National Marine Fisheries Service
Endangered Species Act Section 7 Consultation Biological Opinion

Agencies: United States Navy

National Marine Fisheries Service

Activities Considered: The U.S. Navy Atlantic Fleet's conduct of active sonar training along the Atlantic Coast of the United States and in the Gulf of Mexico from January 2012 to January 2014

Issuance of a Letter of Authorization for the U.S. Navy to "take" marine mammals incidental to the conduct of active sonar training along the Atlantic Coast of the United States and in the Gulf of Mexico during January 2012 to January 2014

Consultation Conducted by: Endangered Species Act Interagency Cooperation Division of the Office of Protected Resources, National Marine Fisheries Service

Approved by: ______________________ **Date:** DEC 19 2011

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1536(a)(2)) requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR 402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service concur with that conclusion (50 CFR 402.14(b)).

For the actions described herein, the action agencies are the United States Navy, which proposes to undertake active sonar training activities along the Atlantic Coast of the United States of America and in the Gulf of Mexico, and NMFS Office of Protected Resources – Permits and Conservation Division (Permits Division), which proposes to issue a Letter of Authorization (LOA) pursuant to the Marine Mammal Protection Act (MMPA) that would authorize the U.S. Navy to "take" marine mammals incidental to those active sonar training activities. The consulting agency for these proposals is NMFS Office of Protected Resources - Endangered Species Act Interagency Cooperation Division. This document represents NMFS biological opinion on the effects of these actions by the U.S. Navy and the NMFS Permits Division on endangered and threatened species and critical habitat that has been designated for those species.

This Opinion has been prepared in accordance with section 7 of the ESA and is based on information provided in the applications for ESA consultation, the MMPA permits, published and unpublished scientific information on the biology and ecology of threatened and endangered whales, endangered and threatened sea turtles, and endangered and threatened fishes that occur along the Atlantic coast of the United States, and other sources of information.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1539(a)(2)) requires each Federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service concurs with that conclusion (50 CFR §402.14(b)).

For the actions described in this document, the action agencies are the United States Navy (U.S. Navy), which proposes to undertake active sonar training activities along the Atlantic Coast of the United States of America and in the Gulf of Mexico, and NMFS Office of Protected Resources – Permits and Conservation Division (Permits Division), which proposes to issue a Letter of Authorization (LOA) pursuant to the Marine Mammal Protection Act (MMPA) that would authorize the U.S. Navy to "take" marine mammals incidental to those active sonar training activities. The consulting agency for these proposals is NMFS Office of Protected Resources - Endangered Species Act Interagency Cooperation (ESA IC) Division.

The biological opinion and incidental take statement portions of this consultation were prepared by NMFS ESA IC Division in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR §402. This document represents NMFS' final biological opinion (Opinion) on the effects of these actions on endangered and threatened species and critical habitat that has been designated for those species.

1.1 Background

This Opinion is based on information provided in the NMFS Permits Division's request for Section 7 consultation under the ESA (NMFS 2011), the proposed LOA, the Federal regulations under the MMPA specific to the proposed activities (50 CFR § 216.240; 74 FR 4844), the programmatic ESA consultation that considered the Navy's proposed activities over a five year period (NMFS 2008c) and, final and draft recovery plans for the endangered or threatened species that are considered in this document, and publications that we identified, gathered, and examined from the public scientific literature.

1.2 Consultation History

Consultation under the ESA related to current and ongoing use by the Navy of Atlantic Fleet Active Sonar Training (AFAST) began in 2008 (see Table 1). The action agencies were the U.S. Navy and National Marine Fisheries Service (NMFS) Office of Protected Resources Permits and Conservation Division (Permits Division). A five-year (2009-2014) ESA programmatic consultation was conducted by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division[1] (ESA IC Division). The programmatic consultation addressed the

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[1] As of an October 2011 office reorganization the former Endangered Species Division was divided into the Endangered Species Conservation Division and the Endangered Species Act Interagency Cooperation Division

Navy's proposal to conduct AFAST over a five year period and the issuance of regulations under the Marine Mammal Protection Act (MMPA) that allowed for the annual issuance of a Letter of Authorization (LOA) to the Navy by NMFS Permits Division. The programmatic consultation was completed in 2009. Tiered from that programmatic consultation, annual LOA issuance requires consultation under the ESA prior to the issuance of the LOA.

On January 21, 2010, NMFS issued a biological opinion on activities similar to what was considered in the programmatic consultation, but 1) included the action of issuing an LOA for activities to be conducted from January 2010 to January 2011 and 2) resulted in the issuance of an Incidental Take Statement (ITS) (NMFS 2010b). An ITS was included because incidental take of ESA- listed marine mammals was authorized under section 101(a)(5) of the MMPA via the letter of authorization (LOA). A summary of the consultation history is provided in Table 1.

Table 1. Time-line of Endangered Species Act section 7 consultations on U.S. Navy Atlantic Fleet Active Sonar Training (AFAST) along the Atlantic Coast of the United States and in the Gulf of Mexico.

Date	Agency	Activity	Comments
4 Feb 2008	U.S. Navy	Submitted application to NMFS Permits Division requesting authorization for incidental "take" of marine mammals from AFAST activities over the next five years	
14 Oct 2008	NMFS	Proposed rule published in the Federal Register (FR) on the U.S. Navy's request for a five year MMPA regulation to allow for annual letters of authorization for the Navy's AFAST activities	7374 FR 6075420155
12 Dec 2008	U.S. Navy	Final AFAST activities Environmental Impact Statement/Overseas Environmental Impact Statement	
16 Jan 2009	NMFS Endangered Species Division	Issued a five year programmatic ESA biological opinion on the Navy's AFAST activities and NMFS Permits Division's MMPA regulations covering 2009-2014	
22 Jan 2009	NMFS Endangered Species Division	Issued an ESA biological opinion on the Navy's AFAST activities and NMFS Permits Division's 2009 LOA	
27 Jan 2009	NMFS	Final rule issuing regulations on the unintentional taking of marine mammals incidental to Navy's AFAST activities from January 2009 through January 2014 published in the Federal Register	74 FR 4843
2 Nov 2009	U.S. Navy	Submitted request to NMFS Permits Division for an LOA for AFAST activities from January 2010 to January 2011	
23 Dec 2009	NMFS Permits Division	Requested NMFS' Endangered Species Division initiate consultation and provided NMFS' Endangered Species Division with a final draft of the 2010 LOA	
21 Jan 2010	NMFS Endangered Species Division	Issued ESA biological opinion on the Navy's AFAST activities and NMFS Permits Division's 2010 LOA	
21 Jan 2010	NMFS	Issued the 2010 LOA for the unintentional taking of marine mammals incidental to Navy's AFAST activities	
26 Aug 2010	U.S. Navy	Submitted application to NMFS Permits Division requesting renewal of the 2011 LOA	
Sep 2010	U.S. Navy	Submitted annual monitoring report to NMFS Permits Division and NMFS Endangered Species Division for activities that occurred from January 2010 to August 2010	

