3000 miles) away. The paper stated that air gun sounds tended to dominate recordings during the summer months, but that loud whale vocalizations could still be detected during intense air gun activity (p. 1838). It also stated that it was unlikely that air guns completely obscured whale sounds, as calls were detected during months of frequent air gun activity, and that the repetition rate of air guns is such that most whale sounds can be heard between pulses.

Air guns typically produce sound repetitively every 10-20 seconds over a span of days to weeks with occasional interruptions. This differs substantially from LFA transmissions, which are 6 to 100 seconds in length, followed by a quiet period of 6 to 15 minutes.

Comment 4.3.37: Draft SEIS (p. 4-61) states that there is the possibility for upward masking of HF noises by LF noises. FOEIS/EIS and Draft SEIS rationale for masking not being severe is maximum 10 seconds at same frequency over a maximum 100 second LFA signal. How does this upward masking affect this rationale? O-008

Response: While the upward spread of masking is known to exist, the phenomenon has a limited range in frequency. Yost (2000) showed that magnitude of the masking effect decreases as the difference between signal and masking frequency increase, i.e. the masking effect is lower at 3x the frequency of the masker than at 2x the frequency. Gorga et al (2002) demonstrated that for a 1.2 kHz masking signal, the upward spread of masking was extinguished at frequencies of 6 kHz and higher. Gorga et al (2002) also demonstrated that the upward spread of masking is a function of the received level of the masking signal. Therefore a large increase in the masked bandwidth would only occur at high received levels of the LFA signal. Therefore while the phenomenon of upward spread of masking does exist, LFA signals are unlikely to have any significant effect on the hearing of HF animals. <u>SEIS Subchapter 4.6.1.2 has been updated.</u>

Comment 4.3.38: The Draft SEIS does not make clear that noise does not need to be the same frequency as the signal of interest to mask it. At low and very high frequencies, a noise can mask a much wider range of frequencies (Richardson et al. 1995). This would apply to LFA, as a low frequency signal. I-011, O-010

Response: See SEIS RTC 4.3.37 above. <u>SEIS Subchapter 4.6.1.2 has been updated.</u>

Comment 4.3.39: The effects of reverberation are not addressed in this Draft SEIS, and how reverberation can increase the effective duty cycle in terms of masking and other impacts. That auditory masking from LFA is not continuous may be true, but reverberations from the ocean floor can make signals (such as pings given every 24 s) all but continuous, as shown by analysis of the Bahamas stranding (Hildebrand and Balcomb, 2004). The same has been found to be true for such noise events as seismic surveys. Masking is not just restricted to the duration of the signal; rather, reverberation effects draw out the duration of the masking considerably. If the LFA signal can be over 1.5 min long in duration and the time between transmissions could be as little as 6 min, then, including reverberations, the noise could be nearly continuous. I-011, O-010, O-013

Response: As a general rule, reverberation "dies off" or decreases with distance from the source as an exponent of time after sound transmission. However, this is not instantaneous and, depending on propagation and ocean boundary conditions, reverberation can linger in an area for seconds or even minutes after a sound transmission, but at greatly reduced levels until it fades into background noise. In special cases (i.e., locations with the correct bathymetry, propagation conditions and signal repetition rates), the reverberation may not completely die off before the next transmission. Generally, however, the reverberation levels several seconds after transmission are so much less than the original signal, (i.e., approaching ambient noise levels) that they do not "add to the duty cycle."

The LFA repetition rate is low (i.e., transmission every 6 to15 minutes, vice transmissions every 10 to 60 seconds for tactical sonar and 5-20 seconds for seismic survey transmissions). Therefore, the reverberation for LFA signals has had sufficient time to significantly decrease to levels much less than 120 dB in the vicinity of the source, prior to the transmission of the next signal. Additionally, reverberation away from the source's location starts at an even lower level than near the source and generally decreases faster than in proximity of the source, so it is always less than near the source.

It is possible to hear distant reverberation from LFA source transmissions many minutes after the transmission, but these levels are so close to ambient noise that it requires a long and powerful receiver array and scientifically-sophisticated signal processing to even have the ability to identify this reverberation in the background noise.

Comment 4.3.40: Low levels of received sound have the potential to disrupt a large portion of a population, if sound reduces hearing sensitivity enough to mask normal stimuli. O-012

Response: Masking is addressed in SEIS RTCs 4.3.23 and 4.3.36 through 4.3.39 above.

Non-Auditory—Bubble growth/Resonance

Comment 4.3.41: Marine mammals can likely sense low frequencies in other ways than through the ear, such as by vibrations of the skin or the lungs. Thus, audiograms or presumed audiograms are not the most reliable measure of which species might be affected. I-011

Response: Detection of vibration from an acoustic signal is possible through two mechanisms. First is resonance of body structures, caused by the gas-filled bladders in the body acting as pressure-release surfaces. The resonant frequency of a structure (e.g., a lung) is a function of the densities of the tissue, the gas pressure and the volume of the structure. The whole-lung resonance of dolphins and belugas have been measured at 36 and 30 Hz, respectively (Finneran, 2003). These measurements were made in shallow water. As an animal dives, the resonance frequency rises, but the degree of tissue movement decreases, making resonance injury less likely at depth (NMFS, 2004). Furthermore, the received sound level needed to create a resonant response in animal tissue is very large, in excess of 180 dB. The mitigation procedures in place on the LFA vessels make such an outcome very unlikely.

Marine mammals may be able to detect physical vibration of the skin, but this is only possible in the acoustic nearfield of the source, where there is net particle motion of water molecules. Again, this is only possible very close to the acoustic source, and the mitigation procedures in place make this very unlikely.

Comment 4.3.42: Behavioral reactions can produce Level A harassment, as has been indicated by beaked whale reactions to sonar. It is not yet known whether a non-auditory behavioral reaction or something else causes the growth of bubbles in beaked whale tissues during a noise event. The best estimate of the average level the Bahamian whales received was on the order of 130 dB (Hildebrand and Balcomb, 2004). How can 180 dB be used as the threshold for impact, even Level A harassment? Why is there no threshold given for behavioral impacts (Level B harassment)? I-011, O-010, O-014

Response: There is no evidence that LFA has caused behavioral reactions in beaked whales. The reality is that all of the evidence states that it should not: 1) beaked whales do not hear LF sounds well and therefore would not be expected to react to LFA signals; 2) LFA has not been associated with any strandings (including the Greek stranding in 1996); 3) beaked whale strandings are reported to have increased since the used of mid-frequency sonar in the 1960s (Balcomb and Claridge, 2001) while LFA was not developed until the 1980s; and 4) LFA does not meet the common features determined by D'Spain et al. (2006) for beaked whale strandings. Hence, beaked whale stranding events are not a foreseeable likely result of the use of SURTASS LFA sonar; and the 180-dB injury threshold used for LFA is valid.

Acoustically mediated bubble growth is based in part on the theory that naval sonar can cause rapid surfacing and diving. As related to LFA, the Navy performed extensive research to determine the potential for LF transmissions to cause significant behavioral effects in whales

(LFS SRP). During these tests, there was no indication that whales surfaced rapidly or dove prematurely in response to LFA source transmissions. See discussion in SEIS RTCs 4.0.3, 4.3.1, and 4.3.12.

The thresholds for Level B harassment for LFA are determined by the risk continuum (see FOEIS/EIS, Subchapter 4.2.3).

Comment 4.3.43: It is an assumption that odontocetes are less likely to be affected by exposure to LF sounds than mysticetes. While odonocetes do specialize more in the mid- to high frequencies, there are other aspects about odontocetes that may make them more vulnerable to noise than mysticetes. For one, the deep divers are all odontocetes, and deep divers are thought more vulnerable to noise (Houser et al., 2001b). Also, odontocetes more frequently mass strand, and beaked whales have been shown to be especially sensitive to noise. These are reasons why mysticetes and odontocetes could be vulnerable to LFA noise exposure. I-011

Response: Beaked whales do not hear LF sounds well and therefore are less likely to have a behavioral reaction to LFA which might cause rapid ascent. As to the hypothesis that noise can produce acoustically mediated bubble growth, Cox et al. (2006) provided a summary of three common features shared by the strandings events in Greece (1996), Bahamas (2000), and Canary Islands (2002), in which bubble growth has been hypothesized as a possible cause. These included deep water close to land (such as offshore canyons), presence of an acoustic waveguide (surface duct conditions), and periodic sequences of transient pulses (i.e., rapid onset and decay times) generated at depths less than 10 m by sound sources moving at speeds of 2.6 m/s (5.1 knots) or more during sonar operations (D’Spain et al., 2006). As stated earlier, these features are not applicable to LFA operations.

Comment 4.3.44: Non-auditory injury of marine mammals was only briefly discussed. Marine mammals do not have control over sound pressure especially when onset is sudden. O-008

Response: As stated in the comment, non-auditory injury of marine mammals was discussed in the Draft SEIS (Subchapter 4.3.1) and the FOEIS/EIS (Subchapter 1.4.2 and RTCs 4-6.11 and 4-6.24). It was generally recognized that a marine animal’s auditory system is the most sensitive to injury by underwater acoustics. Therefore, the auditory system would determine the greatest range from the source that could possibly cause injury (i.e., injury to other organs would only occur if the animal was inside this maximum range for injury). Therefore by addressing this maximum injury range, as both the FOEIS/EIS and Draft SEIS did, all injury was addressed. Since LFA mitigates to preclude any injury to even the most sensitive organ, prevention of auditory injury thus prevents all other types of injury.

Comment 4.3.45: Commenters stated that they knew of no data to support the idea that marine mammals’ adaptation to pressure changes due to diving enables them to tolerate pressure changes from noise. They requested that supporting data be provided for this statement. I-011, O-010

Response: Even though this comment does not appear in the Draft SEIS, it is a logical conclusion. Even if a marine mammal’s adaptation to pressure change may not prove that marine mammals can tolerate pressure changes from noise, their ability to repeatedly be exposed to many other very loud, natural sounds (e.g., lightning strikes, earthquakes, conspecific biological sources, etc.) indicates that they have some ability to handle loud noise, without affecting their hearing ability.

Comment 4.3.46: Nov 2002 NMFS Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans discussed need for research on trained animals to test theory of bubble growth. This is simply not ethical and should never take place. O-008

Response: The Navy currently has no plans for such research.

Comment 4.3.47: While it is not yet known if bubble growth is induced by sonar sound, or the whale's behavioral reaction to that sound, it is widely accepted that *in vivo* bubble growth can occur in supersaturated marine mammal tissues when animals are exposed to sounds as low as 150 dB RL, leading to their injury or death (Houser et al., 2001b; Fernandez et al., 2005; Cox et al., 2006; Crum et al., 2001; Potter, 2004; Moore and Early, 2004; Jepson et al., 2005). O-008, O-014

Response: Cox et al. (2006) stated that gas-bubble disease, induced in supersaturated tissues by a behavioral response to acoustic exposure, is a plausible pathologic mechanism for the morbidity and mortality seen in cetaceans associated with mid-frequency sonar exposure. They also stated that it is premature to judge acoustically mediated bubble growth as a potential mechanism and recommended further studies to investigate the possibility.

Comment 4.3.48: The Navy attempts to discredit the bubble lesion theory but exaggerates the extent to which the theory is controversial. I-058, O-014

Response: See SEIS RTC 4.3.47 above. Since the Draft SEIS was published, there has been additional information available on this theory. If acoustically mediated bubble growth does prove to be the mechanism leading to mortality and/or strandings of beaked whales, then the fact that LFA has not been associated with any of these strandings would indicate that it would be less likely to cause this effect.

Comment 4.3.49: Even at distances of 120 to 200 miles from LFA sonar, severe tissue damage still occurs in marine mammals. O-012

Response: See SEIS RTCs 4.3.47 and 4.3.48 above.

Comment 4.3.50: It is a misconception that inner ear trauma is required to establish a link between a stranding and an acoustic event. Whales may also strand due to panic. I-011

Response: The issues of non-auditory effects are addressed in SEIS RTCs 4.0.3, 4.3.12, 4.3.42, and 4.3.47 above. The strandings suspected of being caused by a behavioral (panic) reaction leading to either rapid surfacing/diving or stranding are not related to LFA. LFA does not fit the profile developed by the workshop on understanding the impacts of anthropogenic sound on beaked whales convened by the Marine Mammal Commission (Cox et al., 2006). In addition, during the LFS SRP where LFA sound transmissions occurred in proximity to both LF-sensitive baleen whales and the shoreline, there were no reactions, such as those caused by panic, nor any strandings.

Comment 4.3.51: While masking is certainly a very widespread potential impact of human-made noise, it is not the only impact. Stress, increased aggression, and effects on the ecosystem are some other widespread potential impacts. I-011

Response: Stress on marine animals is discussed in SEIS RTCs 4.1.11, 4.3.12, and 4.3.23 above. Other effects on the marine ecosystem were discussed in the FOEIS/EIS and SEIS.

Comment 4.3.52: Why has the potential for impacts to marine mammals brought on by the stress caused by LFA sonar noise not been addressed? Where are the discussions of the effects of increased noise levels on young animals' development, physiological effects, pregnancy/birthrates, and aggression? O-008, O-010, O-012

Response: See SEIS RTCs 4.3.12 and 4.3.23 above.

Comment 4.3.53: Beaked Whale Workshop concluded that resonance was considered less likely than non-auditory effects but was still an open question. Resonance was not ruled out as a mechanism for noise-induced strandings. O-010

Response: The issue of resonance is addressed in SEIS RTC 2.5.2. This response concluded that the analysis by the Navy (Cudahy and Ellison, 2002) and reports on two workshops on acoustic impacts (DOC, 2002; Cox et al., 2006) support the conclusion that resonance from LFA operations is not a "reasonably foreseeable" impact.

Comment 4.3.54: The developmental effects of growing up in a noisy environment are not addressed in this Draft SEIS. Experiments with young rats show brain development suffers under even moderate noise conditions (Chang and Merzenich, 2003). Chronic noise increases the risk of cardiovascular disease in humans (Willich et al., 2005). Yet the focus is almost exclusively on PTS and TTS. I-011, O-010

Response: Both Chang and Merzenich (2003) and Willich et al. (2005) demonstrate that noisy environments and chronic noise can be problematic. However, both of these studies involve the long term, or chronic, exposure to noise. NRC (2003) states that sounds resulting from one-time exposures are less likely to have populations level effects than sounds that animals are exposed to repeatedly over extended periods. There is a very small chance that LFA exposure to individual animals and stocks would be repeated over extended periods of time. See SEIS RTCs 4.3.12 and 4.3.23 above for further discussions on stress.

Risk Function

Comment 4.3.55: Risk function is at odds with recent developments in literature: O-014

- **Comment 4.3.55a:** Draft SEIS fails to incorporate several recent studies on effects of LF sound on various marine mammal species demonstrating impacts to large whales at RLs lower than those covered by the risk function; e.g., Weller et al. (2002): Influence of Seismic Surveys on Western Gray Whales off Sakhalin Island, Russia in 2001; Independent Scientific Review Panel (2005): Impacts of Sakhalin II Phase 2 on Western North Pacific Gray Whales and Related Biodiversity; and Norwacek et al. (2003).

Response: Weller et al. (2002) and the Independent Scientific Review Panel (2005) are both concerned with the influence of seismic surveys (air guns) on western gray whales. It is difficult to analyze the results of this study because the study authors were not permitted to include the acoustic information, air gun specifications, and duty schedules in their analysis. As stated in SEIS RTC 4.3.1 above, the coherent LFA signal differs substantially from impulsive seismic survey sounds, and therefore the results of these reports are not applicable to LFA.

Nowacek et al. (2003) in studying potential alerting stimuli for Northern Atlantic right whales found that underwater sounds with an acoustic structure similar to their alert stimulus at RLs of 133-148 dB are likely to disrupt feeding behavior for the duration of the sound exposure, with return to normal behavior within minutes of when the sound was turned off. Their results are consistent with those of the LFS SRP, which exposed baleen whales to RLs ranging from 120 to 155 dB, detecting only minor, short-term behavioral responses. The risk function is based on the LFS SRP results. See FOEIS/EIS Subchapter 4.2.4.3.

Fear that this signal can cause the right whales to surface and thus be vulnerable to ship strikes is not applicable to the LFA vessels because the vessels only move at about 5.6 kph (3 knots) and mitigation measures will detect any large whales well before they enter the LFA migration zone, at which time LFA operations would be suspended.

- **Comment 4.3.55b:** Risk function fails to account for chronic impacts from behavioral changes and non-auditory physiological impacts such as stress, which may occur at levels lower than those tested in LFS SRP. Also includes cumulative effects.

  Response: See SEIS RTCs 4.3.12 and 4.3.23 above.

- **Comment 4.3.55c:** Draft SEIS disregards recent information on masking indicating the potential for masking to interfere with long-distance mating behavior of mysticetes at RLs far lower than those effectively covered by the Navy's standard.

  Response: See SEIS RTC 4.3.23 and RTCs 4.3.36 through 4.3.39 above.

- **Comment 4.3.55d:** Navy is out of step with how the potential for behavioral impacts has been assessed in other contexts; e.g., letter from Rodney F. Weiher, NOAA, to Keith Jenkins, Naval Facilities Engineering Command Atlantic (Jan. 30, 2006).

Response: The NOAA letter referenced relates to MFA activities and is not applicable to LFA.

- **Comment 4.3.55e:** Draft SEIS does not consider impacts from behavioral changes in prey species such as fish will have on marine mammal foraging.

  Response: The impacts from behavioral changes in prey species is discussed in the SEIS (Subchapter 4.1.1). The references on behavioral effects to prey species are based on studies of potential effects from seismic survey sources (Skalski et al., 1992; Engås et al., 1996; McCauley et al., 2000), not LFA; and therefore are not applicable. See SEIS RTC 4.3.1 above for additional information.

ISSUE 4.4 Analyses of SURTASS LFA Sonar Operations Under Current MMPA Rule (Risk Assessment Approach, Risk Assessment Case Study, Marine Mammal Strandings)

LFS SRP

Comment 4.4.1: Draft SEIS (4-35) states that behavioral responses observed during the LFS SRP were short-lived. Does this mean that short-term behavioral changes cannot have serious consequences? To state that LFS SRP Phase I showed no immediate obvious response from either blue or fin whales, when in fact blue whales decreased their vocalizations by 50 percent and fin whales by 30 percent, is misleading. O-008

Response: In a published paper on Phase I of the LFS SRP, Croll et al. (2001a) stated, “In some cases, whale vocal behavior was significantly different between experimental and non-experimental periods. However, these differences were not consistent and did not appear to be related to LF sound transmissions. At the spatial and temporal scales examined, we found no obvious responses of whales to a loud, anthropogenic, LF sound.” This supports the statements made in the SEIS and the FOEIS/EIS.

AIM

Comment 4.4.2: It is impossible to comment fully on AIM because the program has not been released to the public. Disclosure of the model must occur for public comment to be meaningful under NEPA and APA, and for guidelines adopted under Data Quality (or Information) Act to be met. O-014

Response: The Acoustic Integration Model© contains proprietary programming that prevents its release to the public. As a result, AIM has recently undergone an independent scientific review by the NMFS-sponsored Center for Independent Experts (CIE). The CIE review took place September

25-27, 2006. A report from that review is publicly available on the NMFS web-site (http://www.nmfs.noaa.gov/pr/permits/incidental.htm). The Navy believes this review meets the requirements of the Data (Information) Quality Act and the Council for Environmental Quality's Council for Regulatory Environmental Monitoring (CREM) guidelines (see http://cfpub.epa.gov/crem/).

Comment 4.4.3: Based on limited data, the following serious problems can be identified with AIM that results in underestimations of impacts. O-014

- **Comment 4.4.3a:** Assumption of fairly even distribution across wide ocean areas, failing to account for possibility that certain animals like sperm and beaked whales concentrate in particular habitats. O-014

  Response: When there is no specific data on distribution, the impact prediction modeling DOES use an even distribution over the ocean area, since offshore concentrations of animals are not fixed in space or time. Nearshore concentrations can be relatively fixed in time or space, due to physical forcing from the steep bathymetry and seasonal variations (e.g Monterey canyon or Hudson canyon). However, LFA operates in deeper, offshore waters where the concentrations are fluid due to changing water mass conditions. Therefore an even distribution of animals is the one with the least assumptions. Basically, the model assumes that individuals of the species can occur anywhere within their ranges with equal probability over a long time. On any given day, the distribution of any given species is likely to be highly non-uniform. Over a long period of time the fluctuations in density are likely to even out. In light of the above, assuming an even distribution for the purposes of assessing potential impacts is reasonable and prudent.

- **Comment 4.4.3b:** Navy has not conducted research on habitat preferences of beaked whales as recommended by NMFS's Final Rule. O-014

  Response: The Office of Naval Research has funded the following research that has been published:

  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.

  The U.S. Navy/ONR and SERDP have funded the following research on predicting the distribution of marine mammal species, including beaked whales:

  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.

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.

In addition, ONR and SERDP have funded the development and fieldwork for the sound-and-orientation recording tag (DTAG), which has been successfully attached with suction cups to beaked whales (Tyack et al., 2006). These data are providing critically valuable information on the movement and dive behaviors of beaked whales, both of which are important to know in order to understand the acoustic exposure that the animals may receive.

As stated in the SEIS Subchapter 2.7, the NMFS initial LOA under Condition 7(d) required the Navy to conduct research in accordance with 50 CFR § 216.185(e). The SURTASS LFA Sonar LTM Program has been budgeted by the Navy at a level of approximately $1M per year for five years, starting with the issuance of the first LOA. The status of this research was summarized in Table 2-5 of the Draft SEIS. Planning has commenced for a 2007-2008 deep-diving odontocetes BRS to determine the potential effects of LFA, MFA, and seismic sources on beaked whales and other deep diving odontocetes at an estimated cost of $3M per year.

- **Comment 4.4.3c:** Navy assumes populations of marine mammals are unstructured and individuals are improperly considered part of region-wide, basin-wide, or even ocean world-wide stocks. Stock assessments are incomplete and out-of date. O-014

  Response: The modeling analysis considers the total amount of risk for each marine mammal species by summing a particular species' risk estimate within that stock, across areas of operation for each mission. This methodology does not assume that populations are unstructured, but includes the best information available on the reproductive behavior of each species at each mission site in order to determine stock affiliation and the total risk to the sustainability of each stock. Stock assessment data within U.S. waters are required to be updated annually under the MMPA, with new stock assessments being published when new data are available. The best available data were used in all instances of the modeling analysis for determining stock abundance and distribution.

- **Comment 4.4.3d:** Navy claims that significant impacts on stocks and populations would necessarily occur at percentages lower than those assumed in the Navy's modeling of coastal areas and NMFS' final rule, even disregarding the underestimations of take resulting from other errors described above. O-014

Response: The FOEIS/EIS states, "The model runs are designed to portray high potential effects for each site. For example, seasons were selected based on the potential for maximum LF-sensitive animal abundance." See FOEIS/EIS Subchapters 4.2.1 and 4.2.2.2, and RTCs 4-3.8, and 4-3.11**.** The Navy does not agree with the commenter's statement regarding the underestimations of take resulting from other errors; hence, no additional reply is warranted.

- **Comment 4.4.3e:** Navy's approach to modeling behavioral impacts from multiple exposures is not conservative. O-014

  Response: Commenter's issue with the modeling of multiple exposures appears to be partially based on Miller's (2001) assertion that the $5\log_{10}(N)$ formula is not conservative, and $10\log_{10}(N)$ should be used. The $5\log_{10}(N)$ formula is derived from TTS literature for impulsive sounds. Without any data on the effect of multiple exposures on behavioral response, the FOEIS/EIS assumed that behavioral processes operate in a similar manner as physiological processes and that a formulation derived from data is more realistic.