8 Dec 2010	NMFS Permits Division	Requested NMFS' Endangered Species Division initiate ESA consultation on the issuance of an LOA for the Navy's AFAST activities for 2011
20 Jan 2011	NMFS ESA Division	Issued a Biological Opinion on the proposed 2011-2012 Navy activities and the NMFS Permits Divisions issuance of an LOA
20 Jan 2011	NMFS Permits Division	Issued an LOA to the Navy for activities from January 2011 through January 2012
31 Aug 2011	U.S. Navy	Submitted request to NMFS Permits Division requesting renewal of the 2012 LOA and to NMFS ESA IC Division for ESA section 7 consultation
Oct 2011	U.S. Navy	Submitted annual range complex monitoring report to NMFS for activities that occurred from August 2010 to August 2011
16 Nov 2011	NMFS Permits Division	Requested initiation of ESA IC ESA consultation on the issuance of an LOA for the Navy's AFAST activities for 2012 through 2014

On August 31, 2011, the U.S. Navy submitted an application to NMFS Permits Division requesting renewal of the MMPA letter of authorization for incidental “take” of marine mammals and requested initiation of ESA consultation for ESA-listed species related to the Navy’s AFAST activities along the east coast of the U.S. and in the Gulf of Mexico for January 2012 through January 2014 (Navy 2010).

On November 16, 2011, NMFS Permits Division requested NMFS’ ESA IC Division initiate ESA consultation on the issuance of the 2012 LOA for the Navy’s AFAST activities to occur from January 2012 to January 2014 activities and provided a draft LOA.

On November 17, 2011, NMFS ESA IC Division provided the U.S. Navy and the Permits Division with copies of the draft biological opinion on the suite of activities that would be authorized by the LOA the Permits Division proposed to issue pursuant to the MMPA.

On November 22, 2011 and November 30, 2011, the U.S. Navy and the Permits Division respectively, submitted comments on the draft Opinion. NMFS has reviewed all comments submitted and revised the Opinion as warranted.

2 DESCRIPTION OF THE PROPOSED ACTION

The proposed action consists of two separate but related activities: (1) NMFS Permits Division proposal to issue a LOA to the U.S. Navy to “take” marine mammals for a two-year period incidental to the U.S. Navy’s AFAST activities and (2) the U.S. Navy’s proposal to continue conducting AFAST activities from January 22, 2012 to January 22, 2014. The AFAST activities include mid- and high-frequency active sonar and improved extended echo ranging system training (which includes the explosive source sonobuoy AN/SSQ-110A), maintenance, and research, development, test, and evaluation activities within and adjacent to those operating area that occur within the AFAST study area along the Atlantic coast of the United States and within the Gulf of Mexico The purpose of the U.S. Navy’s training activities is to meet the requirements of the U.S. Navy’s Fleet Response Training Plan and allow Navy personnel to remain proficient in anti-submarine warfare and mine warfare skills.

As described in the *Description of the Proposed Action* of NMFS programmatic biological opinion and this opinion on AFAST, Navy training advances through four phases: Maintenance, Basic, Integrated, and Sustainment. The Maintenance Phase primarily involves major shipyard or depot level repair and personnel turnover. During this phase, ship and squadrons focus on individual and team anti-submarine warfare and mine warfare training. During the Basic Phase, the U.S. Navy proposes to continue individual and team training, but shift the focus to Unit Level Training.

Training during the Basic Phase training involves either one unit (Independent Unit-Level Training) or more than one unit (Coordinated Unit-Level Training). Integrated Phase training brings individual units together as strike groups. Sustainment Phase training begins when Integrated Phase training is completed, lasts through deployment, and for several months after a strike group returns to its homeport (before strike groups stands down and individual units begin their maintenance period). Sustainment Phase training can include a variety of anti-submarine warfare and mine warfare training designed to sustain the level of readiness that a group, multi-unit, or unit attains in earlier training phases.

Research, Development, Test and Evaluation activities are conducted as part of developing new technologies and to ensure their effectiveness prior to implementation. Maintenance activities are conducted in port and during transit to training exercise locations. In total, these activities are termed ‘military readiness’ activities in the remainder of this document.

Below we summarizes information on the U.S. Navy’s training scenarios, the acoustic devices (including sonar systems) the U.S. Navy employs in these training activities, and the location of these training activities. Anyone interested in more information on specific activities or all of the activities should refer to the U.S. Navy’s Final Environmental Impact Statement on the Atlantic Fleet Active Sonar Training (Navy 2008b).

2.1 Training Scenarios

The training activities considered in this Opinion result from Independent Unit Level Training (ULT; the term “units” refers to individual ships, submarines and aircraft) activities, Coordinated Unit-Level Training, Strike Group training exercises, Research, Development, Test and Evaluation, and active sonar maintenance. The following narratives summarize the different kinds of activities these training activities involve; for more detailed descriptions of these activities, readers should refer to the U.S. Navy’s Final Environmental Impact Statement on Atlantic Fleet Training (Navy 2008b).

2.1.1 Independent Unit Level Training Scenarios

Independent Unit-Level training events typically last two to six hours and involve one or two ships or aircraft. Active sonar systems are typically used during only portions of these training events. The U.S. Navy plans to continue conducting about 2,400 unit-level training events each year.