  Commenter cites Kastak et al. (2005), which examined the effect of duration of continuous noise on TTS. The one significant result showed that when the exposure duration was increased from 20 to 50 minutes for a California sea lion, there was a 3.9 dB increase in the level of TTS. This result matches the prediction from the $10\log_{10}(T)$ formula used in the FOEIS/EIS for continuous noise of less than two hours ($10\log_{10}(50/20) = 3.9$ dB). The other two experimental animals produced trends of increased TTS with increased exposure duration, but no statistically significant differences were found, probably due to the variability in the experimental results.

<u>Analysis</u>

Comment 4.4.4: There are no confidence limits on any of the numbers of individuals of each species in the area, nor on the number of animals in the stock. These are generally highly inaccurate estimates, so using only one number to denote them is very misleading and gives no sense of the potential range of percentage of animals affected. I-011, O-010

Response: An indication of the level of uncertainty associated with the abundance data was included as often as possible when those data were available in the species descriptions in SEIS Chapter 3. Levels of uncertainty were also included in the annual LOA applications submitted to NMFS (DON, 2002; 2003b; 2004b; 2005b; 2006b). While a measure of uncertainty would provide a sense of the potential range of percentage of animals affected, the point estimates given and used in the analysis represent the best data available. Furthermore, conservative assumptions in the analysis methodology provide an additional measure of protection for the species that is not able to be captured by any uncertainty measures. These assumptions are provided in the FOEIS/EIS (pp. 1-33 to 1-35) and SEIS Subchapter 4.4.1 and 4.4.2). Also, see FOEIS/EIS RTCs 4-3.13, 4-3.14, and 4-3.15.

Comment 4.4.5: If reliable estimates are not available, how can the Draft SEIS possibly determine that no more than negligible impacts will occur to the species and stocks, especially beaked whales? O-008

Response: Throughout the SEIS, the best available data on beaked whale distribution and abundance were used to estimate the potential impact on these species. If data specific to a mission area were not adequate, data from other areas that have received sufficient research attention (e.g., the eastern tropical Pacific) were used.

Comment 4.4.6: The identification of stocks is also very inexact and prone to many errors unless genetic analyses have conclusively ascertained whether populations are interbreeding or not. O-010

Response: Genetic analyses are important for determining the degree of mixing between associated aggregations of a marine mammal species. However, a population "stock" is fundamentally a term of management, and genetics often do not provide data on management time scales (Clapham et al., 2003). It is recognized that several different types of data are appropriate for identifying stocks (NMFS, 2005). The MMPA provides biological and ecological guidance for defining stocks (Barlow et al., 1995). The biological guidance is in the MMPA definition of population stock as "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement that interbreed when mature." The ecological guidance is addressed in the requirement that a stock be maintained as a functioning element of the ecosystem. NMFS (2005b) recommended that in the absence of adequate information on stock structure, a species' range within an ocean should be divided into stocks that represent defensible management units. In all cases, the best available data were used to identify stocks in each mission area.

Comment 4.4.7: What does "% affected < 180 dB" mean? What is the minimum RL considered to affect an animal behaviorally? This information is vital to have to be able to evaluate these numbers adequately. Based on our best knowledge from past research, an appropriate minimum RL for behavioral effects would be 120 dB (though behavioral effects have occurred considerably below these RLs). As the 120 dB isopleth extends out to 1,111 km, the percentage of animals affected would be much greater than given here. Again, it is very telling that nowhere in this Draft SEIS is the range of area affected to RLs of 120 dB ever given. I-011, O-010

Response: As stated in SEIS Subchapter 4.4.1, the SEIS was developed based on the analyses in the FOEIS/EIS. As stated in the FOEIS/EIS Subchapters 4.2.6.3 and 4.2.7, the modeling results using the risk continuum were given as percentage estimates of the portion of the marine mammal stocks potentially affected due to SPE levels. "% affected < 180 dB" refer to the percentage of marine mammal stocks potentially affected by SPE levels less than 180 dB. <u>For clarity, appropriate definitions have been added to the SEIS.</u> The thresholds for Level B harassment for LFA are determined by the risk continuum (see FOEIS/EIS, Subchapter 4.2.3).

The ranges to RL isopleths and the ocean volumes they would encompass vary under different oceanographic conditions and were analyzed in the FOEIS/EIS. Detailed results of these analyses are presented in Subchapter 4.2 of the FOEIS/EIS and in Technical Report #2 (Acoustic Modeling Results). Figures B-1 through B-31 of TR 2 provide the parabolic equation (PE) transmission loss (TL) plots for each of the 31 sites. These plots provide TL as a function of depth and range from the source.

Comment 4.4.8: Why, in the risk analysis/sensitivity flowchart is there no mention of the "No Action" alternative. What if the risks are too great? Is there never the possibility of concluding that the technology must be abandoned? I-011, O-010

Response: The No Action Alternative was addressed in the FOEIS/EIS Subchapter 2.3.1 and SEIS Subchapter 4.7.1. Both documents concluded that the risks of SURTASS LFA sonar operations, with mitigation, to the marine environment are minimal. The No Action alternative would not meet the need for improved capabilities in detecting quieter and harder-to-find foreign submarines at long range. Figure 4.4-1 of the SEIS depicted the sensitivity/risk process utilized to analyze all potential mission areas, starting with the Navy's ASW requirements for SURTASS LFA sonar and ending with the mission sites for the annual LOA applications. This process is not an evaluation of alternatives in the NEPA sense, so the "no action alternative" was not addressed. However, if one or more of the marine mammal factors (Marine Mammal Stocks, Marine Mammal Seasonal Analysis, and Marine Mammal Behavioral Analysis) is/are not favorable, then, as shown in the figure, there is a "No Go" decision, which requires changes to or refinement of the proposed mission area.

<u>Strandings</u>

Comment 4.4.9: The Navy has not yet undertaken and published an analysis of stranding data as related to naval maneuvers around the world. Why isn't this done yet? It would have an important contribution to the Draft SEIS. I-011, O-010

Response: Worldwide stranding events were discussed generally in Subchapter 4.4.3 of the SEIS. In that subchapter, the Navy's intention was to examine in more detail several of the more studied stranding events in which naval sonars were implicated as a potential cause. <u>This subchapter has been expanded in the SEIS based on stranding event information cited in more recent reports, such as ICES AGISC Report (ICES, 2005), and reports on the potential causes presented by ICES (2005), Cox et al. (2006), and D'Spain et al. (2006).</u> The Navy feels that this revision is adequate as related to the potential for SURTASS LFA to cause strandings because LFA was not considered causative in any of these events. Analysis of all naval maneuvers and potential worldwide strandings, both U.S. and international, is beyond the scope of this SEIS. Moreover, it is not warranted from an LFA context because, based on the most recent scientific reports, LFA has not been, nor is it expected to be, causative in marine mammal strandings.

Comment 4.4.10: Since FEIS (Jan 2001), there have been at least five mass strandings associated with ocean noise and several studies and papers related to impacts of noise on marine mammals. There is irrefutable evidence that anthropogenic sound causes marine mammal strandings. The statement in the Draft SEIS that there are no new data that contradict the assumptions or conclusions in the FEIS is questionable. More compelling evidence suggests that: a) mechanisms by which animals strand as a result of noise are very complex; b) different mechanisms can be involved and different impacts can result, depending on the species and circumstances; c) noise intensities at which animals strand are lower than previously assumed; and d) tissue damage is not necessary to cause animals to strand and die. O-013

Response: The issue in this SEIS is not whether anthropogenic sound causes marine mammal strandings, but rather does LFA cause marine mammal strandings. The evidence to date, supported by recent scientific reports, supports the logical conclusion that the U.S. Navy's LFA sonar does not cause marine mammal strandings. An *ad hoc* committee of international experts under the auspices of the ICES reviewed the impacts of sonar on cetaceans and fish. They concluded, "No stranding, injury, or major behavioural change has yet been associated with the exclusive use of low frequency sonar." (ICES, 2005). This is further supported by 36 scientists in their recently published paper which arose from the Marine Mammal Commission workshop on the impacts of anthropogenic noise on beaked whales (Cox et al., 2006). Therefore, the statement in the SEIS that there are no new data contradicting the assumptions or conclusions in the Final OEIS/EIS remain correct. In fact, there are new data from the scientific community that support the conclusions of both the FOEIS/EIS and SEIS (ICES, 2005; Cox et al., 2006; D'Spain et al., 2006). For more detailed information, see SEIS RTCs 4.0.3, 4.3.1, 4.3.2, 4.3.7, 4.3.8, 4.3.9, and 4.3.12 above.

Comment 4.4.11: The Navy should state that "strandings are related to human-made noise," not *potentially* related to anthropogenic sound. Also, there are 33 other stranding events linked to noise that are not mentioned in the Draft SEIS. I-011

Response: In a recently published paper, which arose from the Marine Mammal Commission workshop on the impacts of anthropogenic noise on beaked whales, Cox et al., (2006) discussed "Potential Mechanisms" by which sonar *may* lead to beaked whale strandings. The heading in the Draft SEIS (p. 4-53), "Strandings potentially related to anthropogenic sound", is consistent with Cox et al. (2006). The other 33 stranding events mentioned in the comment were not specified. However, there are numerous stranding events included from other comments on the Draft SEIS. These are listed in the SEIS RTC 4.4.18. Also see SEIS RTC 4.4.17 for additional information. None of these stranding events were linked to SURTASS LFA sonar.

Comment 4.4.12: Draft SEIS states that SURTASS LFA has not been implicated in any stranding events since first operated in the 1980s. This is not accurate. LFA sonar was implicated in the 1996 stranding in Greece. How would investigators know where to look for strandings because these prototype LFA tests were to a very large extent unknown? How many strandings occurred in areas during LFA ops and when LFA was not in use? When was LFA used and how expansive was monitoring for stranded or injured animals? Draft SEIS does not relate the effort undertaken to search for such incidents or mention reports of Level "B" harassment incidents. Also, not all strandings are observed, particularly those which occur in remote areas. O-008, O-010, O-013

Response: While it is true that there was a LF component of the sonar potentially related to the Greek strandings in 1996, only MF components were implicated in the strandings in the Bahamas in 2000, Madeira 2002, and Canaries in 2002. This suggests that the LF component in the Greek strandings was not causative (Cox et al., 2006; ICES, 2005). In its discussion of the Bahamas stranding, Cox et al. (2006) stated, "The event raised the question of whether the mid-frequency component of the sonar in Greece in 1996 was implicated in the stranding, rather than the low-frequency component proposed by Frantzis (1998)." The ICES in its "Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish" is in agreement with Cox et al. (2006) stating that the association of MF sonar in the Bahamas, Madeira, and Canary Island strandings suggest that it was not the LF component in the NATO sonar that triggered the Greece stranding of 1996, but rather the MF component (ICES, 2005). The ICES (2005) report also concluded that no strandings, injury, or major behavioral change have yet to be associated with the exclusive use of LF sonar.

LFA sonar has been restricted by a Court Permanent Injunction in October 2002 to limited areas in the western Pacific Ocean (see SEIS, Subchapter 1.2.1, Figures 1-1 and 4.4-2). Since commencing operations in 2003, the R/V *Cory Chouest* and USNS IMPECCABLE have completed 40 missions from January 2003 to August 2006 under the first four LOAs (DON, 2007). The general areas are known to the public because they are based on the Court Order, published in the Draft SEIS, and incorporated into the NMFS LOAs. The locations and times of LFA active operations are reported to NMFS quarterly (classified report) as required in the Final Rule and annual LOAs (50 CFR §216.186). These operations, with mitigation, have produced no known Level A takes on marine mammals as reported in the Annual Reports (DON, 2003a; 2004a; 2005a; 2006a) and the Final Comprehensive Report (DON, 2007) to NMFS under 50 CFR §216.186. Reviews of stranding reports in the area showed that there were a total of 19 strandings reported in Asia (four in Taiwan, nine throughout the Philippines, two in Thailand, two in Indonesia, and two in China) (The Cetacean Stranding Database, accessed: 11/28/2006). None of these strandings were coincident either temporally or spatially with LFA operations.

The northwestern Pacific Ocean areas where SURTASS LFA sonar is presently operating are some of the most heavily populated areas in the world and cannot be considered "remote."

When SURTASS LFA is in use, visual, passive and active acoustic monitoring mitigation are required to detect any marine mammals and/or sea turtles within or entering the LFA mitigation zone. If a marine mammal or sea turtle is detected either within the LFA mitigation zone or on a projected track that will enter the LFA mitigation zone, SURTASS LFA sonar transmissions are delayed or suspended. SURTASS LFA sonar transmissions can commence/resume 15 minutes after there is no further detection by the HF/M3 sonar or there are no further visual observations within the LFA mitigation zone. To date there have been no Level A takes from LFA sonar transmissions. Level B harassment is calculated based on the times and locations of LFA operations. Both are submitted to NMFS in quarterly reports, including the dates/times and locations of active LFA missions.

As to the possibility of unreported strandings, the Navy does not consider that this is a very likely scenario for LFA operations. Even though a visual observer onboard the vessel will be unable to see an animal that strands on the beach due to operations being greater than 12 nm from land, this is not relevant because LFA is not likely to cause injury beyond the 180-dB mitigation zone (normally 1 km radius). Level A harassments are determined based on actual observations/detections within the LFA mitigation zone. The probability of detection within this zone is over 95 percent for a single animal (See FOEIS, Subchapters 2.3.2.2 and 4.2.7.1.). For multiple animals, the value is nearly 100 percent. The area of the northwestern Pacific Ocean, in which LFA operations are currently restricted to, is not a remote area and there are stranding networks in the region. A review of reported strandings in the area does not show any correlations to LFA operations either spatially or temporally. Finally, in order for LFA to potentially cause injury to a marine mammal, it would have to be exposed to 180 dB or higher RL. In order for this to happen, animals would have to be within the LFA mitigation zone where they are almost certain to be detected.

Comment 4.4.13: To date, none of the many incidents involve LFA Sonar, although (1) LFA Sonar has not been used in close proximity to whale populations and (2) the Navy continues to deny that any military sonar impacts marine life. Earth Island believes LFA Sonar may have more lethal impact over longer distances due to the nature of low frequency sound transmission underwater. The Navy claims that the problem of whale strandings is one of "public perception" is gratuitous and ignores the scientific record. What exactly is meant when the Draft SEIS (4.4.3.3) states, “there is an ongoing issue with public perception of the cause that must be dealt with.”? I-011, O-008, O-011, O-013

Response: The area in which LFA is presently operating (northwestern Pacific Ocean) has relatively abundant populations of marine mammals, as presented in the SEIS, Tables 4.4-2 to 4.4-10. During the LFS SRP in 1997 and 1998, LFA sources were operated in proximity to marine mammals with only minor behavioral effects. As detailed in SEIS RTC 4.3.1 above, LFA sonar has not caused any known marine mammal strandings or injuries.

The “public perception” referred to in the Draft SEIS was one that relates naval sonar to strandings and that LFA is considered the same as any other sonar. The statement from the Draft SEIS (p. 4-55) is as follows:

> “Although much of the public currently have the impression that military sonar usage is a principal cause of marine mammal strandings, the facts that are available indicate otherwise. The biological mechanisms for these effects must be determined through scientific research, while recognizing that there is an ongoing issue with public perception of the cause that must be dealt with. The important point here is that there is no record of SURTASS LFA sonar ever being implicated in any stranding event since LFA prototype systems were first operated in the late 1980s.”

The intent of this statement was that there is a public perception that the effects of LFA sonar are the same as any other naval, or loud, sonars. As noted in the discussion in SEIS RTC 4.3.1 above, the potential for impacts from LFA differs from that of MFA. The best available scientific evidence to date does not indicate that LFA has the potential to cause strandings based on analyses of existing strandings (ICES, 2005; Cox et al., 2006). <u>This paragraph has been rewritten in the SEIS based on the latest available scientific data. The term “public perception” is no longer applicable and has been omitted.</u>

Comment 4.4.14: An LFA-like system has indeed been linked to a stranding in Greece (Frantzis, 1998), and LFA sonar use has been much more limited than mid-frequency sonar use. The Navy overestimates the importance of the facts that the military sonar implemented in stranding events has been another type of sonar known as mid-frequency sonar. The fact that more strandings haven't been linked to LFA sonar may merely be because its use has been more restricted. I-011, O-014

Response: See SEIS RTC 4.4.12 above.

Comment 4.4.15: Navy's attempt to discount the likelihood of strandings from the use of SURTASS LFA system fails to consider: 1) reported connection of strandings to the use of other LF sound sources, 2) lack of any meaningful data on the potential for mortalities given novelty of the system, 3) its general operation in open ocean and remote locations, 4) ignorance of sound-related strandings before 2000, 5) consensus that some of the pathologies seen in sonar-related strandings occur at sea, and 6) NEPA requirement to assess all "reasonably foreseeable" impacts. Navy operations are restricted to the northwestern Pacific, at least 30 to 50 nm from shore, too distant from shore to observe strandings, and these areas lack stranding networks. O-014

Response: The following were considered in the determination that LFA does not have a likelihood to cause strandings:

1) The workshop on understanding the impacts of anthropogenic sound on beaked whales convened by the U.S. MMC in 2004 and the ICES in its "Report of the Ad-Hoc Group on the Impacts of Sonar on Cetaceans and Fish" both support the logical conclusion that the low-frequency component in the Greek stranding was not causative (Cox et al., 2006; ICES, 2005).
2) The commenter's statement that Navy fails to consider the novelty of the LFA system in its analysis of the potential for mortalities is somewhat ambiguous. If by novelty, the commenter meant that LFA is a new technology, than the comment is incorrect. The Navy began developing this technology in the mid-1980s, over 20 years ago (Tyler, 1992). However, if by novelty, the commenter means unusual or innovative, than it is the novelty of LFA that sets it apart from other anthropogenic sources and makes it much less likely to cause strandings of those marine mammals most associated with anthropogenic sound-related strandings (i.e., odontocetes, especially beaked whales). First, odontocetes generally have poor LF hearing. Second, LFA transmit array depth is well below 10 m and thus not likely to be entrained in a surface duct. Third, the 6 to 15 minute off time in between 60-second transmissions and narrow bandwidth (30 Hz) preclude masking. See SEIS RTC 4.3.1 above for additional information.
3) LFA generally does presently operate in the open ocean (about 55.6 km [30 nm] from shore). However, calling the Pacific Rim "remote" is a misrepresentation because this area is one of the world's most populous with very heavy shipping traffic. If the intent of this comment is to opine that LFA operates in areas where animals can be injured and/or strand without being seen; then it must also be noted that in 1997 and 1998 during the LFS SRP, LFA, or LFA sources, operated very close to shore and at time at full power, in proximity to marine mammals (particularly baleen whales, several species of odontocetes and pinnipeds) with no reported strandings. These were very well-publicized tests off the coasts of California and Hawaii where there are numerous viable stranding networks.
4) The comment that there was an ignorance of underwater sound-related strandings before 2000 is also a misrepresentation in that the stranding of Cuvier's beaked whales in Greece occurred in 1996 with the report of the Supreme Allied Commander, Atlantic Antisubmarine Warfare

Research Center (SACLANTCEN) Bioacoustics Panel being published in 1998 (SACLANTCEN, 1998). *Nature* printed a correspondence the same year concerning whale strandings and acoustics (Frantzis, 1998). As early as 1991 there was an article in *Nature* concerning whales and the military (Simmonds and Lopez-Jurado, 1991). Mass beaked whale strandings have been recorded since the 1960s.
5) The statement by the commenter that there is consensus that some of the pathologies seen in sonar-related strandings occur at sea appears to be unfounded. Indeed, there is scientific controversy over this issue especially relating to acoustically mediated bubble growth (Piantadosi and Thalmann, 2004; NRC, 2005; Cox et al., 2006; Tyack et al., 2006).
6) The NEPA requirement to assess all "reasonably foreseeable" impacts is covered in SEIS RTCs 2.5.2, 4.3.13, and 4.3.53 above.

The commenter states that because LFA operations are restricted to the northwestern Pacific at least 55.6 to 92.6 km (30 to 50 nm) from shore, they are too distant from shore to observe strandings. The Navy is required to monitor the area in which there is a potential for marine mammals to be injured. This 180-dB mitigation zone extends approximately 1 km (0.54 nm) radius from the array. The Navy's mitigation protocols are almost 100 percent effective within this zone. As has already been addressed, there is no evidence to suggest that LFA will cause injury leading to a stranding at received levels below 180 dB. Therefore, whether or not the area has stranding networks is considered not to be relevant for LFA.

Comment 4.4.16: In describing the Bahamas 2000 stranding, the Navy places undue reliance on a list of "contributing factors" that it feels make a similar event unlikely. However, Navy provides no assurance that LFA training sites won't exhibit all of the same environmental characteristics. Also there is no indication that a surface duct occurred during similar stranding events in the Canaries and during any of the events reported by the IWC Scientific Committee, with a few occurring in restricted channels. O-014

Response: The Bahamas 2000 stranding event did not involve LFA. The list of "contributing factors" is generally supported by the workshop on understanding the impacts of anthropogenic sound on beaked whales convened by the U.S. Marine Mammal Commission in 2004 (Cox et al., 2006) and the analysis by D'Spain et al. (2006). Whether or not surface ducts occurred during other reported strandings is not relevant to LFA operations. First, LFA operations will not cause injury to marine mammals at received levels below 180 dB. Second, LFA signals are initially transmitted substantially below 10 m (32.8 ft) depth and are not likely to have signal strength above 180 dB in the surface duct. Also, surface ducting conditions were analyzed in the FOEIS/EIS at a number of the 31 model sites. With LFA mitigation, no marine mammals, either with or without a surface duct, are expected to be exposed to injurious levels of LFA signals.

Comment 4.4.17: In only listing three marine mammal stranding incidents "potentially" related to anthropogenic sound, the Draft SEIS is being disingenuous. The Draft SEIS should have discussed all of the following and especially those associated with naval activity. See Table on page 10 of the Animal Welfare Institute comments. O-013, O-014

Response: The Navy's intention was to examine three of the more studied stranding events in which naval sonars were implicated as a potential cause. <u>This subchapter has been expanded</u>

in the SEIS based on stranding event information cited in more recent reports, such as ICES AGISC Report (ICES, 2005), and reports on the potential causes presented by ICES (2005), Cox et al. (2006), and D'Spain et al. (2006). The Navy feels that this revision is adequate as related to the potential for SURTASS LFA to cause strandings because LFA was not considered causative in any of these events.

Comment 4.4.18: Numerous strandings were included in the comments received. For completeness they are listed below.

- Canary Islands, 1989. O-008, O-010
- Greece, May 1996. O-008, O-010, O-014
- Bahamas, March 2000. I-011, O-008, O-010, O-013, O-014, O-015
- Canary Islands, 2002, not adequately discussed. Cite Jepson et al. (2003), Jepson et al. (2005), and Fernandez et al. (2005). I-011, O-008, O-010, O-014, O-015
- Florida (panhandle), U.S., March 2004. O-008, O-010
- Canary Islands, 2004. O-014
- Other strandings: O-008, O-004, O-014, O-015
  - Gulf of Genoa, 1963,
  - Sagami Bay, Japan, 1963, 1978, 1979, 1989
  - Ligurian Sea, 1966
  - Lesser Antilles, 1974
  - Corsica, 1974
  - Sugura Bay, Japan, 1978, 1987, 1990
  - Canary Islands, 1985, 1988, 1989, 1991
  - Vieques Island, 1998
  - U.S. Virgin Islands, 1999
  - Madeira Spain, 2000
  - Gulf of California (Sea of Cortez), 2002
  - Haro Strait, Puget Sound, 2003
  - Hanalei Bay, Hawaii, 2004
  - Taiwan, 2004
  - Gulf of Alaska, 2004
  - North Carolina, U.S., Jan 2005
- SEIS fails to mention the 30 stranding events listed by the IWC Scientific Committee. O-010, O-014

Response: As stated previously, LFA sonar has not been associated spatially or temporally with any marine mammal stranding events, including the above.