Surface Ship Anti-Submarine Warfare Unit-Level Training

In this training scenario, one or two surface ships (guided missile cruisers, guided missile destroyers, or fast frigates) conduct anti-submarine warfare localization and tracking training using the AN/SQS-53, AN/SQS-56, or AN/SLQ-25 NIXIE. In addition, one MK-39 Expendable Mobile Acoustic Training Target or MK-30 target may used as a target during an exercise. In some Surface Ship anti-submarine warfare unit-level training events a MK-1, MK-2, MK-3, MK-4, MK-46 torpedo, and a noise acoustic emitter could be used. These training exercises would generally occur in both deep and shallow water areas throughout the eastern and southeastern coast of the United States.

Surface Ship Object Detection/Navigational Unit-Level Training

Under this training scenario, one ship (guided missile cruiser, guided missile destroyer, or fast frigate) conducts object detection and navigational training while transiting in and out of port using either AN/SQS-53 or AN/SQS-56 in the Kingfisher mode. This training would be conducted primarily in the shallow water shipping lanes off the coasts of Norfolk, Virginia and Mayport, Florida.

Helicopter Anti-Submarine Warfare Unit-Level Training

In this training scenario, one sh-60 helicopter conducts anti-submarine warfare training using the AN/AQS-13 or AN/AQS-22 dipping sonar, tonal sonobuoys (e.g., AN/SSQ-62), passive sonobuoy and torpedoes. One MK-39 Expendable Mobile Acoustic Training Target or MK-30 target may also be used as a target per exercise. This activity would be conducted in shallow and deep waters while embarked on a surface ship. Helicopter anti-submarine warfare unit level training events would also be conducted by helicopters deployed from shore-based Jacksonville, Florida, units.

Submarine Anti-Submarine Warfare Unit-Level Training

This training scenario consists of one submarine conducting underwater anti-submarine warfare training using AN/BQQ-10 active sonar systems and torpedoes. In addition, an MK-39 Expendable Mobile Acoustic Training Target or MK-30 target may be used as a target. Submarines would be conducting this training in deep waters throughout the Study Area, within and seaward of existing East Coast Operating Areas and occasionally in the Gulf of Mexico Operating Area.

Submarine Object Detection/Navigational Training Unit-Level Training

In this training scenario, individual submarines conduct object detection and navigational training while transiting in and out of port using AN/BQS-15 sonar. In this training scenario, submarines would operate sonar to detect obstructions while they transit. This unit-level training occurs primarily in the established submarine transit lanes outside of Groton, Connecticut; Norfolk, Virginia; and Kings Bay, Georgia.

Maritime Patrol Aircraft Anti-Submarine Warfare Unit-Level Training

In this training scenario, individual maritime patrol aircraft conduct anti-submarine warfare localization and tracking training using tonal (AN/SSQ-62), passive (AN/SSQ-53D/E), explosive source (AN/SSQ-110A) or receiver (AN/SSQ-101) sonobuoys. Additionally, one MK-39 Expendable Mobile Acoustic Training Target or MK-30 target for each training scenario may be used as a target. Maritime Patrol Aircraft anti-submarine warfare unit-level training would occur within and seaward of existing East Coast Operating Areas and occasionally within the Gulf of Mexico Operating Area.

Surface Ship Mine Warfare Unit-Level Training

In this training scenario, individual ships would conduct mine localization training using AN/SSQ-32 and AN/SLQ-48 sonar systems. This training would be conducted in the northern Gulf of Mexico in the Gulf of Mexico Operating Areas, and off the east coast of Texas, in the Corpus Christi Operating Area.

2.1.2 Coordinated Unit Level Training

The U.S. Navy plans to continue conducting about 40 coordinated unit-level training events each year. Specific training scenarios include the following activities:

Southeastern Anti-Submarine Warfare Integrated Training Initiative

Southeastern Anti-Submarine Warfare Integrated Training Initiatives (SEASWITI) are exercises with up to two submarines and either two guided missile destroyers and one fast frigate or one guided missile cruiser, one guided missile destroyer, and one fast frigate. The ships and their embarked helicopters would be conducting ASW localization training using the AN/SQS-53, AN/SQS-56, and AN/AQS-13 or AN/AQS-22 dipping sonar. Submarine would also operate AN/BQQ-10 sonar periodically. Up to 24 tonal sonobuoys (e.g., AN/SSQ-62) and two acoustic device countermeasures would also be used in these exercises.

These training scenarios typically occur over 5- to 7-day periods and occur four times per year. This training exercise using the AN/AQS-13 or AN/AQS-22 sonar systems would occur in the deep water within or adjacent to the Jacksonville-Charleston Operating Areas. To meet the operational requirements for these exercises, the western boundary (i.e., training area entry point) of training areas must be no greater than 167 kilometers (km) and 185 km (90 nautical miles [nm] and 100 nm) from port.

Group Sail

Group Sail is a coordinated training scenario with one submarine and either two guided missile destroyers or one guided missile cruiser, one guided missile destroyer and one fast frigate. The ships and their embarked helicopters conduct anti-submarine warfare localization training using AN/SQS-53, AN/SQS-56 and AN/AQS-13 or AN/AQS-22 dipping sonar. Submarine involved in these exercises also operate AN/BQQ-10 sonar periodically. Four tonal sonobuoys and two acoustic device countermeasures (MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the AN/SLQ-25A NIXIE) may also be used per scenario. The number of passive sonobuoys deployed can vary. In addition, up to two MK-48 torpedoes could be fired per exercise.

Integrated Anti-Submarine Warfare Course

The Integrated Anti-Submarine Warfare Course (IAC) is a tailored course of instruction designed to improve Sea Combat Commander and Strike Group integrated anti-submarine warfare skill sets. Key components for this course of instruction include coordinated anti-submarine warfare training for the Sea Combat Commander or Anti-Submarine Warfare Commander and staff, key shipboard decision makers, and anti-submarine warfare watch teams. The IAC consists of two phases, IAC Phase I and IAC Phase II. Phase I is an approved Navy course of instruction consisting of five days of basic and intermediate level classroom training. Phase II is intended to leverage the knowledge gained during IAC Phase I and build the basic anti-submarine warfare coordination and integration skills of the Strike Group anti-submarine warfare Team. Phase II is a coordinated training scenario that typically involves three guided missile destroyers, one guided missile cruiser and one fast frigate, two to three embarked helicopters, one submarine, and one maritime patrol aircraft searching for, locating, and attacking one submarine.

The scenario consists of two 12-hour events that occur five times per year. While the ships are searching for the submarine, the submarine may practice simulated attacks against the ships. The ships and their embarked helicopters conduct anti-submarine warfare localization training using AN/SQS-53, AN/SQS-56, AN/AQS-13 or AN/AQS-22 dipping sonar. Submarines would also operate AN/BQQ-10 sonar periodically. About 36 tonal sonobuoys may also be used per event. Multiple acoustic sources may be active at one time. These events would occur within and seaward of the Virginia Capes, Cherry Point, and Jacksonville-Charleston Operating Areas or within and adjacent to the Gulf of Mexico Operating Area. During these exercises, some activities may occur in more than one Operating Area.

Submarine Command Course Operations

This scenario is conducted as training for submarine Executive and Commanding Officers, and involves two submarines conducting anti-submarine warfare training using AN/BQQ-10 sonar systems, as well as four acoustic device countermeasures (MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the AN/SLQ-25A NIXIE) per scenario. In addition, up to 36 MK-48 torpedoes could be fired during the duration of an exercise.

Submarine Command Course Operations exercises occur two times per year, last from 3 to 5 days, and typically occur in the Jacksonville-Charleston and Northeast Operating Areas in deep ocean areas. Since targets may be employed, a support vessel may be required, which limits the western edge of the exercise boundary to within 148 km (80 nm) of a support facility.

Squadron Exercise and Gulf of Mexico Exercise

The scenario employs from one to five mine countermeasures ships conducting mine localization training using AN/SSQ-32 and AN/SLQ-48 sonars. These scenarios are 10 to 15 days in length and occur four times per year. Either the Squadron Exercise or Gulf of Mexico Exercise would be conducted in both deep and shallow water training areas within and adjacent to the Pensacola and Panama City operating areas in the northern Gulf of Mexico.

2.1.3 Strike Group Training

The Expeditionary Strike Group (ESG) and Carrier Strike Group (CSG) consist of multiple ships, aircraft and submarines operating as an integrated force. A typical Expeditionary Strike Group or Carrier Strike Group consists of up to six surface ships, one to five aircraft, and one submarine.

Composite Training Unit Exercise

Composite Training Unit Exercises (COMPTUEX) are designed to provide coordinated training to entire Expeditionary Strike Group and Carrier Strike Groups. An Expeditionary Strike Group COMPTUEX consists of a U.S. Navy Expeditionary Strike Group and U.S. Marine Corps units conducting integrated maritime and amphibious operations. Activities that employ active sonar during these exercises include anti-submarine warfare proficiency training, battle problem – area search and strait transit (a simulated choke point exercise), littoral anti-submarine warfare activities, coordinated anti-submarine warfare activities, and Improved Extended Echo Ranging (IEER) Systems training. Other activities that occur during these exercises include the insertion of amphibious forces onto a beach, movement of vehicles and troops over land, delivery of troops and equipment from ship to shore via helicopters and fixed-wing maritime patrol aircraft, the use of live-fire and blank munitions from ground-based troops and aircraft, and ship operations. In addition, Navy ships provide indirect Naval Surface Fire Support in support of the landing amphibious forces utilizing non-explosive ordnance.

A Carrier Strike Group COMPTUEX is a major at-sea training event that is the first time before deployment that an aircraft carrier and its carrier air wing integrate operations with surface and submarine units in an at-sea environment. The Expeditionary Strike Group and Carrier Strike Group consist of multiple ships, aircraft and submarines operating as an integrated force, including up to six surface ships, one to five aircraft, and one submarine, approximately half of which would not be equipped with active sonar sensors.

Sonars employed in these exercises include AN/SQS-53, AN/SQS-56, AN/AQS-13 or AN/AQS-22 dipping sonar, and the AN/BQQ-10 sonar. Up to 218 tonal sonobuoys, 28 explosive source sonobuoys (AN/SSQ-110A), 5 receiver sonobuoys (AN/SSQ-101), and four acoustic device countermeasures (MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the AN/SLQ-25A NIXIE) are typically used per exercise. The number of passive sonobuoys deployed during these exercises can vary.

Each Composite Training Unit Exercises lasts about 21 days. Four of these training exercises are conducted each year along the Atlantic Coast of the United States and one in the Gulf of Mexico. Along the Atlantic Coast, these exercises would occur within and seaward of the Virginia Capes, Cherry Point, and Jacksonville-Charleston Operating Areas. Within the Gulf of Mexico, these exercises would occur adjacent to the Gulf of Mexico Operating Area. Some activities that occur during these exercises might occur in more than one Operating Area.

Joint Task Force Exercise

Joint Task Force Exercises (JTFEX) are also major range events that are the culminating exercises in Integrated Phase training for Carrier and Expeditionary Strike Groups. For Expeditionary Strike Groups, Joint Task Force Exercises incorporate Amphibious Ready Group Certification Exercises for amphibious ships and Special Operations Capable Certification for Marine Expeditionary Units. When schedules allow, these exercises may be conducted concurrently for a Carrier Strike Group and an Expeditionary Strike Group. These exercises normally last for 10 days (not including a 3-day force protection exercise that occur in-port) and are the final at-sea exercise for the Carrier or Expeditionary Strike Groups before they are deployed. These exercises have generally occurred three to four times per year.

Joint Task Force Exercises are the final fleet exercises before deployment of Carrier and Expeditionary Strike Groups. These exercises would be scheduled after a Carrier Strike Group COMPTUEX to certify that a Strike Group is ready for deployment. Activities conducted during these exercises include littoral anti-submarine warfare activities, coordinated anti-submarine warfare activities, Improved Extended Echo Ranging (IEER) Systems training, and free play exercises. They typically include other Defense Department services or Allied forces.