Following specific comments were received concerning the Bahamas stranding event of March 2000:

> **Comment 4.4.18a:** Draft SEIS says that hemorrhaging in Bahamas stranding could have been caused by factors other than acoustic trauma (p 4-54). What other factors? This is not consistent with the actual findings in the interim report. I-011, O-010, O-013

Response: The Navy concurs that this statement in the Draft SEIS, “It could have been caused by other factors” on page 4-54, is not consistent with the interim report. It has been deleted from the SEIS.

Comment 4.4.18b: Why hasn’t the report on the Bahamas stranding been released? O-010

Response: The Joint Interim Report on the Bahamas Marine Mammal Stranding Event of 15-16 March 2000 was released by the DOC and DON in December 2001. Additionally, Dr. Darlene Ketten released the Beaked Whale Necropsy Findings for Strandings in the Bahamas, Puerto Rico, and Madeira, 1999-2002, in November 2005 (Ketten, 2005).

Comment 4.4.18c: In the Bahamas stranding, there were baseline survey data available. After the event, the beaked whales that had been photo-identified virtually disappeared, leading researchers to conclude that nearly all of the animals died of physical injury or permanently abandoned their habitat. Five years later the species is slowly returning but sightings are still far below what they had been. In the Bahamas it appears that transient sonar operations can devastate local populations of Cuvier’s beaked whales. Why isn’t this addressed as a population level effect? O-010, O-014

Response: At present, there are no scientific data or published evidence to either support or disprove the conjecture the Bahamas stranding in 2000 had a “local” population level effect. Cuvier’s beaked whales (*Ziphtius. cavirostris)* is the most cosmopolitan of the beaked whales based on stranding records; and Cuvier’s beaked whales are distributed in all oceans and most seas, except in the high polar regions (Heyning, 2002). Heyning also states that based on this species’ feeding habits, Cuvier’s beaked whales are an offshore, deep-diving species. Beaked whales are most frequently sighted around deep canyons, gullies, and walls, probably because their prey is associated with these features. Dalebout et al. (2005), using mitochondrial DNA (mtDNA), support the accepted classification of *Ziphtius* as a globally distributed species. The study stated that the *Ziphtius* in the Mediterranean Sea were found to be highly distinctive from the Eastern North Atlantic. The paper also stated that few conclusions could be drawn concerning regional divisions among *Ziphius* within other ocean basins until more comprehensive sampling is conducted. SURTASS LFA sonar was not utilized in the exercises in the Bahamas (DOC and DON, 2001).

Comment 4.4.19: Draft SEIS fails to discuss the fact that Cuvier’s mass strandings were almost unheard of before 1960 when powerful sonar began to be deployed. I-011, O-010

Response: Tactical sonars were used extensively by the Allies during World War II to combat the German U-boats, and they have been part of most countries’ navies since then. Since World War II, military active sonars have grown larger and more powerful.

Beaked whales mass strand less than other cetaceans, but Cuvier’s beaked whales mass strand more frequently than other beaked whales (DOC and DON, 2001). A report by the Marine Mammal Program, National Museum of Natural History of the Smithsonian Institution listed 49 total stranding events involving 3 or more beaked whales with 9 of these occurring between 1838 and 1954 (Smithsonian, 2000). Historically, from 1838 through 1999, there were 49 reported mass stranding events of beaked whales for a total of 226 animals. The earliest reported beaked whale mass stranding was in 1838 when four northern bottlenose whales stranded in Norway. The first reported single stranded Cuvier's beaked whale was in 1804 and the first mass stranding (3 or more animals) was in 1963 in Genoa, Italy (Podesta et al. 2006). Cuvier's beaked whale mass stranding events in the Mediterranean have been reported more frequently in the last 20 years (Podesta et al., 2006). Since 1960, there have been 41 mass strandings of Cuvier's beaked whales worldwide (Cox et al., 2006). In any event, it should be noted that reporting and detection networks have been much more organized and effective in many countries in recent previous years.

Evidence does not implicate SURTASS LFA sonar in the beaked whale strandings (Cox et al., 2006; D'Spain et al., 2006).

Comment 4.4.20: Strongly suspected, the potential link between stranding events and naval exercises has been borne out in a recent re-examination by prominent biologists of old strandings. Examination shows a concentration of mass beaked whale strandings along the Japanese coast near Yokosuka, one of the Navy's primary bases in the northwestern Pacific since the late 1950s. O-014

Response: The examination by Brownell et al. (2004) evaluated Cuvier's beaked whale strandings from local records between 1950 and 2004 in the waters of Japan. Two facts were put forth: 1) Cuvier's beaked whales stranded in Sagami and Suruga Bays between 1960 and 1990, and 2) U.S. Naval vessels are stationed in Yokosuka, Japan. First, it should be pointed out that the authors' primary source (Ishikawa, 1994) is not readily available to review because it is in Japanese and no translation was provided except for Table 1 in their report. There are inconsistencies in Brownell et al.'s presentation of the data and results, which could not be compared to the cited source of the data. Table 1 is titled "Mass strandings of Cuvier's beaked whales, *Ziphius cavirostris*, on the central Pacific coast of Honshu" and states that the data are from Ishikawa (1994). The number of stranded animals listed from 1960 to 1990 in the table is 47. The first page of their report states that "Ishikawa (1994) reported 68 Cuvier's beaked whales that stranded on the coast of Japan between 1960 and 1993." This begs two questions: 1) Where did the remaining 21 beaked whales strand, and 2) Why were they not listed? In their results Brownell et al. state that Ishikawa (1994) records include eight cases of mass strandings (correct based on Table 1) with a total of 43 individuals (incorrect, based on Table 1—the number is 35). Finally, general data from the National Science Museum, Tokyo, is provided without citation. Given that the data from Ishikawa (1994) is presented in an inconsistent manner, the museum data is vital for any effective analysis of the Brownell et al. report.

It is inaccurate to state in this report that Cuvier's beaked whales are stranding due solely to naval sonar operations. The authors infer several times in the paper that "naval operations with acoustic components" or "the Navy may have tested MFA" has no foundation and is pure speculation. The ports of Tokyo, Chiba, Kawasaki, Yokohama, and Yokosuka are all located on Tokyo Bay, which opens to Sagami Bay. Suruga Bay is separated from Sagami Bay by a large peninsula. Based on the locations, it is most likely that other natural and anthropogenic factors contributed to at least some of the reported strandings. These include dense shipping traffic/shipping-related noise, construction-related noise, dredging, scientific research using active sources, pollution, fisheries interactions, earthquakes, pollution from increased populations, etc.

Therefore, because of the irreconcilable inconsistencies, Brownell et al. do not provide any reliable and supportable linkage between Cuvier's beaked whale stranding events and naval activities in Japanese waters near Yokosuka. The only data that the Navy could confirm were that there is a major U.S. naval base there and that the area is also home to five major Japanese seaports, including Tokyo, one of the world's busiest seaports, with an average of 33,000 vessels calling there every year.

Comment 4.4.21: Full effects of sonar on marine mammals are not known because world lacks network to identify and investigate strandings. NMFS says that most Cuvier's beaked whale strandings go undocumented because of remote siting of sonar exercises and small chance that dead or injured animals would strand. O-014, O-015

Response: According to the Joint Interim Report on the Bahamas Marine Mammal Stranding Event of 15-16 March 2000 (DOC and DON, 2001), reporting and detection networks have been much more organized and effective in many countries over the last 20 years.

The latest U.S. Pacific Marine Mammal Stock Assessments: 2004, which is dated May 2005 (NOAA, 2005) did not make the statement that injuries and mortalities due to sonar activities would not be documented due to the remote nature of these activities and the low probability that the affected animal would strand. See SEIS RTC 4.4.15 above for additional information.

Comment 4.4.22: The Draft SEIS fails to point out characteristics associated with acoustically-induced strandings, such as mixed species, beaked whale presence, species spread out over 10s of kilometers. O-010

Response: The issue in the SEIS is not whether anthropogenic sound causes marine mammal strandings, but rather does LFA cause marine mammal strandings. The evidence to date, supported by recent scientific reports, indicates that LFA sonar does not (ICES, 2005; Cox, et al. 2006; D'Spain et al., 2006). For more detailed information, see SEIS RTCs 4.3.1, 4.3.2, 4.3.7, 4.3.12, and 4.4.15 above.

Comment 4.4.23: Preliminary observations can be drawn from recent beaked whale strandings. Beaked whales are particularly sensitive to active sonar. Every mass stranding on record involving multiple species of beaked whales has occurred with naval activity in the vicinity. Indeed, it is not even certain that some beaked whales naturally strand in numbers. O-014

Response: The use of the terms "active sonar" and "naval activity" are ambiguous. In order to address this comment, it is necessary for the commenter to specify whether the comment is in reference to HF, MF, or LF sonar. The term "naval activity" is also abstruse because this term does not imply the naval sonar was in use. Much of the information associating strandings with sonar and naval activities are based on anecdotal or grey literature. Likewise, the statement that every mass stranding on record involving multiple species of beaked whales has occurred with naval activity in the vicinity is a misrepresentation. Simmonds and Lopez-Jurado (1991) reported a mass stranding of Cuvier's and one Gervais' beaked whale in 1986 with no associated naval activity noted. A review of the Smithsonian stranding database shows that there have been at least seven other instances of beaked whale strandings involving more than one species. One of these activities involved ordnance, two were not identified with military activities, and four were concurrent with military maneuvers (Smithsonian Institution, 2000). The Smithsonian report also reported 49 total stranding events involving 3 or more beaked whales. Naval maneuvers were not associated with 41 of these, casting doubt on the comment that beaked whales do not strand in numbers naturally. More recently, ICES (2005) presented a table based on records from the Smithsonian Institution that showed that from 1914 to 2002, there were 44 strandings of beaked whales (Cuvier's, Gervais' and Blainville's beaked whales) with only four being associated with naval sonar. However, as previously stated, there are no known stranding events associated with the LFA sonar.

Comment 4.4.24: It should be noted that beaked whales are not the only species of whales to mass strand in relation to sonar activities. Examples, minke in Bahamas 2000 and North Carolina, pygmy sperm in Canaries 1988, long-finned pilot and dwarf sperm in North Carolina 2005, melon-headed in Hawaii 2004, and harbor porpoise in Haro Strait 2003. O-014

Response: The above events were neither coincident with nor associated with LFA. The minke whale produces underwater (UW) sound from 80 Hz to 20 kHz and long-finned pilot whales produces UW sound from 500 Hz to 150 kHz. The pygmy and dwarf sperm whales produce UW sounds from 90 to 150 kHz and the melon-headed whales from 8 to 80 kHz. It is logical to assume that these species can also hear these frequency ranges. Of these marine mammals, the minke whale, which is a baleen whale, is probably the only species that has good hearing in the frequency range of SURTASS LFA sonar. The LFS SRP extensively studied four species of baleen whale and determined that the probability of LFA signal affecting a significant biological behavior was minimal. It should also be noted that during the LSF SRP, there were numerous other marine mammals sighted in the vicinity of the tests including long- and 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, California sea lions, elephant seals, and sea otter (SURTASS LFA Sonar FOEIS/EIS Technical Report #1). Exposure of these species to LFA signals at received levels (below 150 dB) did not cause any significant behavioral reactions.

Comment 4.4.25: The use of Macleod et al. (2005) as an example of natural-caused strandings is incorrect. The paper refers to an increase in warm-water species strandings reported in the UK as the result of a shift in species distribution. The species is occurring in greater numbers and so stranding numbers are increasing. The paper does not suggest that global warming causes an increase in cetaceans' stranding rate. I-058

Response: The Navy maintains that the strandings described in Macleod et al. (2005) were not related to anthropogenic noise, and that is the reason for its discussion in the Draft SEIS Subchapter 4.4.3.1 (Strandings related to natural causes). This report observed a change in the cetacean community; an increase in new warm-water species, such as common and striped dolphins, and a decline of cold-water species, such as white-beaked dolphins. Due to the change in cetacean community, the number of strandings for white-beaked dolphins has decreased and the number of strandings for common and striped dolphins has increased.

Comment 4.4.26: Navy discounts the well-established link between sonar use and marine mammal strandings by pointing out that the majority of marine mammal strandings are related to natural causes. This fact does not lessen the navy's responsibility to discuss and prevent strandings related to sonar. O-014

Response: In the SEIS Subchapter 4.4.3, the Navy discusses both anthropogenic and natural causes of marine mammal strandings. In the conclusion in Subchapter 4.4.3.4, it is stated that military sonar is not the principal cause of marine mammal strandings. There was no conclusion that the majority of marine mammal strandings were related to only natural causes. The Navy does not intend to give the impression that it discounts any scientifically-supported links between anthropogenic sources and marine mammal strandings. However, it will point out that there is no known connection between marine mammal strandings and LFA sonar, which is supported by scientific workshops, reports, and published papers (ICES, 2005; Cox et al., 2006; D'Spain et al., 2006).

Multiple LFA Systems

Comment 4.4.27: There is no discussion of the possibility of synergistic effects from several LFA systems working concurrently and with overlapping areas of impact. What if the ensuing sound field is so complex that marine mammals would not know how to escape it (supposing they could otherwise)? Simply using an additive approach (adding the potential impacts from each of the sources) would not address this issue. I-011, O-010, O-013

Response: The potential for synergistic effects of the operation of two sources at one site with overlapping sound fields were analyzed and discussed in the FOEIS/EIS, Subchapter 4.2.7.4, and Draft SEIS, Subchapter 4.4.4. 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, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, and duty cycle. In the very unlikely event that this ever occurred, the analysis demonstrated that the "synergistic" sound field generated would be 75 percent or less of the value obtained by adding the results. Therefore, adding the results conservatively bounds the potential effects of employing multiple sources.

In the areas where marine mammals would potentially be affected by significant behavioral changes, they would be far enough away that they would discern each LFA source as an individual source. Standard operational employment of two SURTASS LFA sonars would call for the vessels to be at least 185 km (100 nm) apart, as analyzed in the FOEIS/EIS Subchapter 4.2.7.4. Moreover, LFA sources would not normally operate in proximity to each other and would be unlikely to transmit in phase as noted above. Based on this and the coastal standoff restriction, it is unlikely that LFA, under any circumstances, could produce a sound field so complex that marine mammals would not know how to escape it if they desired to do so.

ISSUE 4.5 Socioeconomics (Commercial and Recreational Fisheries, Recreational Activities, Research and Exploration Activities)

Comment 4.5.1: It is likely the LFA sonar operations will have considerable impact upon commercial and recreational fisheries. O-008

Response: According to recent fish studies, as stated in SEIS Subchapter 4.1.1.6, 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. The results from the LFA fish controlled exposure studies by the University of Maryland provide evidence that SURTASS LFA sonar sounds at relatively high levels (up to 193 dB RL) have minimal impact on the reference species of fish studied (rainbow trout and channel catfish). Therefore, the University of Maryland data of minimal effects supports the conclusion that SURTASS LFA will have no or minimal effects on commercial or recreational fishing (Popper et al., 2005; Halvorsen et al., 2006). See SEIS RTCs 4.1.2, 4.1.4, 4.1.5, and 4.1.6 for additional information.

Comment 4.5.2: It is likely that LFA operations will have a negative effect on the whale watching industry as whale populations could be reduced or whales could abandon areas. O-008, O-010

Response: The three phases of the LFS SRP in 1997-98, taken together, found that most baleen whales exhibited only minor, short-term behavioral responses (FOEIS/EIS Subchapter 4.2.4). These short-term behavioral responses did not necessarily constitute a change in biologically significant behaviors. The potential for SURTASS LFA operations to affect the whale watching industry was addressed in the FOEIS/EIS Subchapter 4.3.2 and the SEIS Subchapter 4.5.2. There is no additional information that would change the finding that there are no significant impacts to whale watching activities as a result of the deployment of SURTASS LFA sonar.

Comment 4.5.3: Degradation of the environment through LFA noise will likely affect recreational boating, divers, swimmers, and snorklers. O-010

Response: The potential effects of LFA on recreational activities were covered in FOEIS/EIS Subchapter 4.3.2.1 and were incorporated into the Draft SEIS by reference.

Comment 4.5.4: The Navy is ensonifying humans at a level almost 20 times greater than what caused the stranding and death of marine mammals in the Bahamas incident. I-020

Response: The Navy disagrees with this comment because the received level at the whales in the Bahamas incident was estimated to be 160-170 dB (IWC, 2004; ICES, 2005), which is greater than the 145-dB RL for recreational dive sites.

Comment 4.5.5: The data published in the Draft LFA EIS/EIR suggest SCUBA divers' lungs might resonate when exposed to different frequencies of LFAS transmissions at different depths. If this is true, should SCUBA divers spend time at depth and attempt to calculate what frequency we are being exposed to and at what depth our lungs might resonate? I-020

Response: The data cited by the commenter has been published in a peer-reviewed publication (Martin et al., 2005). The highest resonant frequency in that paper was 80 Hz at 132 feet of depth. This frequency is well outside the frequency region of the LFA system. Using the data from that paper the system will not stimulate divers' lungs at resonance, even at depths as great as 300 feet and so does not pose a risk to divers due to resonance.

Comment 4.5.6: How will we be able to figure out if the 145 dB RL transmissions will rupture our lungs or ears? I-020

Response: Technical Report #3 for the FOEIS/EIS presented evidence for divers exposed to received sound pressure levels of 160 dB SPL without damage to the lungs or ears. Thus the 145 received level will be safe for both lungs and ears and without danger of rupture.

Comment 4.5.7: If SCUBA divers are under water on the bottom when LFA transmissions begin, 1) should they remain at depth consuming their remaining air supply and hope that the transmissions stop so that they can ascend without the possibility of lung resonance; 2) should they immediately make a mad dash to the surface through a layer of potential resonance and head for a recompression chamber; or 3) should they allow themselves to be exposed to LFA sonar of unknown RL and continue to dive, hoping to remain uninjured? I-020

Response: Divers should respond to this event in the same manner as any other underwater event. If the sound is extremely loud and the diver wishes to discontinue diving, they should ascend to the surface at a rate in accordance with the dive tables to minimize the risk of decompression sickness or arterial gas embolism. If the sound is comfortably loud or very quiet they could continue diving. Unless the diver is within the 145-dB diver mitigation zone, they are not at hazard for physical damage and mitigation measures are in place to make sure that the sound pressure level at recreational dive sites is 145 dB SPL or below, which has been shown to be a safe level.

Comment 4.5.8: If DAN, the insurance agency who transports SCUBA divers to hospitals in dive emergencies, becomes involved with the Navy and informs divers where and when U.S. Navy LFA sonars will be operational and the potential risks involved with exposure, do you expect we will not enter the water? I-020

Response: As stated in FOEIS/EIS RTC 4-9.17, when the Navy has plans for conducting LFA operations in the vicinity of known recreational and/or commercial dive sites, they will present a plan for setting up a reporting network via DAN; and, in addition, the LTM program includes recreational and commercial diver incident monitoring. Further, as stated in FOEIS/EIS RTC 4-9.22 and 5-1.11, for any potential LFA operations in the vicinity of "recreational blue water" dive sites, the Navy will notify DAN and other diving organizations concerning such operations on a case-by-case basis.

Comment 4.5.9: Would the element of military surprise be lost if our Navy or DAN tells us and the world when and where the Navy sonar assets are deployed? I-020

Response: As stated in FOEIS/EIS RTCs 4-9.22, 5-1.9, and 5-1.10, for any LFA operations in the vicinity of coastal and blue water recreational dive sites, the Navy will notify DAN and other local diving organizations concerning such operations on a case-by-case basis.

ISSUE 4.6 Potential Cumulative Impacts (Cumulative Impacts from Anthropogenic Oceanic Noise)

Ocean Noise

Comment 4.6.1: United Nations, European Parliament, IWC, ACCOBAMS, IUCN have expressed concerns with the potential impacts of ocean noise on marine life. O-005, O-015

Response: The UN, European Parliament, IWC, ACCOBAMS, and IUCN have all expressed concerns with environmental degradation and potential impacts of noise on marine life.

The report on the work of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea at its seventh meeting (17 July 2006, A/641/156) discussed ecosystem approaches and options. Plenary and panel discussions noted that ecosystem-based management “offered an opportunity to address emerging threats to the oceans. In this regard, several delegations referred to the impact of ocean noise on the marine environment and the need to consider its cumulative effect within the context of ecosystem approaches to oceans management. One delegation calls for States to join efforts in exchanging information on the impact of noise pollution and emphasized that it was primarily the responsibility of States to control this phenomenon…It was also noted that an ecosystem approach required that the assessment of the impacts of noise be based on a distinction between different types of noise, such as noise from shipping, the exploitation of oil and gas, or defence, as well as on the impacts of noise on key components of an ecosystem.”

The European Union (EU) Parliament passed a resolution in 2004 that called for the European Commission to bring forward, as soon as possible, a thematic strategy on the marine environment (Calvert and Buck, 2005). The EU resolution adopted a moratorium on the deployment of LFA sonar. However, the moratorium has the contingency that it would not become valid until a global assessment of LFA sonar cumulative environmental impacts on whales, dolphins, fish, and other marine life is completed. It also calls for the European Commission to conduct a study of the potential impact on the marine environment from the deployment of LFA sonar, and to provide an assessment of the effect of current practices in the European Union seas. Through its quarterly and annual reports, the FOEIS/EIS and the SEIS, and through scientific research studies on marine mammals and fish, the U.S. Navy has completed multiple analyses on the effects of SURTASS LFA on the marine environment. With proper mitigation protocols, the operation of SURTASS LFA sonar will have minimal effects on the marine environment, with no lethal takes.

The IWC has also expressed concern about noise in the ocean. The IWC Scientific Committee (IWC-SC) Report, Annex K, Appendix 3, states that "ocean noise is an important component of the marine habitat. Informed estimates suggest noise has increased significantly during the past few decades (IWC, 2004). Expanding use of the sea for commercial shipping and advanced warfare has resulted in noise levels that are at least 10 times higher today than they were a few decades ago." The SEIS discusses these increasing noise levels in Subchapter 4.6.

The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and contiguous Atlantic area (ACCOBAMS), concluded under the auspices of the UN Convention on the Conservation of Migratory Species of Wild Animals, discusses their concern with ocean noise in their Report of the Second Meeting of the Parties to ACCOBAMS (Palma de Mallorca [Spain], 9-12 November, 2004). The discussion involved the lack of knowledge of the impact of many kinds of anthropogenic noise on the conservation status of most cetacean species. It stresses that fundamental research is needed to address the complex question of anthropogenic noise effects on marine mammals. The U.S. Navy has and is funding important research in these areas.

The IUCN published Resolution 3.068: Undersea noise pollution, which:

- Requests the IUCN Director General, with the assistance of the Union's members, Commissions, and Council, to identify and implement measures to promote among world governments the reduction of anthropogenic noise;
- Requests the IUCN Director General to encourage IUCN members and Commissions to support and conduct further research on the effects and mitigation of anthropogenic noise on marine species;
- Calls on the IUCN constituency to recognize that, when there is reason to expect that harmful effects on biota may be caused by such noise, lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimize such effects;
- Calls on the Species Survival Commission (SSC), in cooperation with its specialist groups to take account of noise pollution as a potential impact on species and biodiversity when applying the IUCN Red List categories and criteria and to develop research projects and management recommendations that advance the conservation of marine species;
- Calls on the World Commission on Protected Areas (WCPA) to consider anthropogenic noise in all its work related to marine protected areas and refuges and specifically in its assessments of the conservation status of World Heritage sites and in its efforts to implement the revised *Programme of Work on marine and coastal biological diversity*;
- Calls on the Commission on Environmental Law (CEL) to make recommendations on legal and policy issues arising out of the international management of undersea noise pollution, and counsel IUCN members, governments, and intergovernmental organizations on such issues, particularly in the drafting of legal documents;
- Entreats IUCN member governments to monitor for and investigate the impacts on marine species that are associated with the use of intense anthropogenic noise;

- Encourage the development of alternative technologies and require the use of best-available control techniques and other mitigation measures in reducing impacts from individual noise sources;
- Consider how to limit the use of powerful noise sources until their short-term and long-term effects are better understood;
- In the case of military active sonar, act with particular urgency to reduce impacts on beaked whales, and other potentially vulnerable species, by restricting training to low-risk areas, and by working diligently toward the development of international standards that regulate its use;
- Consider noise restrictions in their management guidelines for marine protected areas; and
- Work together with national and international non-governmental organizations and with the scientific community in accomplishing these goals.