Carrier Strike Group COMPTUEX and Joint Task Force Exercises often take place concurrently to produce exercises that are called Combined Carrier Strike Group COMPTUEX/JTFEX. Typically, four guided missile destroyers, two fast frigates, and three submarines participate in a Joint Task Force Exercises. Sonars employed in this scenario include the AN/SQS-53, AN/SQS-56, AN/AQS-13 OR AN/AQS-22 dipping sonar, and the AN/BQQ-10 sonars. Up to 174 tonal sonobuoys (e.g., AN/SSQ-62), 28 explosive source sonobuoys (AN/SSQ-110A), five receiver sonobuoys (AN/SSQ-101), and 2 four acoustic device countermeasures (MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the AN/SLQ-25A NIXIE) are typically used per exercise. The number of passive sonobuoys that are deployed during these exercises can vary.

These exercises generally last for 10 days and occur two times per year in shallow and deep water portions located within and seaward of the Virginia Capes, Cherry Point, and Jacksonville-Charleston Operating Areas.

2.1.4 Sustainment Training

Sustainment training consists of a variety of training evolutions designed to sustain readiness as a group, multi-unit, or unit until and following employment. Sustainment training, in port and at sea, allows forces to demonstrate proficiency in operating as part of a joint and coalition combined force and ensures that proficiency is maintained in order to maintain Major Combat Operations Ready. The extent of the sustainment training will vary depending on the unit‘s length of time in a Major Combat Operations Ready status, as well as the anticipated tasking. During sustainment training, units/groups maintain a MCO Ready status until the commencement of the maintenance phase, unless otherwise directed by the Fleet Commander. Unit/group integrity during this period is vital to ensure integrated proficiency is maintained. This is especially vital for strike groups.

2.1.5 Maintenance

The U.S. Navy plans to continue conducting about 510 maintenance training events each year. Specific training scenarios include the following:

Surface Ship Sonar Maintenance

This scenario consists of surface ships performing periodic maintenance to the AN/SQS-53 or AN/SQS-56 sonar while in port or at sea. This maintenance takes up to 4 hours. Surface ships would be operating their active sonar systems for maintenance while in shallow water near their homeport, located in either Norfolk, Virginia or Mayport, Florida. However, sonar maintenance could occur anywhere as the system‘s performance may warrant.

Submarine Sonar Maintenance

A submarine performs periodic maintenance on the AN/BQQ-10 and AN/BQS-15 sonar systems while in port or at sea. This maintenance takes from 45 minutes to one hour. Submarines would conduct maintenance to their sonar systems in shallow water near their homeport of either Groton, Connecticut; Norfolk, Virginia; or Kings Bay, Georgia. However, sonar maintenance could occur anywhere as the system‘s performance may warrant.

2.2 Sonar Systems

During anti-submarine warfare and mine warfare training activities, the U.S. Navy uses tactical military sonars that were designed to (1) search for, detect, localize, and classify mine-like object or (2) obtain information concerning distant objects such as enemy vessels. The U.S. Navy typically employs two types of sonars, passive and active:

1. Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment.

2. Active sonars generate and emit acoustic energy specifically for the purpose of obtaining information concerning a distant object from the received and processed reflected sound energy. These sonars may produce high-frequency, mid-frequency, or low-frequency active signals.

The simplest active sonars emit omnidirectional pulses or “pings” and calculate the length of time the reflected echoes return from the target object to determine the distance between the sonar source and a target. More sophisticated active sonar emits an omnidirectional ping and then scans a steered receiving beam to calculate the direction and distance of a target. More advanced sonars transmit multiple preformed beams, listening to echoes from several directions simultaneously and providing efficient detection of both direction and range.

Because passive sonars do not introduce energy into the marine environment, we do not discuss them further in this consultation (readers interested in these sonar systems should refer to Appendix C of the U.S. Navy’s Final Environmental Impact Statement for AFAST ; (Navy 2008a). The active sources that would be used in training activities along the Atlantic Coast of the United States and in the Gulf of Mexico are described below.

2.2.1 Sonar Systems Associated with Surface Ships

A variety of surface ships participate in Navy training exercises, including guided missile cruisers, destroyers, guided missile destroyers, and frigates. Some ships (e.g., aircraft carriers) do not have any onboard active sonar systems, other than fathometers. Others, like guided missile cruisers, are equipped with active as well as passive sonars for submarine detection and tracking. The primary surface ship sonars considered are:

1. The AN/SQS-53 which is a large, active-passive, bow-mounted sonar that has been operational since 1975. The AN/SQS-53 is the U.S. Navy’s most powerful surface ship sonar and is installed on Ticonderoga (22 units) and Arleigh Burke I/II/IIIa class vessels in the U.S. Navy (D'Spain et al. 2006c; Polmar 2001). This sonar transmits at a center frequency of 3.5 kHz at sources levels of 235 dB_{rms} re: 1 μPa at 1 meter. The sonar has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-53 operates at depths of about 7 meters.

   The AN/SQS-53 is a computer-controlled, hull-mounted surface-ship sonar that has both active and passive operating capabilities, providing precise information for anti-submarine warfare weapons control and guidance. The system is designed to perform direct-path anti-submarine warfare search, detection, localization, and tracking from a hull-mounted transducer array. The AN/SQS-53 sonar is installed on Arleigh Burke Class guided missile destroyers and Ticonderoga Class guided missile cruisers. The AN/SQS-53 Kingfisher is a modification that provides a surface ship with the ability to detect mine-like objects.

2. The AN/SQS-56 system is a lighter active-passive bow-mounted sonar that has been operational since 1977. The AN/SQS-56 is installed on FFG-7 (33 units) class guided missile frigates in the U.S. Navy (D'Spain et al. 2006c; Polmar 2001). This sonar transmits at a center frequency of 7.5 kHz and a source level of 225 dB_{rms} re: 1 μPa at 1 meter source level. This sonar also has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-56 operates at depths of about 6 meters.

2.2.2 Sonar Systems Associated with Submarines

Tactical military submarines equipped with hull-mounted mid-frequency use active sonar to detect and target enemy submarines and surface ships. The predominant active sonar system mounted on submarines is AN/BQQ-10 sonar that is used to detect and target enemy submarines and surface ships. Two other systems — AN/BQQ-5 and AN/BSY-1/2 — have operational parameters that would affect marine mammals in ways that are similar to the AN/BQQ-10. In addition, Seawolf Class attack submarines, Virginia Class attack submarines, Los Angeles Class attack submarines, and Ohio Class nuclear guided missile submarines also have the AN/BQS-15 sonar system, which uses high-frequency for under-ice navigation and mine-hunting.