It should be noted that many of the above recommendations that are related to SURTASS LFA sonar have been and are being implemented. Research on the effects of LF underwater sound on the marine environment (SURTASS LFA Low Frequency Sound Scientific Research Program, Fish Controlled Exposure Experiment, and Deep-diving Odontocetes Behavioral Response Study) and mitigation (development of the HF/M3 sonar) have been sponsored by the U.S. Navy and commercial organizations. See SEIS RTC 4.4.3b for additional U.S. Navy/SERDP sponsored and independently published research. Lack of scientific information led to conservative assumptions in the analytical approach for SURTASS LFA environmental impact assessments (FOEIS/EIS, Subchapter 1.4.3), which led to conservative mitigation protocols. During the operational deployment of SURTASS LFA, the operations have been monitored and results reported to NMFS, as required by the LOAs.

Comment 4.6.2: Draft SEIS does not address the effects of possible cumulative stress on marine mammals from LFAS. O-010, O-012

Response: Even though an animal's exposure to LFA may be more than one time, in light of the intermittent nature of the LFA signal, given the fact that both the vessel and the marine mammals are moving, there is a very small chance that LFA exposure for individual animals and stocks would be repeated over extended periods of time, such as those caused by shipping noise. Therefore, impacts from cumulative stress are not a reasonably foreseeable significant adverse impact. The potential effects of stress on marine mammals from LFA sonar transmissions are discussed further in SEIS RTCs 4.3.12 and 4.3.23 above.

Comment 4.6.3: The issue of chronic exposure to noise and the effects of stress, which in turn may have biologically significant effects on cetaceans, have not been considered. Researchers have reported increases in activity of adrenal and defense-related endocrine glands in relation to noise exposure (Welch and Welch, 1970). Several marine species, including both fish and shrimp, have displayed reduced growth and reproductive success when exposed to chronic noise levels 20 to 30 dB above background levels (Banner and Hyatt, 1973; Lagadere, 1982). I-058

Response: The potential effects of stress on marine mammals from LFA sonar transmissions are discussed in SEIS RTCs 4.3.12, 4.3.23 and 4.6.2 above. Banner and Hyatt (1973) is discussed in the FOEIS/EIS RTC 3-2.5.

Comment 4.6.4: LFA sonar operations will add very significantly to the noise levels of oceans which are already too noisy. O-008, O-014

Response: Per Hildebrand (2004), each LFA source adds approximately 1 percent more energy to that already produced by just the air gun arrays in the world. The actual percentage of the total anthropogenic acoustic energy budget added by each LFA source is actually closer to 0.5 percent per system (or less), when other man-made sources are considered (Hildebrand, 2004). When combined with the naturally occurring and other man-made sources of noise in the oceans, LFA barely contributes a measurable portion of the total acoustic energy.

Comment 4.6.5: The Navy proposes employing four LFA systems worldwide. However, Dr. John Hildebrand, in a presentation to the International Whaling Commission Scientific Committee, concluded that two LFA systems would input as much sound energy into the oceans as all of the supertankers in the world. Four systems would presumably input twice as much. I-058

Response: In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (U.S.) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. On an annual basis, four SURTASS LFA systems are estimated to have a total energy output of 6.8×10^{11} Joules/yr. Seismic air gun arrays were two orders of magnitude greater with an estimated annual output of 3.9×10^{13} Joules/year. MFA and super tankers were both greater at 8.5×10^{12} and 3.7×10^{12} Joules/year, respectively (Hildebrand, 2004). Hildebrand concluded that increases in anthropogenic 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. The use of SURTASS LFA sonar is not scheduled to increase past the originally analyzed four systems in the next five years.

As the commenter did not provide a citation to Dr. Hildebrand's presentation to the IWC-SC, it cannot be commented on further except to say that Hildebrand (2004) states otherwise.

Comment 4.6.6: Draft SEIS evaluation must include all noise sources that occur concurrent with LFA ops. The Draft SEIS should evaluate the cumulative impacts of ALL anthropogenic noise (baseline levels) in the ocean, no matter who is the most to blame. O-008, O-010, O-012

Response: Currently, there is no way to evaluate a "baseline" of the impacts of all anthropogenic noise. Cumulative impacts analysis of all anthropogenic noise sources is a very complex problem, which is highly location-, frequency-, azimuth-, depth-, signal type-, and time-dependent. Therefore, three areas were evaluated to compare the incremental impacts of SURTASS LFA sonar operations with "past, present, and reasonably foreseeable future actions" including both noise and non-noise impacts. These include:

- Comparison to anthropogenic oceanic noise levels;
- Comparison of injury and lethal takes from anthropogenic causes; and
- Socioeconomics.

SEIS Subchapter 4.6 provides a detailed discussion of potential cumulative effects.

Comment 4.6.7: Draft SEIS fails to adequately address the issue of LFA sonar sound field combining with the sound fields of seismic surveys and other anthropogenic sound sources. Given the distances that LFA sonar and seismic air guns can travel, the chances of the noises overlapping is too great to be dismissed. O-008, O-013

Response: The FOEIS/EIS addressed the operations of two LFA sources. The findings in the FOEIS/EIS (Subchapter 4.2.7.4) were that, there is minimum cumulative impact if the sources were approximately 185 km (100 nautical miles) apart. Beyond this range, the total cumulative received levels are nearing ambient in many ocean areas, and they are not expected to impact marine mammals. Essentially, the receipt of two near-ambient level signals is approximated by the presence of a slightly higher ambient noise level, which occurs frequently due to other natural sources (rain, biological noise, etc.). The differences between the LFA coherent signal and seismic air gun impulsive "shots" are addressed in SEIS RTC 4.3.1 above. Marine animals would perceive these two sources of underwater sound differently and any addition of received signals would be insignificant. This situation would present itself only rarely, as LFA testing and training operations have not been, and are not expected to be conducted in proximity to any seismic survey activity.

Comment 4.6.8: When the Draft SEIS states that LFA sonar is not likely to be close enough to other noise-producing activities like oceanographic research or oil and gas exploration to interfere with them, it implies that areas devoid of human-made noise will be harder and harder to find. If noise activities space themselves from each other, there will be less overlap yet fewer undisturbed areas. Moreover, it ignores the scale of the area affected by LFA. How are you going to ensure that noise from LFA and seismic surveys don't overlap with each other if one significantly raises noise levels over 3.9 million sq km and the other is heard over 3,000,000 sq km (seismic)? I-011, O-010

Response: The commenter's implication is incorrect. The statement about the separation of sources implies nothing about the availability of areas "devoid of human-made noise." LFA does not raise noise levels in the oceans to levels that would cause a disturbance in significant biological behaviors in over 3.9M km^2, as was scientifically determined in the LFS SRP. See SEIS RTCs 4.6.5, 4.6.7, and 4.6.13.

Comment 4.6.9: The Draft SEIS fails to acknowledge that both commercial and military sonar use will increase and, because of this, noise levels will increase as well. O-008

Response: ICES (2005) states, "Sonar deployment seems likely to increase in the future." <u>The SEIS has been corrected accordingly.</u> See SEIS RTCs 4.6.10 and 4.6.11 for further discussions.

Comment 4.6.10: Draft SEIS should not conclude, as the ICES report does, that "sonar is not a major current threat to marine mammal populations generally." Balcomb and Claridge (2001) showed a well-studied population that seems to have suffered adverse population-level effects from a single sonar transit and the population appears to have been eliminated from the area through death or displacement. I-011

Response: The statement in the initial ICES AGISC 2005 Report concerning "shipping noise projected to increase, where sonar is not" was modified in the 2nd Edition of the Report to state that "shipping accounts for more than 75 percent of all human sound in the sea, and sonar amounts to no more than 10 percent or so." It further stated that sonar (noise budget) will probably never exceed 10 percent, but that "sonar deployment seems likely to increase in the future." (ICES, 2005) <u>The SEIS Subchapter 4.6.1.2 has been modified accordingly.</u>

The potential adverse population effects on Cuvier's beaked whales in the Bahamas strandings are discussed in detail in SEIS RTC 4.4.18c.

Comment 4.6.11: Why isn't noise from sonar projected to increase? The louder the oceans get from use of sonar (and other noise sources), the louder the sonars need to become to maintain a loud enough echo that can be heard above the din. Sonar systems will need to compete with other sonar systems in order to be heard. I-011

Response: As noted in SEIS RTC 4.6.10 above, the deployment of sonar will likely increase in the future. In discussing a noise budget for the oceans, ICES (2005) stated that sonar's noise budget will probably never exceed 10 percent.

The effectiveness of sonar is either ambient noise-limited or reverberation-limited. As the oceans become noisier, it will become more difficult to detect return echoes over the din. Thus, active sonars will become more ambient noise-limited and common perception would be that louder sources would be required to increase the strength of the return signal. However, this would also increase reverberation, and sonars would be reverberation-limited. When sonars become both ambient noise-limited and reverberation-limited, turning up the source level will not help. At that point, other strategies will need to be employed, such as changes in frequency and bandwidths, and more powerful signal processing techniques to pull the submarine echo out of the background noise.

Comment 4.6.12: Geographic restriction imposed by the 145-dB exposure criterion for dive sites does nothing to support the conclusion that LFA sonar contribution to oceanic ambient noise levels are small and incremental (Draft SEIS p 4.63). I-011, O-010

Response: <u>The Navy agrees, and the sentence has been deleted from the SEIS.</u>

Comment 4.6.13: To argue that LFA sonar does not add appreciably to ocean noise is not believable. Flooding areas of 3.9 million sq km with noise levels of 120 dB clearly and significantly adds to ocean noise levels. I-011, O-010, O-013, O-014

Response: The Navy disagrees with this statement. The use of the term "flooding" in this comment is a gross overstatement of the potential impact of LFA sources at ranges approximating the 120 dB isopleth. It must be remembered that an ambient noise level of 120 dB across all frequencies is common in an area with a light to moderate rainfall (which is commonly very large portions of the ocean). In heavy rainfall areas, like those surrounding a hurricane, ambient noise levels can be expected to be 20-30 dB higher than this. Similarly, fish (snapping shrimp, croakers, dogfish, etc.) can project acoustic levels between 110-150 dB across all frequencies, in areas where they are present. Marine mammal signals are typically even louder. Noise from commercial shipping traffic is by far the most dominant source of anthropogenic noise in the oceans; it is continuous, ubiquitous and shows no signs of decreasing (ICES, 2005). Finally, it must be pointed out the LFA signal only has a typical duty cycle of 7.5 to 10 percent during the projected 432 hour of operation per vessel per year, while these natural and other anthropogenic sources are often continuous or many hours or days in duration. Thus, much/most of an area the commenter considers to be "flooded" with an LFA signal, already has substantial ambient noise from natural and anthropogenic sources.

Comment 4.6.14: Dismissing LFA impacts as small compared to the totality of anthropogenic noise being generated in the oceans misapprehends the definition of cumulative impacts, "can result from individually minor but collectively significant actions taking place over a period of time." O-014

Response: As indicated by the LFS SRP, minor changes in behavior only can occur to marine animals relatively close to the LFA source and are addressed by the risk continuum approach of the FOEIS/EIS. For those areas which are outside of the area covered by the risk continuum, the received LFA signal is approximately that of an ambient environment. Thus, the signals do not add appreciably to the ambient noise levels, and therefore do not accumulate, or collect, to greater effects. The conclusion reached in the FOEIS/EIS Subchapter 4.4.4 that even when considered in combination with other underwater sounds, SURTASS LFA sonar does not add appreciably to the underwater sounds that fish, sea turtle and marine mammals are exposed remains valid.

Comment 4.6.15: When LFA sonar is fully operational, over half of the world's oceans could be inundated with sound from LFA sonar, especially if the signal gets into the deep sound channel. O-012

Response: This is not true. The LFA signal may be detectible at long ranges with very sensitive receive arrays and sophisticated signal processing equipment, but this signal is at or near the ambient noise levels (i.e., background noise level). At these levels, it does not appreciably add to those ambient noise levels. This is also true for the small amount of acoustic energy from LFA that may be trapped or contained in the deep sound channel. However, due to the relatively shallow placement of the LFA source, only a minimal amount of the signal will enter the deep sound channel. See the FOEIS/EIS Subchapter 3.1.3 for further discussion on ocean acoustic regimes and sound channels.

Analyses of the first four years of operation of two SURTASS LFA sonar systems demonstrate that the actual transmit times were a maximum of 174 hours (DON, 2007); meaning that for two

LFA vessels actual transmission were less than two percent for the year—hardly enough to "inundate" the world's oceans.

Comment 4.6.16: Listing the maximum SLs of the individual marine mammal species' vocalizations (Chapter 3 of the Draft SEIS) implies that somehow natural sounds can be equated with human-made sounds. To mention "whale vocalizations" as some of these cumulative impacts in this context is highly misleading and inappropriate. Marine mammals have, to some degree, presumably adapted over evolutionary time to natural noise sources, whereas human-made noise is a comparatively new addition to their environment. It is scientifically invalid to compare the two. To compare human-made noise sources with the marine mammals' own vocalizations is particularly deceptive. Surely marine mammals distinguish the two and modify their behavior accordingly (by avoiding accidental ensonification of each other to dangerous levels unless they use their sounds as a weapon occasionally, by spacing themselves when vocalizing loudly, etc.). I-011, O-010

Response: The source levels for mysticete vocalizations are presented in the SEIS (Table 3.2.3) and odontocete vocalizations are presented in Table 3.2.4. Data presented in Chapter 3 are intended to describe the environment. Omission of the description of the vocalizations of these species would be negligent. The description of the vocalizations includes sound type, source level and frequency range. These data are descriptive, and make no inference.

When considering the potential for underwater acoustic physiological effects on marine biota, there can be no distinction drawn between sources of the acoustic energy. Either there is sufficient energy to cause an effect or there is not. No known evolutionary modifications to ears can make them less susceptible to familiar stimuli or more susceptible to novel stimuli in the same frequency range. However, the behavioral response to the perception of the sound can, and almost certainly is, affected by the information in the signal.

Comment 4.6.17: When the document cites the Au and Green (2000) study under "cumulative impacts", there is no mention of behavioral impacts from small boat noise. Yet under the mitigation section, when surveys by small boats are considered, it cites the same study and mentions, for the first time, the behavioral impacts on whales from small boats! Suddenly, when it serves their interest, the Navy is highly concerned about the impacts of small boats and the additional noise animals would be subjected to! According to this reasoning, it is then logical to conclude that we should be very concerned about impacts from LFA sonar which blankets 3.9 million sq km of ocean with noise levels known to cause whale avoidance (120 dB). O-010

Response: The citation to Au and Green (2000) in Draft SEIS Subchapter 4.6.1.3 concerning vessel noise is correct. The authors stated that the ramifications of behavioral changes by the presence of boats are an open question; thus were not discussed in their report. However, in that same subchapter of the Draft SEIS, behavioral effects of watercraft noise on orca and bottlenose dolphins were presented. The Navy agrees with the commenter that the reference to Au and Green (2000) in Draft SEIS Subchapter 5.4 is incorrect. The more appropriate reference is Green and Green (1990), as cited in Green and Au (2000). <u>The sub-bullet has been rewritten in the SEIS as follows:</u>

- Green and Green (1990) reported that humpback whales' reactions to approaching and departing boats included altering their behavior by often reducing the proportional amount of time on the surface, taking longer dives, altering direction, and spending more time underwater. This could potentially make them more difficult to see.

Comment 4.6.18: Draft SEIS should mention that the Au and Green (2000) study concluded that the humpback's auditory system would not be seriously affected by boat noise, but the study did show a disturbance from boats. I-011

Response: See SEIS RTC 4.6.17 above.

Comment 4.6.19: Draft SEIS statement that contribution from SURTASS LFA will be "extremely small" is irresponsible. This is no reason to justify adding even more. O-013

Response: See SEIS RTC 4.6.5 above. The justification and need for SURTASS LFA sonar is provided in the SEIS Subchapter 1.1.

Ship Strike

Comment 4.6.20: The Draft SEIS fails to address the fact that LFA operations would likely increase the number of sea turtle and marine mammals injured or killed by ship strikes and by-catch due to hearing impairment and masking. I-011, O-008, O-010

Response: Because hearing impairments in sea turtles and marine mammals are considered negligible and masking effects are limited, sea turtles and marine mammals are not likely to be injured or killed by ship strikes or by-catch from these effects.

Sea Turtles**:** As stated in Subchapter 4.2 of the SEIS and Subchapter 4.1.2 of the FOEIS/EIS, the potential for SURTASS LFA sonar to cause PTS or TTS in sea turtles is considered negligible. This statement is further supported by the NMFS Biological Opinions (BiOp) issued during consultation under the Endangered Species Act on the latest proposed letters of authorization for the Navy to take marine mammals incidental to its employment of SURTASS LFA (NMFS, 2006). The BiOp states, "Although sea turtles can hear low frequency sounds, they have an insensitive ear." Further, the BiOp states, "A sea turtle's probability of occurring within an ensonified area that would elicit a similar or other behavioral response is also low because most of the turtles remain in shallower, surface waters where the sound field is dominated by wind, waves, and other sound sources…Because the dive profiles of sea turtles would limit their chances of exposure to LFA sonar and their limited sensitivity to low frequency sound if exposed, we would not expect received levels of SURTASS LFA transmissions to affect the behavior of sea turtles in ways that would reduce their reproduction, numbers, or distribution; as a result, these transmissions would not be expected to appreciably reduce these turtles likelihood of surviving and recovering in the wild."

See RTCs 4.3.1, 4.3.23, and 4.3.36 to 4.3.39 above for discussions on masking.

Marine mammals: As stated in Subchapter 4.3.6 of the SEIS and Subchapter 4.2.7 of the FOEIS/EIS, the potential effects from SURTASS LFA 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. This statement is further supported and emphasized by the BiOp under the Endangered Species Act on the proposed letters of authorization to authorize the Navy to take marine mammals incidental to its employment of SURTASS LFA sonar (NMFS, 2006), which states, "Although the number of studies is limited, the available evidence suggests that at received levels below 180 dB, exposure to LFA sonar transmissions are not likely to result in injury, masking, stranding, resonance effects, or other behavioral effects in baleen whales." Additionally, the BiOp also states that despite the limited number of studies, the available evidence suggests that the risk of injury, masking, stranding, resonance effects, or behavioral effects in sperm whales is very low.

The masking effects of the SURTASS LFA signal will be limited. These are discussed above and in SEIS RTCs 4.3.1, 4.3.23, and 4.3.36 to 4.3.39.

Comment 4.6.21: Todd et al. (1996) found that more humpback whales were entrapped in fishing gear in an area where underwater explosions were taking place, apparently causing hearing impairment. Such impairment seems likely to have caused whales to blunder into nets, based on the unusual entrapment patterns observed (repeat entrapments, unusual age classes entrapped, area of entrapment, etc.). I-011, O-010

Response: Todd et al. (1996) states in their abstract that it appeared that the increased entrapment rate of humpback whales in Trinity Bay may have been influenced by the long-term effects of exposure to deleterious levels of sound. Todd et al. discussed the entrapment of humpback whales in fixed fishing gear due to the industrial activity, including the use of underwater explosives and drilling activities, in Newfoundland. They stated, "Direct observation of whales during blast sequences indicated no unusual behaviours associated with the blasts…During the blast sequence no abrupt surface reactions (such as sudden dives, abnormal surface behavior, or course changes) were noted, nor were any vocalizations recorded." Further, they stated, "…the behavioural assessment of humpbacks in situ, based on analysis of distribution, resighting rate, residency, and general behaviour, suggests that animals were not reacting to the intense acoustic stimuli from the detonations." This study did not measure the hearing abilities in the humpback whales, but their reactions, or lack of reactions, to acoustic stimuli.

This study involved broadband noise from large underwater explosives and drilling over extended periods of time, localized to a relatively small area (Trinity Bay, Newfoundland). Todd et al.'s conclusions are not applicable to SURTASS LFA sonar operations because the LFA transmissions are coherent, narrow-band signals, and are not transmitted over the extended time periods required to cause permanent hearing impairment or masking in marine mammals. Also underwater explosions create shock waves that differ from the coherent sound produced by sonar. These shock waves may have played an important part in the causation of impacts to the humpback whales. In addition, because of the geographical mitigation restriction and operational restrictions on SURTASS LFA sonar due to the lengths of the horizontal and vertical arrays, LFA operations cannot occur in constrained areas with water depth restrictions such as Trinity Bay.

Comment 4.6.22: Whales killed by collisions with high-speed ferries showed hearing impairment when later necropsied (Andre et al. 1997). O-010

Response: High-speed ferries and vessels produce broadband, continuous noise covering large frequency ranges, which could, over extended exposure times, cause permanent hearing impairment in marine animals. Because of the intermittent nature of the coherent, narrow-band LFA signal, the potential for LFA to cause non-auditory or permanent loss of hearing is considered negligible. In addition, because of the 22-km (12-nm) geographical mitigation restriction and operational restrictions on SURTASS LFA sonar due to the lengths of the horizontal and vertical arrays, LFA operations cannot occur in constrained areas where high speed ferries would routinely operate.

Comment 4.6.23: How many cargo or military ships studiously monitor the number of whales they've struck? I-011, O-010

Response: As stated in Jensen and Silber (2004), "Federal vessels are more likely to report a strike than commercial vessels due to their standardized reporting practice. In addition, awareness that an animal has been struck may depend on the number of people on board. Federal ships carry a substantial crew, a number of whom are generally on the bridge at any one time (bridge crew on Navy vessels often consists of a half dozen individuals or more). Such crews are more likely to spot a whale and/or register that a collision has occurred than a container ship or tanker with only one or two individuals at the helm."

It should be noted that the Navy and Coast Guard have adopted several requirements for their vessels to minimize the potential for lethal ship strikes regarding the endangered northern right whale. The Navy has committed to stationing an extra lookout—specifically trained in spotting and identifying marine mammals—on surface vessels present within the southeast critical habitat during northern right whale calving season. Navy and Coast Guard vessels avoid operating in the critical habitat area during calving season, and operate at slow safe speeds in the critical habitat and whenever in the vicinity of a right whale. Both the Navy and Coast Guard are members of the Southeast Right Whale Recovery Implementation Team and are involved in the Southeast Early Warning System (EWS). The Navy has instituted a centralized Geographic Information System (GIS) that tracks all whale sightings reported by the EWS and notifies Navy vessels in, or about to enter, the right whale southeast critical habitats of recommended actions that may be needed to avoid right whales. Other measures adopted by the Navy for calving season in the southeast include: 1) prohibiting north-south transits through the critical habitat; 2) requiring direct east-west transits when entering or leaving port; 3) avoiding transits at night and in bad weather to the extent practicable; and 4) moving naval operations that require high vessel speed as far from the critical habitat as practicable. The Navy has also produced a training video for ships' crews explaining the importance of avoiding right whales and how to identify them.

In addition, SURTASS LFA Sonar operations are restricted year round within the 200-m isobath of the U.S. Eastern Seaboard. The OBIA boundaries encompass Northern Right Whale Critical Habitat, Stellwagen Bank NMS, Monitor NMS, and Gray's Reef NMS.

Comment 4.6.24: Ship strikes are not just a function of ship speed, as many small sailing vessels strike whales. A ship speed of 10-12 knots could easily result in a ship strike. I-011

Response: The most severe and lethal injuries to marine mammals by ship strikes appear to be caused by vessels traveling at 25.9 kph (14 knots) or faster (Laist et al., 2001). During sonar operations, SURTASS LFA vessels, on average, travel at 5.6 kph (3 knots), due to speed restrictions with the arrays deployed. Transit speed for the SURTASS LFA vessels is no greater than 22.2 kph (12 knots). Therefore, the probability of these vessels causing severe and lethal injuries to a marine mammal by striking it is low.

Other

Comment 4.6.25: LFA cumulative impacts analysis must be considered in combination with other/existing naval activities, whaling, by-catch/entanglement, ship strikes, major shipping lanes, oil and gas exploration, geophysical research, habitat degradation, contaminants and debris. Evaluate how LFA activities might work synergistically with other threats. These should be discussed in the conclusions. O-012, O-013, O-014

Response: The Navy did, in fact, discuss other military sonars, whaling, by-catch and entanglement, ship strikes, oil and gas exploration, geophysical research, and shipping in terms of noise in SEIS Subchapter 4.6 for Cumulative Impacts. It states that, even if considered in combination with other underwater sounds (from the aforementioned activities), the SURTASS LFA sonar systems do not add appreciably to the underwater sounds to which fish, sea turtles, and marine mammals stocks are exposed. Also, see SEIS RTCs 4.6.5, 4.6.6, 4.6.7, 4.6.8, 4.6.13, 4.6.14, 4.6.19, 4.6.20, 4.6.21, 4.6.22, and 4.6.23 for additional information.

Based on the FOEIS/EIS analysis and the experience gained from SURTASS LFA operations over the last five years, SURTASS LFA sonar has not, nor is it expected to have, any more than negligible effects on ocean habitats, including the open water and the ocean bottom.

Contamination is not discussed in Subchapter 4.6 of the SEIS. However, contamination from the SURTASS LFA ships was discussed in Chapter 6 of the FOEIS/EIS under the Clean Water Act and the Act to Prevent Pollution from Ships. Operation of the SURTASS LFA sonar systems and their vessels will not result in the discharge of any pollutant to such waters. Operation of the vessels will result only in discharges incidental to normal operations of a vessel. No permit is required for these discharges.

Comment 4.6.26: The magnitude of cumulative and synergistic effects of anthropogenic noise and the contribution from SURTASS LFA sonar are minimized in the Draft SEIS. Much is made of discussing other anthropogenic noise sources and citing the nonsensical statement in the International Council for Exploration Report 2005 that "shipping noise projected to increase, where sonar is not." The Draft SEIS proposes a two fold increase in LFA sonar use. O-013

Response: Cumulative and synergistic effects regarding SURTASS LFA sonar operations are discussed in SEIS RTCs 4.1.9, 4.3.23, 4.4.27, 4.6.2, 4.6.6, 4.6.16, 4.6.25, 4.6.27, and 4.6.29. In order to effectively evaluate potential cumulative effects of SURTASS LFA, it is necessary to draw comparisons between LFA and other sources of anthropogenic effects. As such, SURTASS LFA sonar was compared to anthropogenic noise levels and injury/lethal takes from other anthropogenic causes.

For SURTASS LFA's contribution to anthropogenic noise, comparisons were made to oceanic noise level; changes, commercial shipping, vessel noise sources, oil and gas industry, and military and commercial sonars. In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (U.S.) and the Joint Nature Conservation Committee (UK) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output (Hildebrand, 2004). This analysis included SURTASS LFA sonar, in which he estimated that on an annual basis four SURTASS LFA systems would have a total energy output two orders of magnitude less than seismic air gun arrays and one order of magnitude less than MFA and super tankers. This is discussed in more detail in SEIS RTC 4.6.5 above.

As stated in the SEIS, Subchapter 4.6.2, SURTASS LFA sonar will cause no lethal takes of marine mammals. This is supported by the ICES (2005) report that stated, "No strandings, injury, or major behavioural change has yet been associated with the exclusive use of low frequency sonar."

The FOEIS/EIS (pp. ES-5, 2-1) analyzed the potential impacts of up to four SURTASS LFA systems. Because during the timeframe of the current five-year rule the Navy only expected to have two of the four vessels available for LFA deployment, the NMFS's initial five-year rule authorized two systems. The use of SURTASS LFA sonar is not scheduled to increase past the originally analyzed four systems in the next five year Rule. Therefore, the number of systems has not increased over the number initially proposed in the FOEIS/EIS (DON, 2001).

The statement in the initial ICES AGISC 2005 Report concerning "shipping noise projected to increase, where sonar is not" was modified in the 2nd Edition of the Report to state that "shipping accounts for more than 75 percent of all human sound in the sea, and sonar amounts to no more than 10 percent or so." It further stated that sonar will probably never exceed 10 percent (noise budget), but that "sonar deployment seems likely to increase in the future." (ICES, 2005) <u>The SEIS Subchapter 4.6.1.2 has been modified accordingly.</u>

Comment 4.6.27: Cumulative impact analysis does not consider any species other than marine mammals. O-014

Response: The commenter is incorrect. In the Draft SEIS Subchapter 4.6, the cumulative impact analysis considered fish, sea turtles, and marine mammals. <u>Clarification to this effect has been made to SEIS Subchapter 4.6.</u>

Comment 4.6.28: Draft SEIS does not mention the potential impacts to marine mammals from climate change. O-013

Response: Climate change has the potential to affect fisheries, bleach coral, cause sea ice to retreat, change water temperature on large scales, and more. Information in this area is largely incomplete and controversial. Moreover, it is outside of the scope of the SURTASS LFA SEIS analysis to provide this analysis. However, under the MMPA, the Navy will be required to apply for annual LOAs for the specific areas in which they intend to operate. The applications for these LOAs include the most current scientific data relating to marine mammal habitats and population figures, which would include any impacts due to climate change in those areas that have been incorporated into these data. Except for the small amount of fossil fuels consumed by the vessels, SURTASS LFA sonar will not cause any environmental consequences or direct/indirect effects potentially related to climate change.

Comment 4.6.29: Cumulative impacts analysis must include; a) species other than marine mammals, such as sea turtles and fish; b) evaluate potential for cumulative impacts; c) assess for potential; synergistic adverse effects; d) long-term cumulative impacts of activities actually covered by the Draft SEIS; e) assess long term impact of LFA even if it is considered small, consider whether other activities in combination could produce a significant effect. O-014

Response: Cumulative impacts analysis, including the commenter's issues, are discussed in SEIS RTCs 4.1.9, 4.3.23, 4.4.27, 4.6.2, 4.6.6, 4.6.16, 4.6.25, and 4.6.27 above.

ISSUE 4.7 Evaluation of Alternatives

Comment 4.7.1: NOAA supports the preferred alternative which incorporates the protections for national marine sanctuary resources developed in the course of consultation pursuant to section 304(d) of the National Marine Sanctuaries Act (16 U.S.C. 1434(d)). This consultation concluded with a commitment by the Navy to ensure this system is operated in a manner that minimizes the potential for the system to injure sanctuary resources. NOAA asks that the Navy consider adding Davidson Seamount to the list of OBIAs. Davidson Seamount is an important feeding ground for sperm whales along the California coast and is close to the OBIA established for the Monterey Bay National Marine Sanctuary. G-003

Response: NOAA Office of Program Planning and Integration requested that Davidson Seamount be listed as an OBIA because it is an important feeding ground for sperm whales along the California coast. It is very close to the Monterey Bay NMS (MBNMS), and NOAA is currently in the process for expanding the MBNMS. The center of the seamount is 35 degrees 43 min 12 sec N, 122 degrees 43 min 12 sec W. Davidson Seamount is located 120 km (65 nm) to the southwest of Monterey, 150 km (81 nm) west of Cambria. It is 42 km (22.7 nm) long and 13.5 km (7.3 nm) wide at a depth of 1,300 m (4,265 ft).

The Navy is currently evaluating the proposal to make Davidson Seamount an OBIA and will provide a response prior to the termination of the current NMFS Rule authorizing SURTASS LFA operations.

Comment 4.7.2: The Draft SEIS's conclusion that the proposed operations are unlikely to have biologically significant impacts on any marine mammal species or stocks is based primarily on two assumptions: 1) Behavioral responses to the sonar transmissions would be temporary (of biologically insignificant duration), and exposure to received levels at and below 180 dB would not have biologically significant effects on the behavior of any marine mammals; and 2) The mitigation and monitoring measures described in Chapter 5 of the Draft SEIS will reduce, to a negligible likelihood, the risk that any marine mammal would be exposed to received levels greater than 180 dB. MMC questions whether these assumptions are valid. Also MMC questions the conclusion that Alternative 4 would pose a greater risk of harassing marine mammals than would Alternative 2. G-008

Response: MMC's statement that the Draft SEIS conclusions are based on the above assumptions is partially incorrect. The first assumption is two-fold. The Draft SEIS does not directly state that behavioral responses would be temporary or of biologically insignificant duration, but that potential impacts to biologically important behavior were considered to be minimal. This analysis is based on the low percentage of marine mammal stocks that were estimated to be exposed to single-ping-equivalent received levels below 180 dB that could potentially cause biologically significant effects. The analysis does not state that exposures to RLs below 180 dB would have no biologically significant effects on the behavior of marine mammals. In fact, the analysis of behavioral responses is based partially on the results of the LFS SRP field research in 1997-98, which 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. 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 (Miller et al., 2000; Clark et al., 2001; Croll et al., 2001a; Fristrup et al., 2003). Based on the risk function (FOEIS/EIS Subchapter 4.2.3), marine mammals are considered to have been exposed to LFA levels that would cause a risk for biological behavior modification from 120 dB (no significant behavioral response) to 165 dB (50 percent risk of significant behavioral response) to 180 dB (95 percent risk of significant behavioral response). As shown in the risk assessment approach and the case study presented in SEIS Subchapter 4.4, there are marine mammals with estimated exposures to levels below 180 dB RL (single ping equivalent) (SEIS Tables 4.4-2 to 4.4-10). All animals exposed to 180 dB or greater are treated as though they were injured (a conservative assumption).

LFA has not experienced difficulties in executing its mitigation procedures required by NMFS, which is based on protecting marine animals from injury. LFA sonar has been operating since 2003 in a restricted area in the northwestern Pacific Ocean with a total of 470 hours of transmit time under the first four LOAs (DON, 2007). These extensive operations, with mitigation, have produced no known Level A takes on marine mammals. Further information on mitigation effectiveness is provided in the Reports as required under the conditions of the LOAs (DON 2003, 2004, 2005, 2006, and 2007).

The conclusion that Alternative 4 would pose a greater risk of harassing marine mammals than would Alternative 2 is discussed in RTCs 4.7.14, 4.7.15, and 4.7.16 below.

Comment 4.7.3: None of the alternatives presented in the Draft SEIS will adequately protect this nation and the marine environment. The alternative that would address the threat of quieter and harder to find foreign submarines would be to negotiate international treaties which forbid the development, production, sale, possession, and use of these weapons. O-008

Response: SURTASS LFA sonar is the best technology available for the foreseeable future to adequately meet this threat. See Subchapter 1.1 of the FOEIS/EIS, Subchapter 1.1 of the SEIS, and RTC 1-1.1 in the FOEIS/EIS for additional information. The removal of the worldwide threat of quiet submarines through negotiation and international treaties is not reasonably foreseeable during the period of the follow-on five-year rule (2007 to 2012).

Comment 4.7.4: No Action Alternative is the only logical decision. O-013

Response: The No Action Alternative is not a logical decision because, as stated in the SEIS Subchapter 4.7.1, the SURTASS LFA sonar system would not be deployed and the U.S. need for improved capability in detecting quieter and harder-to-find foreign submarines at long range would not be met. Given that the primary detection method for quiet diesel submarines, particularly in the littorals, would still be active sonar, shorter-range tactical sonars would need to compensate for the loss of long-range detection capability afforded by SURTASS LFA sonar. Any attempt to achieve a near-comparable level of security for U.S. and allied ships and the personnel who man them, would require a greater number of tactical sonars (deployed from ships and aircraft). This, in turn could lead to increased underwater noise, both spatially and temporally, albeit in a different frequency regime (i.e., MF vice LF), so that relevant impacts on marine species could be different. Because some marine mammal strandings are suspected of being associated with the use of MFA, there would be the potential for increases in stranding events. In addition, there would be an increase in fuel consumption and expenditure of energy resources associated with additional ships or increased time at sea, most likely accompanied by an increase of petroleum by-product pollution, and solid and liquid wastes. Thus, there would be greater environmental impacts resulting from implementation of this alternative.

Comment 4.7.5: Commenter disagrees with Alternative 2 as the Preferred Alternative, but would prefer the extended standoff distance (Alternative 3) which would not be perfect but better. O-010

Response: The Navy acknowledges this comment.

Comment 4.7.6: LFA broadcasts have an enormous and unprecedented potential area of impact. The long-term population consequences of the lower intensity noise levels heard over these huge areas has not been examined in any marine species. This all adds up to taking a gamble of vast proportions with our marine environment. Therefore, the “No Action” alternative should be pursued. Only if the No Action alternative is impossible should Alternative 4 be chosen. This Draft SEIS has contributed no new information which would warrant modification of the conclusion that LFA is indeed a threat to the marine environment. O-010

Response: The commenter's preferences of the No Action Alternative or Alternative 4 are noted. The Navy disagrees, however, that SURTASS LFA sonar is a threat to the marine environment. The Navy concluded in both the FOEIS/EIS and the SEIS that SURTASS LFA sonar would have environmental effects, but that these would be minimal. There has been new information that support these findings such as Cudahy and Ellison (2002), Laurer et al. (2002), ICES (2005), Cox et al. (2006), and D'Spain et al. (2006).

Comment 4.7.7: As mitigation, the Navy promises only to turn off LFA sonar if they spot or detect whales in a very small area around the ships. Since the impacts of underwater sound, both to do physical harm to whales and also to disrupt and harass whales' and dolphins' own communication, feeding, and orientation, cover enormous distances, these mitigation measures are too paltry to protect the health of whales and dolphins and are unacceptable. O-011

Response: The potential for SURTASS LFA sonar to cause harm to marine mammals and the validity of the 180-dB injury threshold for SURTASS LFA are discussed in SEIS RTCs 4.0.1, 4.0.2, 4.0.3, 4.3.1, 4.3.2, 4.3.8, 4.3.9, 4.3.10, and 4.3.12 above. LFA will not cause physical harm to marine mammals below 180 dB RL. Moreover, inside of the 180-dB mitigation zone, the tripartite monitoring has a high probability of detecting the presence of marine mammals.

Comment 4.7.8: MMC recommends that the final SEIS should (1) acknowledge the aforementioned uncertainties concerning the effectiveness of the 180-dB impact threshold to mitigate impacts on marine mammals and (2) provide a description of the research being done and planned to address the uncertainties. G-008

Response: The MMC's assumption that the Navy does not consider exposure below 180 dB RL to potentially have biologically significant effects is mistaken. The MMC states on page 2 of their comments that the Draft SEIS conclusions are based on two assumptions. The first states that "exposure to received levels at and below 180 dB would not have biologically significant effects on the behavior of any marine mammal." This is not true. Based on the risk function (FOEIS/EIS Subchapter 4.2.3), marine mammals are considered to have been exposed to LFA levels that would cause a risk for biological behavior modification from 120 dB (no significant behavioral response) to 165 dB (50 percent risk of significant behavioral response) to 180 dB (95 percent risk of significant behavioral response). As shown in the risk assessment approach and the case study presented in SEIS Subchapter 4.4, there are marine mammals with estimated exposures to levels below 180 dB RL (single ping equivalent) (SEIS Tables 4.4-2 to 4.4-10). All animals exposed to 180 dB or greater are considered as though they are injured (a conservative assumption). Therefore, the uncertainties concerning the effectiveness of the 180-dB injury threshold to mitigate impacts (harm) on marine mammals are not considered to be reasonably foreseeable and thus no research to that effect is warranted.

Comment 4.7.9: The Navy fails to consider training in areas of reduced risk. Experts agree that proper siting and geographic mitigation are among the most effective ways to lessen harm from acoustic sources. O-014

Response: As noted in SEIS Subchapter 2.5.2.1, SURTASS LFA sonar operations are planned for areas with reduced risk by avoiding areas of high marine life concentrations to the greatest extent feasible considering national security tasking. This process is detailed in Draft SEIS Subchapter 4.4.

Comment 4.7.10: The Navy fails to consider extending shutdown procedures to fish. Disagree that impacts to fish will be negligible. Even though the Navy's mitigation does extend the shutdown procedures to fish among the alternatives, its dismissal of mitigation opportunities is far too casual. O-014

Response: The monitoring mitigation for SURTASS LFA operations is designed to prevent injury to marine mammals by monitoring the LFA Mitigation (180 dB) zone.

Based on recent controlled exposure experiments on fish (University of Maryland), it was determined that LFA received levels up to 193 dB did not produce injury or mortalities. See SEIS RTCs 4.0.1, 4.1.2, 4.1.4, 4.1.17, and 4.1.20 above.

In the SEIS, Subchapter 2.5.2.2, it was stated that the implementation of fish mitigation procedures was impractical, given that visual monitoring (daylight only) cannot be relied upon to detect fish schools, passive acoustic detection is infeasible, and active acoustics would give so many false alarms that the impact on the effectiveness of the military readiness activity (and, hence impact on National Security) would be very high. Moreover, the potential for a fish or school of fish to be harmed (thus impacting fish stocks) by exposure to LFA signals (within 200 m (656 ft) of the LFA source array based on recent field research results is negligible (Popper et al., 2005a; Halvorsen et al., 2006). Therefore, mitigation for fish is not warranted.

Comment 4.7.11: The Navy omits reasonable alternatives of maintaining the current 330 Hz restriction and 1-km buffer zone. Both of these would avoid or minimize adverse impacts, have been shown to be practical, and should be considered. One-km buffer zone was rejected without analysis or explanation. Resonance remains a reasonably foreseeable impact. O-014

Response: It should first be noted that the current 330-Hz restriction and 1-km buffer zone were interim operational restrictions required by NMFS during the MMPA permitting process. These are discussed in SEIS Subchapter 2.5.1 and SEIS RTCs 2.5.1 and 2.5.2 above.

<u>330 Hz restriction</u>: This restriction is discussed in SEIS RTC 2.5.2 above. There is no rationale that supports an increase in the probability of LFA to cause injury to marine mammals through resonance in the frequency range of 330 to 500 Hz. The frequency requirements for the Compact LFA to be installed onboard the VICTORIOUS Class vessels are above 330 Hz, but still within the 100 to 500 Hz range in both the FOEIS/EIS and Draft SEIS/Final SEIS. This restriction was considered and determined that it was not required (SEIS Subchapter 2.5.1).

<u>One-km buffer zone</u>: This restriction is discussed in SEIS RTC 2.5.1 above. The Navy concurs that this interim restriction has proven to be practical under the current operations, but analysis has not shown that it would appreciably avoid or minimize adverse impacts. The monitoring of the 180-dB mitigation zone is to prevent injury to marine animals. The area between the 180-dB

radius and the 1-km buffer zone (estimated to extend to about the 174 dB isopleth) is an area where marine mammals will experience Level B takes in accordance with the risk continuum (FOEIS/EIS Subchapter 4.2.3). The determination of the percentage of marine mammal stocks potentially affected by LFA operations in the risk assessment case study (SEIS Subchapter 4.4.2) was determined based on monitoring mitigation in 180-dB injury zone, without accounting for the 1-km buffer zone. The area without the buffer zone is 3.14 km² and the area with the buffer zone is 12.6 km², a difference of 9.5 km². The model analysis was rerun using the total 2-km mitigation+buffer zone. The differences in the number of animals affected were insignificant because the difference in the area is very small compared to the overall area in the analysis for Level-B harassment. Thus, the removal of this restriction would not appreciably change the percentage of animals potentially affected.

Resonance: As discussed in SEIS RTC 2.5.2 above, analysis by the Navy (Cudahy and Ellison, 2002) and reports on two workshops on acoustic impacts (DOC, 2002: Cox, et al. 2006) support the conclusion that resonance from LFA operations is not a “reasonably foreseeable” impact.

Comment 4.7.12: The Navy fails to consider all reasonable alternatives for expanding coastal exclusion zones, instead limiting its analysis to the 22 km (12 nm) and 46 km (25 nm) scenarios. The Navy provides no explanation for its choice of 46 km (25 nm) as the sole alternative coastal zone considered. Other alternatives that should have been considered include the dual-criteria alternative like the one used in the Permanent Injunction (which sets a coastal exclusion zone in the Philippine Sea of 111 km (60 nm) or 56 km (30 nm) seaward of the 200-meter isobath, whichever is greater); zones greater than 46 km (25 nm) and large enough to shield shelf and shelf-break species, but still narrow enough to permit training with LFA, like the zone of at least 111 km (60 nm) now employed in the Philippine Sea; and an “inverse” coastal exclusion zone—perhaps called a coastal shelf exclusion zone—that puts the areas of highest impact to coastal species, as defined by the Navy’s coastal zone exclusion modeling, off-limits to training. O-014

Response: SEIS Subchapter 4.7.6 and, in particular, Table 4.7-2 provide a very detailed analysis. The choice of 46 km (25 nm) as an alternative standoff range was not arbitrary. It was selected because it was just over twice the current coastal exclusion restriction, and it was seaward of the hypothetical shelf break for all three shelf cases examined in this analysis. The Philippine Sea dual-criteria alternative referred to by the commenter was pertinent to only the Permanent Injunction and should be clarified as 111 km (60 nm) from the coast or 56 km (30 nm) seaward of the 200-meter isobath, whichever is greater. The FOEIS/EIS analysis was based on a coastal geographic restriction of 22 km (12 nm); whereupon it was incorporated into the Navy’s ROD, NMFS’s Final Rule and subsequent LOAs. In the Navy’s good faith attempt to respond to a Court-identified deficiency, additional alternatives were analyzed in the Draft SEIS, including more than doubling the coastal standoff range. The results summarized in SEIS Table 4.7-7 indicate that increasing the coastal standoff range does decrease exposure to higher RLs for the concentrations of marine animals closest to the shore (shelf species) but does so at the expense of increasing exposure levels for shelf break species and pelagic species. Increasing the range to 56 km (30 nm) or even 111 km (60 nm) would not make a significant difference in the outcome. The meaning of “inverse” coastal exclusion zone is unclear. However, coastal shelf areas, in many cases, are already excluded. SEIS Table 2-4 delineates OBIAs that should be considered a coastal shelf exclusion zone. For example, the North American east coast exclusion zone includes all shelf waters landward of the 200-meter isobath between 28 deg N to 50 deg N latitude, west of 40 deg W longitude. This is a year-round restriction and encompasses the Northern Right Whale Critical Habitat, the Stellwagen Bank NMS, the Monitor NMS, and the Gray's Reef NMS.

Comment 4.7.13: Court has already held that it was unlawful for NMFS and Navy to reject increased coastal exclusion zones, and the Navy cannot reopen this debate. O-014

Response: The Court's findings related to the current 5-year regulations. The Stipulation Regarding Permanent Injunction issued on 14 October 2003 by the U.S. District Court, Northern District of California set up coastal zone restrictions. As agreed to by the parties, the Stipulation remains in effect until the expiration of the Final Rule, 50 CFR, Part 216, Subpart Q, on 15 August 2007 (§216.181). The commenter was one of the parties that agreed to this stipulation.

Comment 4.7.14: The Navy's modeling fails to account for several factors that are key to showing that more harm to marine species will, indeed, occur with a coastal standoff range of 25 nm: O-014

Response: This analysis was not portrayed in the Draft SEIS as a modeling effort, but as a "generic analytical methodology for coastal standoff range comparison" as clearly stated in the Draft SEIS. As further stated, "The methodology used to assess the change in potential impacts to marine animals was designed to utilize several sets of simplified assumptions in order to determine a relative trend in these potential impacts for a variety of oceanic and biological conditions. This approach allows one to assess the trends without the extensive process of modeling all the conditions that exist." This was a method of relative analysis of 3 shelf cases vs. 3 biology types (yielding 9 different combinations of the factors) for each of two potential coastal standoff cases to estimate relative impacts. In order to answer the question of whether a standoff range farther from the coast would, in fact, generate fewer marine mammal takes, a generic analysis was performed (SEIS Subchapter 4.7.6).