1. AN/BQQ-10 (also known as Advanced Rapid Commercial-Off-the-Shelf Insertion– a four-phase program for transforming existing submarine sonar systems (i.e., AN/BQQ -5) from legacy systems to more capable and flexible active and passive systems with enhanced processing using commercial-off-the-shelf components. The system is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-10 is installed on Seawolf Class SSNS, Virginia Class SSNs, Los Angeles Class SSNs, and Ohio Class SSBN/nuclear guided missile submarines (SSGNs). The BQQ-10 systems installed on Ohio Class SSBNs do not have an active sonar capability.

2. AN/BQQ-5 – a bow- and hull-mounted passive and active search and attack sonar system. The system includes the TB-16 and TB-23 or TB-29 towed arrays and Combat Control System MK-2. This sonar system is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-5 sonar system is installed on Los Angeles Class nuclear attack submarines (SSNs) and Ohio Class ballistic missile nuclear submarines (SSBNs), although the AN/BQQ-5 systems installed on Ohio Class SSBNs do not have an active sonar capability. The AN/BQQ-5 system is being phased out on all submarines in favor of the AN/BQQ-10 sonar.

2.2.3 Sonar Systems Associated with Aircraft

Aircraft sonar systems that typically operate during Navy training exercises include sonobuoys and dipping sonar. Current dipping sonar systems used by the Navy are either AN/SQS-22 or AN/AQS-13. The AN/AQS-13 is an older and less powerful dipping sonar system (maximum source level 215 dB re µPa-s^2 at 1m) than the AN/AQS-22 (maximum source level 217 dB re µPa-s^2 at 1m). In its modeling, the Navy assumed that all dipping sonar were AN/AQS-22. Aircraft (P-3) may deploy sonobuoys while helicopters may deploy sonobuoys or dipping sonars (the latter are used by carrier-based helicopters). Sonobuoys are expendable devices used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. In addition, the U.S. Navy employs tonal sonobuoys (DICASS, AN/SSQ-62) and the Improved Extended Echo Ranging (IEER) System discussed earlier.

1. The AN/SSQ-62C Directional Command Activated Sonobuoy System (DICASS) sonar system is part of a sonobuoy that operates under direct command of fixed-wing aircraft or helicopters. The system can determine the range and bearing of the target relative to the sonobuoys position and can deploy to various depths within the water column. After it enters the water, the sonobuoy transmits sonar pulses (continuous waveform or linear frequency modulation) upon command from the aircraft. The echoes from the active sonar signal are processed in the buoy and transmitted to the receiving station onboard the launching aircraft.

2. The AN/SSQ-110A Explosive Source Sonobuoy – a commandable, air-dropped, high source level explosive sonobuoy. The AN/SSQ-110A explosive source sonobuoy is composed of two sections, an active (explosive) section and a passive section. The upper section is called the “control buoy” and is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the signal underwater sound charges explode, creating a loud acoustic signal. The echoes from the explosive charge are then analyzed on the aircraft to determine a submarine’s position. The AN/SSQ-110A explosive source sonobuoy is deployed by maritime patrol aircraft.

   In their request for a 2012 Letter of Authorization, the U.S. Navy proposed to maintain the number of AN/SSQ-110A (IEER explosive) sonobuoys it would employ at 1,725 each year while eliminating the use of the high-frequency active sonar, variable depth mine detection and classification system (AN/SQQ-32).

3. The AN/SSQ-125 Advanced Extended Echo Ranging (AEER) Sonobuoy - a third generation of multi-static active acoustic search systems to be developed under the Extended Echo Ranging family of the systems and is being developed as the replacement for the AN/SSQ-110A. The AN/SSQ-125 sonobuoy is composed of two sections, the control section and the active source section. The control section is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of the active sonar source. The echoes from pings of the sonar are then analyzed on the aircraft to determine a submarine's position. The AN/SSQ-125 sonobuoy will be deployed by maritime patrol aircraft.

   In their request for a 2012 Letter of Authorization, the U.S. Navy proposed to maintain the number of AN/SSQ-125 (AEER sonar) sonobuoys it would employ at 1,550 each year while eliminating the use of the high-frequency active sonar, variable depth mine detection and classification system (AN/SQQ-32).

2.2.4 Torpedoes

Torpedoes (primarily MK-46 and MK-48) are the primary anti-submarine warfare weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively ensonifying the target and using the received echoes for guidance.

In addition to these torpedoes, the U.S. Navy employs Acoustic Device Countermeasures in several of their training exercises. These countermeasures (which include MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the AN/SLQ-25A NIXIE) act as decoys by making sounds that simulate submarines to avert localization or torpedo attacks. The U.S. Navy proposed to maintain the 2010 increase in the number of sonar hours associated with the AN/SLQ-25 NIXIE system and operate up to 2,500 hours each year while maintaining the zero hours use of the AN/SQQ-32 system.

2.2.5 Mine Warfare Sonar Systems

The U.S. Navy uses a variety of different sonar systems during mine warfare training exercises. These sonar systems are typically high-frequency sonars (i.e., greater than 10 kHz) that detect, locate, and characterize moored and bottom mines and can be deployed by helicopters, unmanned underwater vehicles, surf zone crawlers, or surface ships. The most mine warfare systems are deployed by helicopters and typically operate at high (greater than 200 kHz) frequencies. The types of tactical acoustic sources used during mine warfare sonar training activities include the following:

*Surface ship sonars***.** Guided missile destroyers, fast frigates, and guided missile cruisers can use their hull-mounted sonars (AN/SQS-53 and AN/SQS-56) in the object detection (Kingfisher) mode. These ships, as well as mine hunters, may utilize over-the-side unmanned underwater vehicle systems containing sonar sensor packages to detect and classify mine shapes. Navy minesweepers use the AN/SQQ-32, a variable depth mine detection and classification high-frequency active sonar system; although the U.S. Navy does not propose to employ this system as part of the active sonar training it plans to conduct along the Atlantic coast over the next twelve months. In addition, mine hunters are equipped with underwater acoustic communication systems.

*Submarine sonars***.** Submarines can use a sail-mounted sonar, AN/BQS-15, to detect mines and objects. In addition, they employ the AN/BLQ-11 Long Term Mine Reconnaissance System which is an unmanned underwater vehicle that, when in operation, can be launched and recovered through the torpedo tubes by all classes of submarines. It can be equipped with mid-frequency active sonar to detect mines and is intended to extend a submarine's reach for mine reconnaissance missions.

In addition, the U.S. Navy employs active sonar systems from aircraft as part of its mine warfare scenarios, including two systems in particular – AN/AQS-14, which is an active-controlled, helicopter-towed mine-hunting active sonar, and AN/AQS-24 which is an upgraded version of AN/AQS-14 – operate above 200 kHz.

2.3 Location of Training Activities

The U.S. Navy's Final Environmental Impact Statement for Atlantic Fleet Active Sonar Training (AFAST) identified specific areas where different training activities would occur. Some of those areas have been included in the narratives for specific training scenarios; the other locations are as follows:

2.3.1 Anti-submarine Warfare Training Areas

Anti-submarine warfare activities for all platforms could occur within and adjacent to the existing East Coast operating area beyond 22.2 km (12 nm) with the exception of sonar dipping activities, however, most anti-submarine warfare training involving submarines or submarine targets would occur in waters greater than 183 m (600 ft) deep due to safety concerns about running aground at shallower depths.

2.3.2 Helicopter Anti-Submarine Warfare Unit-Level Training Areas

Helicopter anti-submarine warfare Unit-Level Training is the only anti-submarine warfare activity that could occur within 22 km (12 nm) of shore. This activity would be conducted by helicopters embarked on a surface ship in the waters of the East Coast Operating Areas. Helicopter anti-submarine warfare Unit-Level Training events are also conducted by helicopters deployed from shore-based Jacksonville, Florida, units. These helicopter units use established sonar dipping areas off of Mayport, Florida, which are located in territorial waters and within the southeast Atlantic Ocean, off the coast of Jacksonville, Florida.

2.3.3 Torpedo Exercise Areas

Torpedo Exercises could occur anywhere within and adjacent to East Coast and Gulf of Mexico Operating Areas. The exception is in the Northeast Operating Area where the North Atlantic right whale feeding area exists. Torpedo Exercise areas that meet current operational requirements for proximity to torpedo and target recovery support facilities were established during earlier ESA Section 7 consultations with NMFS. As a result of these consultations, Torpedo Exercise activities in the northeast are limited to these established areas.

Torpedo firing activities would occur within the Virginia Capes and Gulf of Mexico Operating Areas, and within and seaward of the Northeast Operating Area. Due to operational requirements for torpedo recovery operations, support facilities must be located within 148 km (80 nm) of the torpedo exercise area.

2.3.4 Mine Warfare Training Areas

Mine Warfare Training could occur in territorial or non-territorial waters. Independent and Coordinated Mine Warfare Unit-Level Training activities would be conducted within and adjacent to the Pensacola and Panama City Operating Areas in the northern Gulf of Mexico and off the east coast of Texas in the Corpus Christi Operating Area. Squadron or Gulf of Mexico Exercises would be conducted in both deep and shallow water training areas.

2.3.5 Object Detection/Navigational Training Areas

Surface Ship training would be conducted primarily in the shallow water port entrance and exit lanes for Norfolk, Virginia and Mayport, Florida. The transit lane servicing Mayport, Florida, crosses through the southeast where North Atlantic right whales spent part of the year with calves. Submarine training would occur primarily in the established submarine transit lanes entering/exiting Groton, Connecticut; Norfolk, Virginia; and Kings Bay, Georgia. The transit lane servicing Kings Bay, Georgia, crosses through the southeast, where North Atlantic right whales spent part of the year with calves.

2.3.6 Surface Ship Sonar Maintenance Areas

Surface ships would be operating their active sonar systems for maintenance while pier side within their homeports, located in either Norfolk, Virginia or Mayport, Florida. Additionally open ocean sonar maintenance could occur anywhere within the non-territorial waters of the AFAST Study Area as the system's performance may warrant.

2.3.7 Submarine Sonar Maintenance Areas

Submarines would conduct maintenance to their sonar systems pier side in their homeports of either Groton, Connecticut; Norfolk, Virginia; or Kings Bay, Georgia. Additionally, sonar maintenance could occur anywhere within the waters of the AFAST Study Area as the system‘s performance may warrant.

2.4 Scope of the MMPA Letter of Authorization

The proposed LOA would authorize the "taking" of marine mammals by the Navy only if it occurs within the AFAST Study Area, which extends east from the Atlantic Coast of the U.S. to 45 degrees W longitude and south from the Atlantic and Gulf of Mexico Coasts to approximately 23 degrees N latitude, excluding the Bahamas (see Figure 2). The proposed LOA would authorize annual take levels for a two year period. The "taking" of marine mammals (as that term is defined for the purposes of the MMPA) by the Navy in 2012 and 2013 is only authorized if it occurs incidental to the use of the following mid-frequency active sonar (MFAS) sources, high frequency active sonar (HFAS) sources, or explosive sonobuoys for U.S. Navy anti-submarine warfare (ASW), mine warfare (MIW) training, maintenance, or research, development, testing, and evaluation (RDT&E) in the annual amounts indicated as follows (± 10 percent):

1. AN/SQS-53 (hull-mounted sonar) – 3214 hours
2. AN/SQS-56 (hull-mounted sonar) – 1684 hours
3. AN/SQS-56 or 53 (hull mounted sonar in object detection mode) – 216 hours
4. AN/BQQ-10 or 5 (submarine sonar) – 9976 pings (an average of 1 ping per two hours during training events, 60 pings per hour for maintenance)
5. AN/AQS-22 or 13 (helicopter dipping sonar) –2952 dips – 10 pings per five-minute dip
6. SSQ-62 (Directional Command Activated Sonobuoy System (DICASS) sonobuoys) – 5,853 sonobuoys
7. MK-48 (heavyweight torpedoes) – 32 torpedoes