> **Comment 4.7.14a:** Model fails to consider or account for absolute number of animals affected within each of the three zones studied (shelf, shelf-break, and pelagic). Instead, for every species considered it assumes a normalized density of 4 animals per sq nm in the species' prime habitat. This methodology makes it very difficult to weigh the real-world impact of the two scenarios analyzed. The Navy concedes, for example, that increasing the coastal standoff zone decreases harm to marine animals closest to shore (i.e., shelf species). If there are many more animals on the shelf than in the shelf-break or pelagic zones, any increased risk for pelagic and shelf-break species might be outweighed by the decreased risk for shelf species. The analysis does not provide sufficient information to allow this comparison.
>
> **Response:** The commenter's statement regarding the failure to consider or account for "absolute" numbers of animals is unscientific, given the general marine biological community's acceptance that absolute numbers of animals in any open ocean area are impossible to come by. The 4 animals per sq nm used here is a normalized value, to show

on a relative scale where the concentration of that species would be. The Navy disagrees with the commenter that the analysis does not provide sufficient information to allow the comparison mentioned. SEIS Tables 4.7-2, 4.7-3, 4.7-4, 4.7-5, 4.7-6, and 4.7-7; Figures 4.7-1, 4.7-2, and 4.7-3; and the supporting text (SEIS Subchapter 4.7.6), provide the requisite information.

Comment 4.7.14b: Model fails to account for the absolute number of animals that will be exposed to the most dangerous levels of LFA sound. The central difference between the two alternatives is the location of the area of intense sound in relation to the shelf break. In comparing these alternatives, therefore, one crucial question is whether more or fewer marine animals are likely to be found within the area of most intense ensonification. This is a question that the model never asks or answers, since it never compares abundances of shelf, shelf-break and pelagic species.

Response: Again, it is common knowledge that absolute numbers of open-ocean animals are not available. This analysis was not intended to address animals that will be exposed to the most dangerous levels of LFA sound (i.e. $\geq$180 dB RL). The commenter fails to recognize that the proven LFA monitoring mitigation out to the 180 dB isopleth ensures that there is a high probability that no marine mammal enters the area of intense sound around the LFA source undetected, as has been stated in numerous places in the Draft SEIS and in many SEIS RTCs above. Hence, the "crucial question of whether more or fewer marine animals are likely to be found within the area of most intense ensonification" is moot.

Comment 4.7.14c: Model fails to account for the types of animals that will be exposed to the highest and most dangerous levels of LFA sound, treating all species as equivalently vulnerable to acoustical harms. In fact, we know that some species found along the coast are particularly vulnerable, such as harbor porpoises (4 references cited). Failure to take into account especially sensitive species and their likely habitats is a significant flaw.

Response: As for the commenter's statement that, "Model fails to account for the types of animals that will be exposed to the highest and most dangerous levels of LFA sound" see SEIS RTC 4.7.14b above. Further, the accepted risk analysis explained in detail in FEOIS/OIS Subchapters 4.2.3-4.2.5 utilized one risk continuum for all marine mammal species, although it was based on the marine mammals most susceptible to LFA, mysticetes. Hence, the use of this methodology with odontocetes yields conservative results. The Navy disagrees with the commenter's "significant flaw" statement, particularly given that the references to harbor porpoises should be considered immaterial, since their hearing sensitivity is very low at frequencies below 1 kHz. (Kastelein et al., 2002)

Comment 4.7.14d: The model assumes that the propagation loss from LFA source is spherical for the first 1,000 m from the source and cylindrical beyond that range. Propagation loss in shallow coastal waters is not, however, necessarily spherical for that duration, and reverberations can play a significant role in increasing received levels (2 references cited). Because coastal shelf widths vary greatly, both the 12 nm and the 25 nm coastal exclusion zones will sometimes permit LFA use in coastal waters less than 200 m deep—as the Navy itself acknowledges by including, in its model, a shelf break 80 nm offshore. Thus, the Navy should update its propagation loss model to account for shallow water propagation effects.

Response: The comment regarding spherical versus cylindrical spreading is correct; however, this methodology was employed to add conservativeness to the analysis. The Navy disagrees with the commenter's statement regarding reverberation. Reverberation does not add directly to received levels. Reverberation is typically identified as "backscatter" from ocean interfaces (surface and bottom) and inhomogeneities in the ocean volume, which can partially obscure a return echo to an acoustic receiver (like a sonar hydrophone), nominally located near the acoustic source. For a marine animal receiving a signal, the "forward" scattering from these interfaces and inhomogeneities is actually what spreads out (and reduces) the individual multi-path components, which is accounted for in the Navy's sophisticated underwater acoustic modeling (e.g., using the Parabolic Equation [PE] model). Reverberation normally does not occur until after the original acoustic signal has passed the exposed animal.

The commenter's statement regarding LFA use in coastal waters less than 200 m deep has merit—the Navy will rarely, if ever, conduct LFA operations in waters shallower than 200 m (656 ft). As stated clearly in the Draft SEIS, detailed propagation loss models were not used in this relative analysis of two potential LFA operational sites to estimate relative impacts. This would be a secondary effect within the framework of the analysis conducted and would not impact the conclusions that this analysis technique were intended to supply.

Comment 4.7.14e: Model treats all three shelf-break scenarios (5 nm, 15 nm, and 80 nm from the shore) as equally likely to occur in LFA operational areas. Placement of the shelf break, however, has a significant effect on the harm to which species are exposed in each scenario analyzed. Rather than assume an equal likelihood for each shelf-break type, the Draft SEIS should therefore make an estimate, based on best available science, as to the proportion in which these three types occur in LFA operational areas.

Response: The Navy agrees that placement of the shelf break has a significant effect on the outcome, which is why three shelf-break scenarios were analyzed. As for estimating the proportion in which these three shelf-break scenarios occur in LFA operational areas, this was not the point of this generic analysis and would not have made a significant difference in the results. As stated in the Draft SEIS (p. 4-67), "The methodology used to access the change in potential impacts to marine mammals was designed to utilize several sets of simplified assumptions in order to determine a relative trend in the potential effects from a variety of oceanic and biological conditions."

Comment 4.7.15: If LFA were operated at a good distance beyond the shelf, it would affect far fewer marine mammals and marine mammal species. Marine mammals concentrate at the shelf break, and thus the stand-off distance should be related to the shelf break and not the coast.

The shelf break could be very close to the coast or extend very far out from land. This is the relevant feature that needs to be used to determine safer distances from marine mammal concentrations. While we may be concerned with reducing the affected area, we should be more concerned with reducing the number of animals ensonified. Also, calculation of the area ensonified should state which RL is being used. I-011, O-010

Response: The Navy agrees that some marine mammals do concentrate at the shelf break, and that a prime concern should be reducing the number of animals ensonified. To accomplish this, the Navy uses the best available scientific data (including marine mammal distribution, abundance and density) for the calculations of its estimates of percentage of marine mammal stocks potentially affected in proposed LFA operating areas. This procedure is outlined in SEIS Subchapter 4.4. SEIS Table 4.7-2 and Figure 4.7-1 provide the RL information used in the Subchapter 4.7.6 analysis: 155 dB SEL, 160 dB SEL and 165 dB SEL. SEIS RTC 5.0.2a discusses the coastal exclusion zone relating it to the continental shelf.

Comment 4.7.16: There is no indication in the Draft SEIS of the numbers or proportions of operations to be conducted in offshore vs. coastal areas. If a large proportion of the operations is expected to occur beyond the 25 nm standoff, the conclusion is moot. If, as the Draft SEIS assumes, exposure to received levels of less than 180 dB poses no more than negligible impacts on marine mammals, then the conclusion is also moot. Alternative 4 seems to offer greater protection to marine mammals than Alternative 2 unless most or at least a major portion of the operations are to be conducted between 12 and 25 nm from the coast. If operations inside the 25-nm standoff range are considered essential for training purposes, the Navy should say so. Before concluding that the additional standoff range is detrimental to marine mammals, the Navy needs to better explain where the training will occur relative to coastlines. G-008

Response: The Navy's analyses in the FOEIS/EIS and SEIS concludes that the potential for LFA operations to cause injury to any stock of marine mammals is 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 minimal. Hence, the Navy agrees with the commenter that the point of this comment can be considered moot. Nevertheless, the following amplifying remarks are provided. The analyses in the FOEIS/EIS and the SEIS were performed with the goal of minimizing marine environmental impacts while, at the same time, providing the necessary flexibility for the Navy to effectively carry out LFA testing and training operations. These are essential for ensuring the Fleet's LFA ships are manned and operated so as to have the LFA systems ready and functioning to their fullest capabilities at all times. That is a matter of National Security, given that LFA is the Navy's best available long-range ASW detection system. How far the LFA vessels need to be offshore to effectively perform LFA testing and training missions is determined by a number of factors, many of which involve information on aircraft, ship and submarine schedules and locations, which are classified. The Navy will need to conduct essential LFA training within 25 nm of the coast, but outside the 12-nm geographical restriction.

Comment 4.7.17: The entry for the Northwestern Hawaiian Islands Coral Reef Ecosystem should be clarified. Currently the location of the area is defined as "Within 12 or 25 nm." The description should be revised to more clearly describe the location. The boundary of the Reserve is described generally in Executive Order 13178 as being 50 nm from the center line of the island chain. G-003

Response: Under Presidential Proclamation 8031—Establishment of the Northwestern Hawaiian Islands Marine National Monument dated 15 June 2006 and Executive Order 13178—Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve of 4 December 2000, the prohibitions do not apply to Armed Forces Actions that are consistent with applicable laws and are carried out in a manner that avoids, to the extent practicable and consistent with operational requirements, adverse impacts on monument resources and qualities. <u>The SEIS has been corrected accordingly.</u>

Therefore, consistent with the above, the geographic restriction/coastal exclusion zone and mitigation protocols are applicable for SURTASS LFA sonar operations in the vicinity of the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. No additional OBIA status is warranted.

Comment 4.7.18: Fails to propose additional OBIAs other than seven National Marine Sanctuaries. No new OBIAs outside of U.S. waters are even considered in Draft SEIS. O-014

Response: Additional OBIAs are addressed in SEIS RTC 4.7.19 below. It should be noted that the Coast Rica Dome OBIA, North American East Coast OBIA (including Canadian waters), and Antarctic Convergence Zone OBIA include non-U.S. waters. Other major areas initially excluded from LFA operations, listed in the FOEIS/EIS and Draft SEIS, include the Arctic Ocean, Bering Sea, and major parts of Antarctic Ocean.

Comment 4.7.19: Additional OBIAs:

1. Davidson Seamount. G-003, O-014
2. Northwestern Hawaiian Islands. O-014
3. Gully MPA. G-005, O-014
4. Location of any endangered species (especially those whose numbers are so small). O-008
5. Areas specifically mentioned in the Court Opinion as potential OBIAs. O-014
6. MPAs established by other countries, non-U.S. protected areas listed in Hoyt 2005 and those listed by IUCN (1995). O-014
7. Channel Islands NMS. O-014
8. Gray whale migratory path outside the Olympic Coast NMS off the coast of Washington State. O-014

Response: In accordance with NMFS' first five year rule (50 CFR §216.191) concerning the designation of additional OBIAs, NMFS required that the nominations for OBIA status including the following: geographic region, list of marine mammals within this geographic region, whether the proposal is year-round or seasonal, detailed information (estimated population size, distribution, density, status, biologically important activities). Areas are not eligible that are within the 12 nm (22 km) of coastlines or in designated non-operating areas. Under this present rule, no nominations have been received.

1. See SEIS RTC 4.7.1 above.

2. Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve is not being considered as an OBIA because of the exemptions for Armed Forces Activities as noted in SEIS RTC 4.7.17 above. The coastal exclusion zone and mitigation protocols are applicable for SURTASS LFA sonar operations in the vicinity of the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve.

3. The Gully lies within the 200-m isobath of the larger North American East Coast OBIA. The Gully is further protected by a straight-line projection of the 200-m isobath across the canyon mouth, as stated in NMFS' RTC MIC8 in the Final Rule (67 FR 46785).

4. The location of any listed species does not in itself meet the requirements for nomination as a new OBIA under 50 CFR §216.191. OBIAs proposed must have geographic boundaries. The coastal zone restriction includes almost all marine-related critical habitats and NMSs. When listed species of marine mammals and sea turtles are not in a restricted area (OBIA, NMS, or 22 km [12 nm] coastal restriction), they are protected from RLs greater than 180 dB by the SURTASS LFA sonar tripartite monitoring and mitigation protocols. Therefore, no OBIA status is required based on individual species location.

5. Areas mentioned by the Court's Opinion and Order of 26 August 2003 are Oyashio/Kuroshio area off Kamchatka, and the Emperor Seamount Chain (45 to 55 deg N latitude and 170 to 160 deg W longitude—the Court document listed this longitude as 60 degrees, but more correctly it is assumed that they meant 160 degrees). The northern part of the Oyashio/Kuroshio area off Kamchatka is within the Bering Sea, which is a non-operational area as presented in the FOEIS/EIS, Figure 1-1. The southern portion of this area and the Emperor Seamount Chain are large ocean expanses. As stated by NMFS in the Final Rule RTC MIC11, animals in unspecified migration corridors and open ocean concentrations are adequately protected by the tripartite mitigation protocols.

6. Most MPAs, as discussed in Hoyt (2005), fall within nations' EEZ limits. Five international sanctuaries and high-seas MPAs are listed in Hoyt (2005), which include the Eastern Tropical Pacific Seascape, the Indian Ocean Sanctuary, Pelagos Sanctuary for Mediterranean Marine Mammals, Southern Ocean Sanctuary, and Wadden Sea Nature Reserve. The Eastern Tropical Pacific Seascape is located in the waters off Columbia, Costa Rica, Ecuador, and Panama. The Indian Ocean Sanctuary includes the entire Indian Ocean southward to 55 degrees S latitude. The Pelagos Sanctuary for Mediterranean Marine Mammals is located in the Ligurian, Corsican and northern Tyrrhenian Sea and in the waters adjacent to France, Italy, and Monaco, and the high seas. The Southern Ocean Sanctuary is located in the Antarctic Ocean region, where SURTASS LFA will not normally operate. Wadden Sea Nature Reserve is located in the coastal waters of southwest Denmark, Germany, and The Netherlands, extending 12 nm from the coast, with is in the exclusion zone of SURTASS LFA operations.

Hoyt (2005) lists 16 designated national sanctuaries extending in most cases to the limits of each country's EEZ. It is important to note, however, that each MPA has its own regulations and enforcement concerning commercial shipping and commercial/recreational fishing activities.

When listed species of marine mammals and sea turtles are not in a restricted area (OBIA, NMS, or 12 nm coastal restriction), they are protected from RLs greater than 180 dB by the SURTASS LFA sonar tripartite monitoring and mitigation protocols. Therefore, no OBIA status is required based on individual species location.

7. The Channel Islands National Marine Sanctuary is within the 12-nm exclusion zone because the Sanctuary extends only 6 nm around each island. Therefore, the Channel Islands National Marine Sanctuary is already excluded from SURTASS LFA sonar operations.

8. Gray whale migratory paths within the Olympic Coast NMS off the coast of Washington State were considered in designating OBIA Area 8, Olympic Coast NMS (see Draft SEIS, Table 2-4). As stated in the Draft SEIS Subchapter 3.2.4.1 and FOEIS/EIS Subchapter 3.2.4.3, gray whales are confined to the shallow waters of the continental shelf in the North Pacific. Gray whales are by far the most coastal of all of the great whales, inhabiting primarily inshore or shallow offshore continental shelf waters (Jones and Swartz, 2002). Because gray whale migratory paths are near-shore, they are protected within OBIA 8. As stated by NMFS in the Final Rule RTC MIC11, animals in unspecified migration corridors are adequately protected by the tripartite mitigation protocols, which would include those few gray whales that might migrate outside of this OBIA.

Comment 4.7.20: The Navy has not done sufficient work to identify offshore biologically important areas and to place these as off-limits to LFA use. The statement that the majority of biologically important areas for marine mammals and turtles are in the coastal zone is incorrect. While coastal waters may be important for some species, or some periods of life history, the large majority of biologically important areas for marine mammals are in non-coastal waters, such as continental shelf edges, seamounts, oceanic divergences and non-coastal upwellings. The Sargasso Sea is a crucial offshore habitat for juvenile and hatchling sea turtles and should be included in the OBIAs. It fails to include many recognized marine protected areas and sanctuaries, such as Xiamen Marine National Park and Conservation Area of the Fujian Province. There are also marine protected areas on the south coast of Russia, abutting the Sea of Japan, the Far Eastern Marine Nature Reserve (Zapovednik) in Peter the Great Bay, Sea of Japan, Vostok Bay National Comprehensive Marine Sanctuary, the Siargao Island Protected Land and Seascape off the coast of the Philippines, Batanes Island Protected Land and Seascape, Calayan Island Protected Area, and Sierra Madre Natural Park. I-058

Response: NMFS and the Navy have in place a means to propose OBIAs, from any source, including the public. While the Navy appreciates the recommendations from this commenter, more information is required to consider these suggested areas as OBIAs. NMFS will accept petitions for OBIAs in accordance with 50 CFR 216.191, as stated in the Final Rule (67 FR 46748). However, to further respond to this comment, LFA has very little effect on the surface of the ocean (within the top 6 ft), as explained in the FOEIS/EIS Subchapter 4.3.2.1, which is the important biological factor in the Sargasso Sea. Additionally, based on the conclusions of this SEIS and the NMFS Biological Opinions (2002-2006), SURTASS LFA is not likely to affect fish or sea turtles. The analyses in the FOEIS/EIS and SEIS support the conclusion that LFA operations will have negligible potential to cause injury to marine mammals, and minimal potential to cause significant changes in biologically important behaviors.

The Xiamen Marine National Park and Conservation Area MPA is located in the Fujian Province to the west of Taiwan. The exact coordinates of this MPA are not listed. However, the two species of concern in this MPA are the finless porpoise (*Neophocaena phocaenoides*) and the humpback dolphin (*Sousa chinensis*), both of which inhabit only shallow, coastal waters (Amano, 2002; Ross, 2002). It is therefore assumed that the MPA is in shallow waters and will not be affected by SURTASS LFA sonar operations.

The Far Eastern Marine Nature Reserve is located 60 km (37 mi) south of Vladivostok, Primorskiu Krai, Peter the Gray Bay, and the Sea of Japan. Exact coordinates of this MPA are unavailable, however Hoyt (2005) states that it protects marine shelf ecosystems and bird colonies. It is therefore assumed that the MPA is in shallow waters and will not be affected by SURTASS LFA sonar operations.

The Vostok Bay National Comprehensive Marine Sanctuary is located in Vostok Bay, Primorye. This MPA was created to preserve Vostok Bay for research, development of the biological fundamentals of mariculture and organization and development of mariculture plantations[5] Since mariculture tends to be coastal and the MPA has only a 500 m-wide sanitation zone, it is assumed that the Vostok Bay National Comprehensive Marine Sanctuary is in shallow waters that will not be affected by SURTASS LFA operations.

The Siargao Island Protected Land and Seascape is located at Siargao Island, off northeast Mindanao of the Philippines. This is a coastal and marine protected area. Since it is a coastal and marine protected area within the Philippine Islands, it is assumed that it is too shallow for SURTASS LFA to operate within this MPA and therefore, would not be affected by SURTASS LFA operations.

The Batanes Islands Protected Land and Seascape is located in the northernmost Philippines in the Luzon Strait, 180 km (112 mi) southeast of Taiwan. The Batanes and Babuyan Island groups are at the northern tip of the Philippines, between Luzon and Taiwan, and extend for more than 200 km from north to south[6] Due to the fact that this MPA is located within a group of islands, it is therefore assumed that it is in shallow waters and will not be affected by SURTASS LFA sonar operations.

The Sierra Madre Natural Park is in northeastern Luzon of the Philippines, southeast of the Babuyan Channel. Like the Batanes Islands Protected Land and Seascape and the Calayan Island Protected Area, this MPA is located within a group of islands. It is therefore assumed that it is in shallow waters and will not be affected by SURTASS LFA sonar.

Comment 4.7.21: Draft SEIS mitigation allows for a sound field of up to 180 dB RL in OBIAs, which could kill, injure, disrupt behavior, cause masking, and cause stress and other long-term impacts. I-011, O-008, O-010, O-012

[5] Primorye Protection. Vostok Bay National Comprehensive Marine Sanctuary. http://www.fergi.ru/prim/range/zak-vost.htm. Accessed: 11/28/2006.
[6] ARCBC [ASEAN Regional Centre for Biodiversity Conservation]. 2006. Management Plan of Batanes. http://arcbc.org/cgi-bin/abiss.exe/ld?SID=157957283&ld=phl_ibas/PH001.htm . Accessed: 11/28/2006.

Response: The Draft SEIS mitigation stated that SURTASS LFA sonar operations would be conducted such that the sound field is below 180 dB RL in any designated OBIAs. RLs below 180 dB will not cause injury or death. The FOEIS/EIS provided detailed analyses of the potential effects of exposures to LFA received levels < 180 dB and ≥ 180 dB for 31 separate sites. These included numerous sites that were at the closest proximity to land based on SURTASS LFA operational limits where biological densities were high. These analyses determined that potential effects from exposures to LFA received levels ≥ 180 dB were negligible and < 180 dB were minimal. However, during the annual LOA application process for operations in the vicinity of any OBIAs (and elsewhere for that matter), the potential for marine mammal stocks to be potentially affected at RLs <180 dB are determined as outlined in the SEIS Subchapter 4.4. As is shown in Tables 4.4-2 to 4.4-10, minimal percentages of marine mammal stocks will be affected, which includes the potential to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or significantly altered. The potential for masking is discussed in SEIS RTC 4.3.1 and 4.3.23 above. Stress on marine animals is discussed in SEIS RTCs 4.1.7, 4.1.11, 4.3.12, and 4.3.23 above.

Comment 4.7.22: Commenter disagrees that Alternative 2 would only slightly decrease the potential for impacts to marine mammals from LFA. Depending on how many and which of these biologically important areas are excluded from LFA transmissions, concentrations of marine animals of many different species could be better protected. It would not offer perfect protection, but could be a significant improvement. I-011

Response: Given the fact that LFA operations have negligible potential to cause injury to marine mammals, and minimal potential to cause significant changes in biologically important behaviors in any case, the Navy stands by its SEIS conclusion (Subchapter 4.7.7) for Alternative 2 that, “Any change to the Alternative 1 conclusion would be to slightly decrease the potential for impacts to marine animals from SURTASS LFA sonar operations.”

Comment 4.7.23: The federal court that struck down the Navy's earlier EIS wrote: "...endangered species, including whales, listed salmon and sea turtles, will be in LFA Sonar's path. There is little margin for error without threatening their survival." The court therefore urged the Navy to consider protective measures such as wide coastal exclusion zones, more effective surveys for whales before sonar exercises, shut-down procedures for fish, and the use of training areas that present less risk to marine life. The Navy's SEIS rejects each of these ideas. O-011, O-012

Response: The Navy evaluated each of the protective measures in the SEIS as follows:

- <u>Wider coastal exclusion zones</u>: SEIS Subchapter 4.7.6 and RTCs 4.7.12, 4.7.13, 4.7.14, and 4.7.15
- <u>Preoperational surveys</u>: SEIS Subchapter 5.4 and RTCs 5.4.1, 5.4.2, 5.4.3, 5.4.4, 5.4.5, and 5.4.7
- <u>Shut-down procedures for fish</u>: SEIS Subchapter 2.5.2.2 and RTC 4.7.10
- <u>Training areas that present less risk to marine life</u>: SEIS Subchapter 2.5.2.1 and 4.4 and RTC 4.7.9

Comment 4.7.24: Commenter understands the law as requiring that not only should the effect on the stock of any marine mammal from significant change in a biologically important behavior be minimal, but that natural behavior patterns cannot be disrupted to a point where patterns are abandoned or significantly altered in individual animals. This is not reflected under Alternative 1. I-011

Response: For military readiness activities, like 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 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) (see Draft SEIS pp. 4-2 and 4-3). In the FOEIS/EIS the biological risk and the determination of the risk function were based on the assumption that behavioral harassment would be a significant change in a biologically important behavior, consistent with the NRC's characterization (NRC, 2000), which are consistent with the newer definition for military readiness activities. The analyses in the FOEIS/EIS and Draft SEIS are consistent with the above definition of Level B harassment.

CHAPTER 5 MITIGATION MEASURES

ISSUE 5.0 General Mitigation Measures

Comment 5.0.1: The mitigation measures described in Chapter 5 are inadequate. Despite extensive discussion of the locations of many key populations of marine animals in the open oceans, only a few will actually be sheltered in offshore biologically important areas that have been proposed as exclusions. Others that seem worthy of such protection would be any areas where mass strandings have been reported after either SURTASS LFA operations or mid-frequency sonar operations, such as the Canary Islands, the Gulf of California, parts of the Mediterranean Sea, and the Bahamas. Perhaps the Navy is concerned that excluding too many such areas would provide havens for enemy submarines. If so, I would like to see a discussion of war strategy that might deal with this concern so those who are concerned about natural resources could understand the tradeoffs. I-002

Response: The commenter states that mitigation measures are inadequate because there are too few offshore biologically important areas that have been proposed as exclusions. In particular, areas where recent strandings have occurred, such as the Canary Islands, the Gulf of California, parts of the Mediterranean Sea, and the Bahamas, should have been considered. First, areas listed above were sites of recent beaked whale strandings. Based on several scientific reports, LFA sonar was not causative in these strandings nor does LFA sonar meet the profile of these strandings and thus is not anticipated to cause any future strandings (ICES, 2005; Cox et al., 2006; D'Spain et al., 2006). For more details see SEIS RTC 4.3.1. Therefore, there is no scientific rationale to support the commenter's contention that these areas are at high risk of strandings from LFA sonar.

Exclusion zones do have the potential to hinder the Navy's ability to protect U.S. and Allied vessels from possible attack by stealthy submarines. Any discussion of war strategy is beyond the scope of the SEIS because this analysis does not apply in armed conflict or direct combat support operations, nor during periods of heightened threat conditions.

Under the federal regulations governing the taking of marine mammals incidental to the Navy's operation of SURTASS LFA sonar, there is a process for offshore biologically important areas to be nominated by NMFS or the public (50 CFR §216.191, Designation of Biologically Important Marine Mammal Areas). Since these rules were issued in 2002, there have been no nominations.

Comment 5.0.2: Mitigation measures are not well calculated to protect marine species from LFAS: O-014

> **Comment 5.0.2a:** Coastal exclusion zone is relatively narrow and not tied to the width of the continental shelf.
>
> **Response:** The intention of the 12-nm (22 km) coastal restriction is to provide protection to areas of larger concentrations of marine animals and migration routes. The 12-nm exclusion zone is not tied to the width of the continental shelf because of the large

variability of the shelf's distance from coastlines around the world. For example, on the U.S. eastern seaboard this distance is 60 to 70 nm (111 to 130 km) from the coast while in Hawaii it can be 5 nm (9.3 km) or closer. In order to provide protection to biologically important areas outside of 12 nm, the OBIAs have been designated. Because of animal concentrations and migration routes on the eastern seaboard over the continental shelf, this area has been designated as an OBIA in the FOEIS/EIS with limits extended to the 200-m (660-ft) isobath for the East Coast of the United States (from 28°N to 50°N west of 40°W) to protect more species. The 12-nm (22-km) restriction includes almost all marine-related critical habitats and NMSs. However, some parts of NMSs, that are recognized to be important for marine mammals, are outside 12 nm (22 km). These areas have been designated as an OBIA as shown in SEIS Table 2-3 (Offshore Biologically Important Areas).

Comment 5.0.2b: Efficiency of the safety zone to prevent injury is tied to the limits of visual and acoustic monitoring.

Response: The potential for SURTASS LFA sonar to cause harm to marine mammals and the validity of the 180-dB injury threshold for SURTASS LFA are discussed in SEIS RTCs 4.0.1, 4.0.2, 4.0.3, 4.3.1, 4.3.2, 4.3.8, 4.3.9, 4.3.10, and 4.3.12. LFA will not cause physical harm to marine mammals below 180 dB RL. Mitigation effectiveness within the 180-dB mitigation zone is estimated to be close to 100 percent. The proposed mitigation procedures include the HF/M3 sonar that was specifically developed to improve detection of marine mammals and potentially sea turtles, through active acoustic detection, ensuring that they are not within the LFA mitigation zone during SURTASS LFA sonar transmissions. It provides 24-hour detection for marine animals, even during poor visibility conditions. Analysis and testing of the HF/M3 sonar operating capabilities indicates that this system substantially increases the chances of detecting marine mammals (and possibly sea turtles) within the LFA mitigation zone (i.e., inside the 180-dB sound field). The probability of detection of various marine mammals is presented in the FOEIS/EIS, Figure 2-5. The probability of detection for large cetaceans is over 0.95 at greater than 1 km (0.54 nm). For small cetaceans at 1 km (0.54 nm), the value ranges from 0.73 to 0.95. Because of their size, detection rates for sea turtles should be similar to those of small cetaceans.

Comment 5.0.2c: Navy fails to explain how it will monitor for sea turtles because they are small, spend a lot of time underwater, and don't vocalize.

Response: No mitigation effort can totally eliminate the possibility of impact on an individual sea turtle. See SEIS RTC 5.0.2b above for a more detailed discussion of the proposed mitigation procedures.

Comment 5.0.2d: For divers, the 40 meter contour fails to account for popular dive sites such as wrecks.

Response: As stated in the FOEIS/EIS and Draft SEIS (Subchapters 5.1.2), 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 145 dB RL. Recreational dive sites are generally defined as coastal areas from the shoreline out to the 40-m (130-ft) depth contour. The depth limit was used because recreational divers, who make up the bulk of divers, are trained not to dive deeper than that; but it is recognized that there are other sites that may be outside this boundary. See FOEIS/EIS RTCs 4-9.21, 4-9.22, 5-1.8, 5-1.9, and 5-1.10 for additional information.

Comment 5.0.2e: Resumption of operations after 15 minutes is inappropriate given longer underwater time durations of large whales and sea turtles, up to an hour. I-058

Response: The resumption of operations after 15 minutes is not based only on visual observations, but also on passive and active acoustic monitoring. The HF/M3 sonar was developed by the Navy specifically to overcome the low probabilities of detection of both visual and passive acoustic monitoring. Primarily because of the HF/M3 sonar, mitigation effectiveness within the 180-dB mitigation zone is close to 100 percent. Therefore, 15 minutes resumption time is more than adequate.

Comment 5.0.3: Navy fails to consider the following mitigation measures: O-014

Comment 5.0.3a: LFA ramp-up.

Response: Ramp-up of the LFA source is not required because the HF/M3 sonar will be "ramped-up" prior to LF transmissions to verify that the LFA mitigation zone is clear of marine animals. See FOEIS/EIS RTCs 5-2.26 and 5-2.27 and NMFS Final Rule RTCs MOC19, MOC20, and MOC21 for additional information.

Comment 5.0.3b: Third-party marine biological visual observers.

Response: There would be marginal benefit from third-party observers. Subchapter 5.2.1 of the FOEIS/EIS states that visual monitoring is required during daylight hours. The effectiveness of visual monitoring declines during high sea states and periods of reduced visibility. Because of the limitations of both passive acoustic and visual monitoring, the Navy developed the HF/M3 sonar to provide 24-hour, all-weather active acoustic monitoring of an area of approximately 2-km (1.1-nm) radius from the array.

Utilization of third-party marine biological visual observers is not feasible. First, there is no available berthing for additional personnel on the LFA vessels. To accommodate visual observers(s), it would require the reduction of the number of operational personnel on the vessel, which would reduce mission effectiveness. Moreover, because of the nature of the missions, third-party observers would require security clearances. Although it is possible for these personnel to obtain the proper security clearances, the time and cost of applying for clearances for previously uncleared individuals is high. See NMFS Final Rule RTC MOC32 for further discussion.

Comment 5.0.3c: Acoustic monitoring using existing acoustic nodes and other external platforms.

Response: Monitoring mitigation is designed to preclude marine mammals from being within the 180-dB mitigation zone of the LFA array to protect them from potential injury. This zone is approximately 1-km in radius, thus making the use of other existing acoustic nodes (assuming the commenter is referring to fixed arrays such as SOSUS) and other external platforms not only impractical, but virtually impossible. The SOSUS arrays are no longer manned nor maintained, so their operations are degraded and not real-time. Other external platforms would only be vessels of opportunity. Because the SURTASS LFA vessel would have limited or no communications with these vessels and the time delay in relaying information, the use of these platforms is impractical.

Comment 5.0.3d: Modification of sonar signal characteristics.

Response: The Navy does not consider modification of sonar signal characteristics to be a practical mitigation option. First, the analyses and actual operations have demonstrated that the present mitigation methods are effective. The LFS SRP utilized actual LFA signal, sometimes at full power, with only minor behavioral effects. The Fish CEE also utilized actual LFA signals and source levels with no injury and minimal behavioral responses at received levels up to 193 dB. During the first four LOAs, the LFA vessels completed 40 missions with over 470 hours of actual transmission (sound-in-the-water) with no known Level A takes and Level B takes estimated well within the requirement of the LOAs. Second, wavetrain characteristics and array source levels are optimally designed to detect threat submarines at long distances. Return signals are below ambient levels and any changes would potentially cause degradation in detection effectiveness. Therefore, there is no need for the Navy to consider modification of LFA sonar’s signal characteristics.

Comment 5.0.3e: Avoidance of enclosed areas and coastal areas with complex, steep sea bed topography.

Response: The Navy concurs that LFA operations should avoid enclosed areas and coastal areas with complex, steep seabed topography. First, because of the lengths of both the passive (SURTASS) and active (LFA) line arrays, enclosed areas are avoided. Second, during the annual LOA application process (SEIS Subchapter 4.4 and Figure 4.4-1), marine mammal habitats, seasonal activities, and behavioral activities are considered in the process of determining potential mission areas. Thus these areas will be analyzed as part of the annual LOA application process. Therefore, the Navy avoids planning and conducting LFA sonar operations in areas of known high marine animal densities or “hot spots,” to the greatest extent feasible considering national security tasking.

Comment 5.0.3f: Lower power levels.

Response: As stated in RTC 5.0.3d above, there is no need for the Navy to consider modification of LFA sonar’s signal characteristics. This includes lower power levels.

Comment 5.0.3g: Wider safety zones.

Response: During the first four LOAs, the LFA vessels completed 40 missions with over 470 hours of actual transmission (sound-in-the-water) with no known Level A takes. Recent scientific research supporting this safety zone is discussed in SEIS RTC 4.0.1. Safety zones (180-dB) at distances greater than those necessary to protect animals from 180-dB RL or greater are not required. However, NMFS has the option to add an additional buffer zone.

Comment 5.0.3h: Operational procedures in coastal zones that allow escape routes.

Response: Because SURTASS LFA will have a coastal standoff distance (at least 12 nm [22 km]), any LFA signal heard by marine animals in the coastal zone will come from the same general direction, thus allowing an animal to move laterally away from the signal's source.

Comment 5.0.3i: Meaningful geographic restriction, avoidance of hot-spots. O-015

Response: As noted in Draft SEIS Subchapter 2.5.2.1, SURTASS LFA operations are planned for areas with reduced risk by avoiding areas of high marine life concentrations. This process is detailed in SEIS Subchapter 4.4. Additionally, nominations for inclusion as OBIA can be made under 50 CFR §216.191, thus providing protection for specific geographic "hot spots."

ISSUE 5.1 Geographic Restrictions (Offshore Biologically Important Areas, Recreational and Commercial Dive Sites, Sound Field Modeling)

Comment 5.1.1: Why are acoustic models updated nominally only every 12 hours? Why not more frequently since it is simulating real-time? O-008

Response: Acoustic models are updated every 12 hrs, or more frequently if meteorological or oceanic conditions change significantly, for oceanographic data that will affect sound velocity within the water column. These data change very slowly over time and distance. With the slow speed of the LFA vessel (5.6 km/hr [3 knots]), it will only cover 67 km (36 nm) in 12 hours. Therefore, 12 hours is sufficient to determine changes in sound velocity that may affect propagation.

Comment 5.1.2: Because SPL estimates are not accurate, why can't actual measurements be made? I-011, O-010

Response: SPL estimates are made by applying measured environmental data, such as sound velocity profiles from periodic expendable bathythermograph (XBT) sensor drops, and LFA operational characteristics into Navy standard acoustic performance prediction models. See FOEIS/EIS, Subchapter 2.3.2.1, Subchapter 5.1.3 and RTC 5-1.3 for additional details. Actual measurements are not required, and launching a small craft for such measurements is unsafe and impractical during LFA operations.

Comment 5.1.3: It is unclear whether the Navy plans to employ a static radius of impact. Static radii of impact assume that sound diminishes equally around the sonar array and there is no effect of weather conditions, water temperature, water depth, salinity, or any other factor that might possibly increase the distance at which disturbing levels of sound could travel from the source. I-058

Response: For the 180-dB injury mitigation zone, the Navy uses the distance from the LFA array out to the 180-dB isopleth. As stated in FOEIS/EIS Subchapter 5.1.3 and Draft SEIS Subchapter 5.1.3, these sound pressure levels are determined prior to and during operations using near-real-time environmental data and underwater acoustic performance prediction models. These are updated every 12 hours or more frequently if meteorological or oceanographic conditions change significantly. This radius is usually 0.7 to 1.0 km (0.4 to 0.54 nm) from the array. For additional information, see SEIS RTCs 4.3.15 and 4.3.16.

Comment 5.1.4: The 40 m (130 ft) coastal contour rule of thumb for dive sites is a gross oversimplification. Does this include all shallow offshore areas, or just a thin strip around the coastline? What about barrier reefs, islands, and wrecks in waters deeper than 40 m? Has the Navy produced a map of dive sites? Are areas avoided based on location of resorts or dive shops? Has any effort been made to determine where diving companies and boat tours take their divers? I-058

Response: The potential impacts to divers was the subject of extensive research performed during the initial EIS process and reported in Technical Report 3—Summary Report on the Bioeffects of Low Frequency Waterborne Sound. The purpose of this research, performed by a consortium of university and military laboratories, was to develop guidelines for safe exposure limits for recreational and commercial divers. The guideline was endorsed by both the Navy's Bureau of Medicine and Surgery and the Naval Sea System Command (Appendix A of the FOEIS/EIS). The subject of potential effects of LFA on divers was extensively covered in the FOEIS/EIS and incorporated by reference into the SEIS (Subchapter 4.5.2). The commenter is invited to read the FOEIS/EIS Subchapters 4.3.2.1 and 5.1.2, Appendix A, Technical Report 3, RTCs 5-1.3, 5-1.8, 5-1.9, and 5-1.10.

As stated previously, recreational dive sites are generally defined as coastal areas from the shoreline out to the 40-m (130-ft) depth contour. The depth limit was used because recreational divers, who make up the bulk of divers, are trained not to dive deeper than that; but it is recognized that there are other sites that may be outside this boundary. This limit includes all areas that are 40-m (130-ft) or shallower. Diver areas deeper than this limit are reviewed on a case by case basis. The mapping of all known dive sites is beyond the scope of this SEIS.

As stated in FOEIS/EIS RTC 4-9.17 and RTC 4.5.8 above, when the Navy has plans for conducting LFA operations in the vicinity of known recreational and/or commercial dive sites, they will present a plan for setting up a reporting network via DAN. Further, as stated in FOEIS/EIS RTC 4-9.22 and 5-1.9, for any potential LFA operations in the vicinity of "recreational blue water" dive sites, the Navy will notify DAN and other diving organizations concerning such operations on a case-by-case basis.

ISSUE 5.2 Monitoring to Prevent Injury to Marine Animals

Comment 5.2.5: How extensive was the monitoring for Level A takes? I-011

Response: The 180-dB mitigation and 1-km buffer zones were monitored at all times during LFA active transmissions as required by NMFS Final Rule (50 CFR § 216.185 and 50 CFR § 216.186) and the conditions of the LOAs as issued. In addition, available stranding data from the operating areas are continuously reviewed, and no strandings have coincided spatially or temporally with LFA operations.

Comment 5.2.6: MMC recommends that the Navy (1) assure that the information from the monitoring is included in the LMRIS and OBIS SEAMAP systems and (2) analyze and include an empirical evaluation of the effectiveness of the monitoring and mitigation measures. MMC also recommends that copies of the data recording forms be included in the Final SEIS. Further, if it is not already being done, MMC recommends that the Navy and NMFS review the monitoring data at least annually to identify possible marine mammal "hot spots" that should be avoided or be considered for the designation as OBIAs. If this data is not collected, MMC recommends that the Final SEIS indicate why this is the case and that the Navy begin collecting and analyzing relevant information. G-008

Response: LMRIS and OBIS SEAMAP: NMFS stated in the Final Rule in RTC MOC1 that the Navy will be operating for the most part in waters that are not areas known for high concentrations of marine mammals; therefore, few, if any, marine mammals would be within the SURTASS LFA mitigation zone. This has proven to be the case as reported to NMFS in the required quarterly and annual reports. NMFS further stated that, at this time, the use of the SURTASS LFA sonar vessel as a full-time platform of opportunity to assess marine mammal populations is not practical since the marine mammal observers aboard the SURTASS LFA sonar vessels will not have the expertise needed for producing scientifically acceptable line transect population assessments and the SURTASS LFA vessel scheduling will preclude conducting the type of line transect surveys required for adequate population assessments. Even though the SURTASS LFA vessel cannot do transects, visual sightings and HF/M3 contacts are reported to NMFS under the conditions of the LOAs. Whether or not this data is provided to LMRIS or OBIS SEAMAP is a decision of NMFS.

Under Condition 8(a) of the LOAs, the Navy must provide classified mission reports on a quarterly basis. Specifically, these data will include dates/times of exercises, dates/times of LFA transmissions, locations of vessel, LOA area(s), marine mammal observations, and records of all delays or suspensions of operations. Marine mammal observations will include animal type and/or species, number of animals sighted, date and time of observations, type of detection (visual, passive acoustic, HF/M3 sonar), bearing from vessel, range from vessel, abnormal behavior (if any), and remarks/narrative (as necessary). There is no requirement for the Navy to provide copies of the data recording forms, or logs.

Evaluation of Mitigation Effectiveness: An evaluation of the effectiveness of the monitoring and mitigation measures has been provided to NMFS in the final comprehensive report (DON, 2007) submitted under 50 CFR § 216.186(c).

Estimated marine mammal densities are determined for each potential LFA operations area proposed in the annual requests for LOAs under the current regulations. The Navy limits requested operations in areas of higher density because of limitations placed by NMFS on the percentages of stocks that can be affected. Therefore, the Navy avoids planning and conducting LFA sonar operations in areas of known high marine animal densities or "hot spots," to the greatest extent feasible considering national security tasking. Monitoring mitigation has not detected any oceanic areas where these predictions have been in error.

Visual

Comment 5.2.7: It is not enough to have marine mammal biologists qualified in conducting at-sea visual monitoring for marine mammals train and qualify ship personnel to conduct the visual monitoring. Marine mammal biologists should be conducting the visual monitoring. I-011

Response: See SEIS RTC 5.0.3b above.

Comment 5.2.8: The Navy should provide further detail on the mechanics of its visual monitoring program. How many observers does the Navy plan to use? Will LFA use be stopped in sea states greater than 4 because the likelihood of sighting animals is reduced? What does the training and qualification process for visual observers entail? I-058

Response: The Navy uses one trained observer during daylight hours. Operations will not be stopped during times of reduced visibility. Subchapter 4.2.7.1 of the FOEIS/EIS states that visual monitoring is limited to daylight hours and its effectiveness declines during high sea states. Because of the limitations of both passive acoustic and visual monitoring, the Navy developed the HF/M3 sonar to provide 24-hour, all-weather active acoustic monitoring of an area of approximately 2-km (1.1 nm) radius from the array. In calculating the effectiveness for the various monitoring systems for purposes of the FOEIS/EIS, the visual monitoring component of the three-part monitoring system was estimated at 0.09, or 9 percent.

As stated in NMFS Final Rule RTC MOC 8, personnel trained in detecting and identifying marine animals will make observations from the SURTASS LFA sonar vessel. At least one observer, qualified by NMFS, has trained, tested and evaluated other visual observers. Visual observation effectiveness estimates will be provided to NMFS in accordance with LOA reporting requirements.

Comment 5.2.9: For marine mammal observers, Draft SEIS does not state: 1) how much training, 2) measures of level of expertise, 3) amount of refresher training, 4) other duties performed while observing, and 5) number and topside locations. O-013

Response: In accordance with 50 CFR § 216.185(a)(1) visual monitoring must be conducted from the bridge during all daylight hours by qualified personnel. Designation of qualified personnel and training is required as per LOA Condition 7(c), as issued, by qualified marine mammal biologists, highly trained in marine mammal observations. For additional information see FOEIS/EIS Subchapter 5.2.1, SEIS Subchapter 5.2.1, and Final Rule RTCs MOC8 and MOC32.

Comment 5.2.10: SURTASS LFA operations should cease during darkness when chances of spotting a marine mammal or sea turtle approximates zero. O-013

Response: Because of the limitations of both passive acoustic and visual monitoring, the Navy developed the HF/M3 sonar to provide 24-hour, all weather active acoustic monitoring. **S**ee SEIS RTC 5.2.8 for additional information.

Comment 5.2.11: The Navy states that visual monitoring can continue past sunset if LFA operations extend past sunset, but this would be useless. The likelihood of spotting a marine animal at night would be negligible. I-058

Response: The Draft SEIS subchapter 5.2.1 stated that visual monitoring will occur during the daytime, which is defined as from 30 minutes before sunrise until 30 minutes after sunset. The Navy concurs that visual monitoring past that point would be of negligible value.

Comment 5.2.12: Diving marine mammals spend great lengths of time underwater. Probability of seeing a beaked whale is 2 percent. BWs can be underwater for up to 68 minutes (Baird et al. 2005). O-013

Response: The Navy concurs. This topic was addressed in the FOEIS/EIS Subchapter 4.2.7.1. In calculating the effectiveness for the various monitoring systems for purposes of the FOEIS/EIS analyses, the visual monitoring component of the three-part monitoring system was estimated at 0.09, or 9 percent, taking into account diving behavior, nighttime, inclement weather, and high sea state. Because of the limitations of both passive acoustic and visual monitoring, the Navy developed the HF/M3 sonar to provide 24-hour, all weather active acoustic monitoring.

Passive Acoustic

Comment 5.2.13: Using SURTASS for passive monitoring would be limited to LF and most marine mammals would therefore not be detected. Passive acoustic monitoring should be accomplished by equipment that can detect more than just low frequency. I-011, O-010, O-013, O-015

Response: This topic was addressed in FOEIS/EIS Subchapter 4.2.7.1. In calculating the effectiveness for the various monitoring systems for purposes of the FOEIS/EIS analyses, the passive monitoring component of the three-part monitoring system was estimated at 0.25, or 25 percent. Because of the limitations of both passive acoustic and visual monitoring, the Navy developed the HF/M3 sonar to provide 24-hour, all weather active acoustic monitoring.

Comment 5.2.14: Passive acoustic monitoring does have the ability to detect some cetacean species, but not species whose vocalizations are unstudied or that rarely vocalize. The use of active sonar may also significantly decrease the likelihood of detecting cetaceans passively, even if they are in the area. I-058

Response: The Navy acknowledged the limitation of passive acoustic monitoring because of the limited frequencies (0 to 500 Hz) and because not all animals vocalize (See FOEIS/EIS Subchapter 4.2.7.1). Whether or not the use of the HF/M3 sonar would decrease the ability of passive detection is not relevant because the probability of the HF/M3 sonar to detect marine mammals before they enter the 180-dB mitigation zone is estimated to be near 100 percent with multiple pings. See SEIS RTC 5.2.13 above.

Comment 5.2.15: Passive acoustic monitoring states that the O-in-C will be notified if the sound is estimated to be from a marine mammal that may potentially be affected by LFA sonar. This needs clarification as to a) “estimated to be from a marine mammal” and b) “potentially be affected” leave leeway as to interpretation. I-011, O-010, O-013

Response: The Navy operators of the SURTASS arrays are highly qualified and experienced, but they cannot be 100 percent positive that sounds are from marine mammals, thus what they report is an “estimate” based on their training experience. The word “potentially” is also correctly used. The Officer in Charge of the Military Detachment onboard the LFA vessel has no leeway for interpretation as he is required to alert the HF/M3 sonar operator and visual observers for confirmation. If the potential contact is confirmed, than LFA transmissions will be delayed or suspended.

Active Acoustic

Comment 5.2.16: It is difficult to see why active acoustics would be unable to reliably detect fish schools, especially since this is the standard measure of fish abundance used by fishers. Fishers and fisheries scientists use active acoustics devices to detect fish schools yet the Navy finds it unreliable. This needs to be explained. I-011, O-010, O-013

Response: Based on recent scientific research into the potential impacts of LFA on fish (as discussed in SEIS Subchapter 4.1.1), the potential effects on fish stocks will only occur within 200 m (656 ft) of the LFA source array. Therefore, there is no justification for the installation of a fish-finder sonar onboard the LFA vessels.

There are no active acoustic devices onboard the SURTASS LFA vessels designed specifically to track fish. Fish-finder sonars are generally forward- and downward looking active sonars for spotting fish schools. Fish-finder transducers have horizontal beamwidths from 10 to 46 degrees at ranges on the order of 1 km (0.54 nm). The HF/M3 sonar utilizes four ITC 1032 transducers with 8-degree horizontal and 10-degree vertical beamwidths, which sweep a full 360 degrees in the horizontal every 45 to 60 seconds with a maximum range of approximately 2 km (1.1 nm). The HF/M3 sonar was designed to detect, locate, and track marine mammals and possibly sea turtles. Its design was based on HF-commercial type sonar, but its design differs from a fish-finder.

Comment 5.2.17: Commenter does not recommend using the HF/M3 sonar because marine mammals may be affected by this noise as well as LFA. Sound perception can occur through various means, not just the ear. Mitigation should not add yet more noise to the original noise-producing activity. Moreover, the effectiveness of HF/M3 to reliably detect marine mammals or turtles without many false positives has not been demonstrated. I-011

Response: There is recent scientific evidence that sonars, similar to the HF/M3, which are in common use in the fishing and maritime industries, do not harm marine life. In a recently published paper, Benoit-Bird et al. (2006) examined the hypothesis that marine mammals acoustically stun their prey by exposing three species of fish commonly preyed upon by odontocetes to pulsed signals at 18 kHz, 55 kHz, and 120 kHz with exposure levels from 193 dB, 208 dB, and 213 dB, respectively. They observed: 1) no measurable changes in the behavior for any of the species during the exposures; 2) no noticeable change in swimming activity; 3) no apparent loss of buoyancy; 4) no movement away from the transducer; and 5) no mortality. Despite the use of signals at the maximum source levels recorded for odontocetes clicks, the researchers could not induce stunning or even disorientation in the fish tested.

In addition, a requirement to ramp-up the HF/M3 ensures that marine mammals and sea turtles are detected by the HF/M3 sonar at the lowest sound level possible. If a marine mammal or sea turtle is detected during ramp-up within the 180-dB sound field, further increases in power are not initiated until the animal is no longer detected. At that time, ramp-up would continue unless that animal, or another, was detected. The HF/M3 sonar effectiveness has been discussed in a report by Ellison and Stein (2001), which is available to the public on the SURTASS LFA Sonar website at http://www.surtass-lfa-eis.com/Download/index.htm. In addition, a paper on this subject was presented at the 2001 Acoustical Society of America meeting (Stein et al., 2001).

For additional information see FOEIS/EIS Subchapter 4.2.7.3 and RTCs 5-2.4, 5-2.11, 5-2.12, 5-2.13, 5-2.19, 5-2.21, and 5-2.22; and NMFS Final Rule RTCs MOC10, MOC12, MOC14, and MOC17.

Comment 5.2.18: HF/M3 sonar first used a frequency thought to be above gray whale hearing detection. Later, gray whales were shown to respond to it after all. We cannot afford to keep making mistakes like this. O-010

Response: The commenter did not provide any reference for the statement that gray whales were shown to respond to the HF/M3 sonar. Therefore, the specific comment cannot be addressed. However, recent work with a whale detection system (similar in frequency to the HF/M3) did demonstrate that gray whales do hear and respond to 21 kHz signals. There was no obvious behavioral reaction, merely a slight avoidance which was not noticeable in any one animal, but in the statistical analysis of hundreds of pods (Frankel, 2005). So gray whales can hear 21 kHz (or higher, perhaps), but there is no evidence that there was a biologically meaningful response to the sonar. The response was just great enough to show that the animals did detect the signal. It is possible that gray whales can hear at 30 kHz, but predictably they would be less sensitive at this frequency than 21 kHz. The HF/M3 sonar frequency range is 30 to 40 kHz.

Also, the Draft SEIS, Subchapter 3.2.4.1 stated that gray whales produce a variety of sounds from 15 Hz to 20 kHz, which is near the frequency of the HF/M3 sonar (30 to 50 kHz). It is usually accepted that animals can hear in the range that they vocalize.

As stated above in SEIS RTC 5.2.17, there is no scientific evidence that HF sonar, similar to the HF/M3, which are in common use in the fishing and maritime industries, harm marine life.

Comment 5.2.19: It is unclear how the Navy will monitor for sea turtles since they, aside from the leatherback, are significantly smaller than cetaceans, they typically only put their nostrils above water, they typically are alone and not found in groups, like many cetaceans, they don't vocalize, and the size makes active acoustic detection impossible. I-058

Response: The Navy cannot assure that individual sea turtles will not be incidentally taken, but has proposed mitigation measures to reduce the potential impacts. Sea turtles will be monitored both visually and with active acoustics. Because sea turtles do not make sounds that can be detected passively and are smaller than most marine mammals, the overall monitoring effectiveness will be less than that for most marine mammals. An analysis of the leatherback sea turtle (the most pelagic and most widely distributed) in the Pacific Ocean demonstrated that the potential for SURTASS LFA sonar operations to encounter (within the 180-dB sound field) an individual leatherback sea turtle would be less than 0.2 animals per year per vessels. This analysis did not apply any mitigation. Thus, the potential for LFA operations to impact a sea turtle stock is negligible.

Additionally, a Biological Opinion published in 2002 (NMFS) explains that, "the probability of an interaction between SURTASS LFA sonar and individuals of any one of these species is statistically small". This is supported by the analyses in the FOEIS/EIS Subchapter 4.1.2.1 and Draft SEIS Subchapter 4.2.6. In addition there is no reason to believe that sea turtles would be at higher risk of potential injury from SURTASS LFA sonar signals that cetaceans or fish

For additional information, see SEIS RTCs 4.2.1, 4.2.4, 4.2.6, and 4.2.7.

Comment 5.2.20: Why is there no indication of the error rates in the detection of various species by HF/M3? How many animals of which species escape detection? How many false positives? O-010

Response: Testing of the HF/M3 sonar was covered in detail in the FOEIS/EIS Subchapter 2.3.2.2 The HF/M3 sonar effectiveness has been discussed in a report by Ellison and Stein (2001), which is available to the public on the SURTASS LFA sonar website at http://www.surtass-lfa-eis.com/Download/index.htm. In addition, a paper on this subject was presented at the 2001 Acoustical Society of America meeting (Stein et al., 2001).

Comment 5.2.21: The Navy must provide more detail concerning this system. How large does the marine animal need to be before it can be detected by the system? What range does the active beam have? I-058

Response: This information was provided in detail in the FOEIS/EIS Subchapter 2.3.2.2. See SEIS RTC 5.2.20 above for additional information.

ISSUE 5.3 Long Term Monitoring and Reporting

Comment 5.3.1: Draft SEIS does not make clear what long term monitoring and reporting will occur to assess the impacts of LFA sonar operations on the marine environment. Commenter questions whether the Navy will report negative impacts. Would these be made public? O-008

Response: In accordance with Draft SEIS Subchapter 5.2, all visual sightings and passive/active contacts are recorded and provided as part of the LTM Program as discussed in FOEIS/EIS Subchapter 2.4.2, to monitor for potential long-term environmental effects. As stated in the Draft SEIS (p. P-3), the information in the SURTASS LFA sonar FOEIS/EIS remains valid, except as noted or modified in the Draft SEIS. The contents of the FOEIS/EIS are incorporated into the Draft SEIS by reference, except as noted or modified. The LTM discussion in the FOEIS/EIS remains valid. Under NMFS Final Rule, 50 CFR § 216.186, the Navy is required to provide quarterly, annual, and final comprehensive reports. The Navy also must submit requests for renewals of annual letters of authorization (50 CFR § 216.189). All of the items listed in the FOEIS/EIS Subchapter 2.4.2 (p. 2-25) are provided to NMFS in these reports and/or requests. All results are reported as required by the regulations under the MMPA.

Comment 5.3.2: The LTM Program budget of $1M per year is way out of proportion considering the huge impacts that will result from LFA operations and the cost of those impacts to the environment. O-008

Response: Overall, the Navy is a world leader in marine mammal research, spending nearly $10 million per year on research to understand how marine mammals hear and how they are affected by underwater sound.

Specifically, the Navy determined that in order to fill critical data gaps for the initial NEPA process, original research was required. The SURTASS LFA sonar program sponsored several independent research projects including: 1) the LFS SRP to determine the potential behavioral effects of LF sound on baleen whales at a cost of over $10M, 2) the Diver's Studies to determine the physical and behavioral effects to divers exposed to LF sound, and 3) the development of the HF/M3 sonar to provide 24 hour, all weather, high-efficiency monitoring of the 180-dB mitigation zone around the LFA transmit array.

As stated in the Draft SEIS Subchapter 2.7, the NMFS initial LOA under Condition 7(d) required the Navy to conduct research in accordance with 50 CFR § 216.185(e). The SURTASS LFA Sonar LTM Program has been budgeted by the Navy at a level of approximately $1M per year for five years, starting with the issuance of the first LOA. The status of this research was summarized in Table 2-5 of the Draft SEIS. Planning has commenced for a 2007-2008 deep-diving odontocetes BRS to determine the potential effects of LFA, MFA, and seismic sources on beaked whales and other deep diving odontocetes at an estimated cost of $3M per year.

In addition to the research on marine mammals, the Navy is presently sponsoring fish controlled exposure experiments being conducted by the University of Maryland to determine the potential effects of LF sound on fish (SEIS Subchapter 4.1.1). This experiment has recently been expanded to include MFA sonar.

Recent and ongoing research has supported the findings of the FOEIS/EIS and the Draft SEIS that the potential for SURTASS LFA sonar, under proper mitigation protocols, to injure marine animals is negligible and to cause changes in biologically significant behavior is minimal. Therefore, the commenter's premise that there will be huge impacts from LFA operations and the statement that the LTM Program budget of $1M per year is "way out of proportion" are considered to be incorrect.

At this time, there is no Navy commitment to sponsor LTM research past the completion of the BRS. The need for further LTM research will be made by the decision-maker in the ROD and in consultation with NMFS during the follow-on permitting process.

ISSUE 5.4 Pre-operational Surveys

Comment 5.4.1: We concur that carrying out small boat or aerial surveys immediately before and during SURTASS LFA sonar operations in the various offshore training areas would not be a practical mitigation option. G-008

Response: The Marine Mammal Commission's comment is noted.

Comment 5.4.2: The Navy rejected mitigation urged by the federal court, specifically small craft pre-operational surveys for marine mammals in missions close to shore. O-010, O-014

Response: The Stipulation Regarding Permanent Injunction issued on 14 October 2003 by the U.S. District Court, Northern District of California, as agreed to by the parties (including one of the commenters), stated that the Navy is not required to conduct "pre-operation surveys" as described in the Opinion and Order. In response to the Opinion and Order, the Navy provided an evaluation of the use of small boats and aircraft for pre-operational surveys in the Draft SEIS Subchapter 5.4. That evaluation demonstrated that small boat and pre-operational aerial surveys for SURTASS LFA operations are not feasible because they are not practicable, not effective, may increase the harassment of marine mammals, and are not safe to the observers. Therefore, under the revisions to the MMPA by the NDAA FY04, pre-operational surveys are not considered as a viable mitigation option. As noted in SEIS RTC 5.4.1 above, the MMC concurs that small boat or aerial surveys immediately before and during SURTASS LFA sonar operations in the various offshore training areas would not be a practical mitigation option.

Comment 5.4.3: The Draft SEIS dismisses the small boat and pre-operational aerial surveys as not practicable, but perhaps it would be more truthful to say that they would be inconvenient. I-011, O-008, O-010, O-014

Response: The inconvenience of such surveys is eclipsed by their impracticality and unsafe nature. However, as noted above (SEIS RTC 5.4.1), MMC concurs that small boat or aerial surveys immediately before and during SURTASS LFA sonar operations in the various offshore training areas would not be a practical mitigation option.

Comment 5.4.4: Why were pre-operational surveys using large boats not considered as an option? I-011, O-010

Response: Boats that are larger than those that can be launched from the LFA vessels were not considered because they are not an option. These would have to be vessels of opportunity sailing from ports within reasonable distance from the operations site. Because of the classified nature of LFA operations, National Security considerations would preclude the ability to arrange these vessels in advance. Also the costs would be prohibitive.

Comment 5.4.5: The Navy analysis does not consider:

> **Comment 5.4.5a:** Possibility of using boats launched from shore, rather than from LFA ships. O-014
>
> **Response:** See SEIS RTC 5.4.4.
>
> **Comment 5.4.5b:** Any minor disturbance from small planes and small boats would be far outstripped by the risk of serious injury and death if marine mammals and sea turtles remain in area of highest impact. O-014
>
> **Response:** SEIS Subchapter 5.4 provided a detailed discussion of why aerial and small craft surveys were not considered as a viable mitigation option. The possible harassment of marine mammals from these surveys was only one factor in this consideration. See SEIS RTCs 5.4.1, 5.4.2, and 5.4.3 for additional information.
>
> **Comment 5.4.5c:** Using more than a single boat. O-014
>
> **Response:** The primary concern with the utilization of small boats is not their effectiveness, but their unsafe nature and the impracticality of their operations from the LFA vessels. Therefore, if the use of a single survey boat is considered impractical and unsafe, then this would concomitantly apply to the utilization of additional boats. See SEIS RTC 5.4.1.
>
> **Comment 5.4.5d:** Because of limited effectiveness of visual monitoring (high sea state, weather, etc), increased mitigation is more important. Why would boat-based (LFA vessel) observers be able to see cetaceans more effectively than aerial surveys? O-014
>
> **Response:** The issues is not whether the visual observer on board the LFA vessel would be able to see cetaceans more effectively than aerial observers, but rather that aerial surveys for mitigation were evaluated not to be a viable mitigation option (See

SEIS Subchapter 5.4), a conclusion with which the MMC agrees (See SEIS RTC 5.4.1 above).

Comment 5.4.5e: Comparative costs of operating LFA in a manner that exposes coastal marine mammals to a higher risk of stranding and other injuries. O-014

Response: When operated under the mitigation protocols, marine mammals will not be exposed to LFA sound levels that will cause strandings or injuries regardless of whether they are in coastal or open ocean waters. In order for a potential injury to occur, marine mammals will have to be exposed to $\geq$ 180 dB RL. In addition, LFA has never caused, nor is expected to cause, marine mammal strandings. Therefore, there is no "cost" to compare.

Comment 5.4.6: Although surveying in a small powerboat at high speed would probably be effective, it is interesting to note that the Navy cites a paper reporting that whales may dive and be impossible to spot if approached by a vessel at speed. Assumedly, the vessel employing LFA will be traveling at speed so this implies that whales may dive and not be sighted by the deploying vessel. If visual observations from a fast vessel are sufficient for cetacean detections, then a smaller vessel traveling at speed would also be useful. I-058

Response: In the referenced paper (Au and Green, 2000), the small craft speed was 10 knots. NMFS normally performs vessel surveys at speed of 10-12 knots. The commenter's issue is moot because the average speed of the LFA vessels with the arrays deployed is 3 knots (5.6 kph).

Comment 5.4.7: The Navy states that the behavior of animals, high sea states and poor visibility all make it unlikely for aerial surveys to spot cetaceans from helicopters, but fails to explain why, in these conditions, its proposed boat-based observers would be able to see cetaceans. I-058

Response: The Draft SEIS did not state that the visual observers onboard the LFA vessels would be able to see marine mammals better than visual observers during aerial surveys, nor were helicopters mentioned. Subchapter 4.2.7.1 of the FOEIS/EIS states that visual monitoring is limited to daylight hours and its effectiveness declines during high sea states. Because of the limitations of both passive acoustic and visual monitoring, the Navy developed the HF/M3 sonar to provide 24-hour, all-weather active acoustic monitoring of an area of approximately 2-km (1.1 nm) radius from the array. In calculating the effectiveness for the various monitoring systems for purposes of the FOEIS/EIS, the visual monitoring component of the three-part monitoring system was estimated at 0.09, or 9 percent. Thus, the Navy relies primarily on the near-100 percent marine animal detection effectiveness of the HF/M3 sonar.

Chapter 6 RELATIONSHIP OF THE PROPOSED ACTION TO FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

Comment 6.1: The Maine State Planning Office, Maine Coastal Program that if SURTASS LFA exercises are to be undertaken in or in the areas proximate to the Gulf of Maine that further CZMA consultation is required.

Response: The Navy has no plans or intensions to operate SURTASS LFA sonar in or in areas proximate to the Gulf of Maine.

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APPENDIX A

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DEPARTMENT OF THE NAVY
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(INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON, D.C. 20350-1000

APR 11 2003

MEMORANDUM FOR THE DEPUTY CHIEF OF NAVAL OPERATIONS, NAVAL WARFARE, REQUIREMENTS AND PROGRAMS (N7)

Subj: SURTASS LFA Supplemental EIS

I have reviewed the Final Overseas Environmental Impact Statement and Environmental Impact Statement (OEIS/EIS) for the Surveillance Towed Array Sensor System Low Frequency Active Sonar (SURTASS LFA) and the July 16, 2002 Record of Decision (ROD) concerning employment of the SURTASS LFA system. I find the analysis of the OEIS/EIS to have taken the requisite "hard look" at the environmental consequences of the decision to employ the SURTASS LFA system and that the ROD adequately addresses the issues raised.

However, due to recent concerns raised by the Court over employment of the SURTASS LFA system, I have determined that the purposes of the National Environmental Policy Act would be furthered by the preparation of supplemental analysis related to employment of system. This analysis will take the form of a Supplemental Overseas Environmental Impact Statement/ Supplemental Environmental Impact Statement and will provide additional information regarding the environment that could potentially be affected by employment of SURTASS LFA and additional information related to mitigation of the potential impacts of the system.

Specifically, I direct that the analysis focus on identifying geographic areas and seasonal periods of high marine mammal abundance in those areas where the Navy intends to use SURTASS LFA for routine training and testing. Once completed, information developed from this analysis will be used to assist the Navy in selecting the operating areas that it requests for routine SURTASS LFA training and testing in applications for Letters of Authorization submitted to the National Marine Fisheries Service.

While I have no reason to believe that any impacts from the employment of SURTASS LFA will occur inside U.S. territory, I direct that this analysis comply with both the National Environmental Policy Act and Executive Order 12114.

Donald R. Schregardus
Deputy Assistant Secretary of the Navy
(Environment)

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO

9462
N774T/3U630157
28 Jul 03

From: Chief of Naval Operations (N774)
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

Ref: (a) Deputy Assistant Secretary of the Navy (Environment) Memorandum for the Deputy Chief of Naval Operations, Naval Warfare, Requirements and Programs (N7), SURTASS LFA Supplemental EIS, 11 April 2003
(b) Acting Director, Office of Protected Resources, National Marine Fisheries Service, National Oceanic And Atmospheric Administration letter of 14 April 2003

1. In reference (a), the Deputy Assistant Secretary of the Navy for Environment directed the Navy to prepare a supplemental environmental impact statement (SEIS) to provide additional information regarding the environment that could be potentially affected by employment of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar and additional information related to mitigation of the potential impacts of the system. In reference (b), the National Marine Fisheries Service (NOAA Fisheries) stated that they supported the decision to produce an SEIS and would agree to serve as a cooperating agency under 40 CFR 1501.6, upon formal request from the Navy.

2. In preparation for the important work ahead in developing the SEIS, the Navy desires to formalize the working relationship between National Marine Fisheries Service (NOAA Fisheries) and the Navy. The Navy therefore invites the National Marine Fisheries Service (NOAA Fisheries) to be a "cooperating agency" under 40 CFR 1501.6 for the preparation of the SURTASS LFA Sonar Supplemental EIS.

Subj: COOPERATING AGENCY REQUEST FOR SURTASS LFA SONAR SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

3. The CNO point of contact is Mr. Joseph S. Johnson (Code N774T), who can be reached at 703-604-7389, E-mail: joe.johnson@navy.mil.

F. J. Diemer
Captain, U. S. Navy
Head, Undersea Surveillance

UNITED STATES DEPARTMENT OF COMMER
National Oceanic and Atmospheric Administrat
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910
THE DIRECTOR

SEP 2 6 2003

Captain F. J. Diemer
Department of the Navy
Office of the Chief of Naval Operations
2000 Navy Pentagon
Washington, D.C. 20350-2000

Dear Captain Diemer:

Thank you for your letter requesting the National Marine Fisheries Service (NOAA Fisheries) to be a cooperating agency (as that term is defined by the Council on Environmental Quality (40 CFR 1501.6) in the preparation of a Supplemental Environmental Impact Statement (SEIS) addressing the potential impacts from operational deployment of the Surface Towed Array Surveillance System Low Frequency Active (SURTASS-LFA) Sonar.

We support the U.S. Navy's determination to do an SEIS on this activity as we have participated in the preparation of previous SURTASS LFA sonar documents under the National Environmental Policy Act and have permitted recent scientific research on the impacts from SURTASS-LFA sonar on marine mammals. In cooperating with the U.S. Navy on this activity, NOAA Fisheries has a dual role, both through review of and comment on the preparation of the SEIS and in the processing of incidental take applications for Letters of Authorization (LOAs) under section 101(a)(5)(A) of the Marine Mammal Protection Act. NOAA Fisheries will also be in formal consultation under section 7 of the Endangered Species Act on the LOAs. Therefore, NOAA Fisheries agrees to be a fully cooperating agency in the preparation and review of the SEIS but also reserves the ability to review that document when it is released to the general public, and to provide the U.S. Navy with appropriate comments. Provided our comments are satisfactorily addressed in the Navy's Administrative Record, NOAA Fisheries is prepared to adopt the U.S. Navy SEIS when making its determination on the issuance of further LOAs.

If you need any additional information, please contact Mr. Kenneth Hollingshead, (301) 713-2055, ext. 128, or Ms. Kimberly Skrupky, (301) 713-2322, ext. 163, who will be the points of contact for the preparation of the SURTASS-LFA sonar SEIS.

Sincerely,

W.T. Hogarth

William T. Hogarth, Ph.D.

THE ASSISTANT ADMINISTRATOR
FOR FISHERIES