8. MK-46 or 54 (lightweight torpedoes) – 24 torpedoes
9. AN/SSQ-110A (IEER explosive sonobuoy) and AN/SSQ-125 (AEER sonar sonobuoy) – 1725 and 1550 buoys, respectively
10. AN/SLQ-25 (NIXIE – towed countermeasure) – 2,500 hours
11. AN/BQS-15 (submarine navigation) – 450 hours
12. MK-1 or 2 or 3 or 4 (Submarine-fired Acoustic Device Countermeasure (ADC)) - 225 ADCs
13. Noise Acoustic Emitters (NAE – Sub-fired countermeasure) - 127 NAEs

Notwithstanding the forms of takings contemplated in the regulations and that would be authorized by the proposed LOA, the regulations do not authorize persons connected with the activities the regulations cover to:

1. “Take” any marine mammals that are not specifically identified in the regulations;
2. “Take” any of the marine mammals identified in the regulations other than by incidental take;
3. “Take” a marine mammal identified in the regulations if such taking results in more than a negligible impact on the species or stocks of such marine mammal; or
4. Violate, or fail to comply with, the terms, conditions, and requirements of the regulations or Letter of Authorization issued under the regulations.

2.5 The U.S. Navy’s Mitigation Measures

As required to satisfy the requirements of the MMPA, the U.S. Navy’s has developed and implements measures that are designed to allow their training activities to have the least practicable adverse impact on marine mammal species or stocks (which includes considerations of personnel safety, practicality of implementation, and impact on the effectiveness of the “military readiness activity”). Those measures are summarized in this section of this Opinion; for a complete description of all of the measures applicable to its training activities, readers should refer to the U.S. Navy’s request for a letter of authorization and the Permit Division’s MMPA regulations:

The U.S. Navy does not currently conduct active sonar training in feeding or calving habitat for the North Atlantic right whale with the exception of object detection and navigation off shore Mayport, Florida and Kings Bay, Georgia; helicopter anti-submarine warfare training activities offshore Mayport, Florida; and torpedo exercises in the northeast during the months of August and September. The U.S. Navy does not plan to conduct active sonar activities within the Stellwagen Bank, Monitor, Gray’s Reef, Flower Garden Banks, and Florida Keys National Marine Sanctuaries and will avoid these sanctuaries by observing a 5 km (2.7 nm) buffer. In addition, the U.S. Navy uses the following measures to mitigate the effects of its training activities on marine mammals: [2]

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[2] The numbering of this section is consistent with the LOA rather than adopting the numbering outline of this biological opinion.

1.0 *Measures Applicable to Hull-Mounted Surface and Submarine Active Sonar*.

1.1 Personnel Training

1.1.1 All lookouts onboard platforms involved in ASW training events will review the NMFS approved MSAT material prior to MFA sonar use.

1.1.2 All Commanding Officers, Executive Officers, and officers standing watch on the Bridge will have reviewed the MSAT material prior to a training event employing the use of MFA sonar.

1.1.3 Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).

1.1.4 Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, Lookouts will complete the Personal Qualification Standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). This does not preclude personnel being trained as lookouts from being counted as those listed in previous measures so long as supervisors monitor their progress and performance.

1.1.5 Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

1.2 Lookout and Watchstander Responsibilities

1.2.1 On the bridge of surface ships, there will always be at least three personnel on watch whose duties include observing the water surface around the vessel.

1.2.2 In addition to the three personnel on watch noted previously, all surface ships participating in ASW exercises will have at least two additional personnel on watch as lookouts at all times during the exercise.

1.2.3 Personnel on lookout and officers on watch on the bridge will have at least one set of binoculars available for each person to aid in the detection of marine mammals.

1.2.4 On surface vessels equipped with MFA sonar, pedestal mounted “Big Eye” (20x110) binoculars will be present and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.

1.2.5 Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).

1.2.6 After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook.

1.2.7 At night, lookouts would not sweep the horizon with their eyes, because this method is not effective when the vessel is moving. Lookouts would scan the horizon in a series of movements that would allow their eyes to come to periodic rests as they scan the sector. When visually searching at night, they would look a little to one side and out of the corners of their eyes, paying attention to the things on the outer edges of their field of vision. Lookouts will also have night vision devices available for use.

1.2.8 Personnel on lookout will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the Officer of the Deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided as warranted.

1.3 Operating procedures

1.3.1 Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.

1.3.2 All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) will monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.

1.3.3 During MFA sonar operations, personnel will utilize all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.

1.3.4 Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

1.3.5 Aircraft with deployed sonobuoys will use only the passive capability of sonobuoys when marine mammals are detected within 200 yards of the sonobuoy.

1.3.6 Marine mammal detections will be immediately reported to assigned Aircraft Control Unit (if participating) for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.

1.3.7 Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically), the Navy will ensure that MFA transmission levels are limited to at least 6 decibels (dB) below normal operating levels if any detected animals are within 1,000 yards of the sonar dome (the bow)

(i) Ships and submarines will continue to limit maximum MFA transmission levels by this 6-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards beyond the location of the last detection.

(ii) The Navy will ensure that MFA sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level if any detected animals are within 500 yards of the sonar dome. Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards beyond the location of the last detection.

(iii) The Navy will ensure that MFA sonar transmissions will cease if any detected animals are within 200 yards of the sonar dome. MFA sonar will not resume until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards beyond the location of the last detection.

(iv) Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the Officer of the Deck concludes that dolphins or porpoises are deliberately closing to ride the vessel's bow wave, no further mitigation actions are necessary while the dolphins or porpoises continue to exhibit bow wave riding behavior.

(v) If the need for MFA sonar power-down should arise as detailed in “Safety Zones” above, the ship or submarine shall follow the requirements as though they were operating MFA sonar at 235 dB—the normal operating level (i.e., the first power-down will be to 229 dB, regardless of at what level above 235 dB the MFA sonar was being operated).

1.3.8 Prior to start up or restart of MFA sonar, operators will check that the Safety Zone radius around the sound source is clear of marine mammals.

1.3.9 MFA sonar levels (generally)—the ship or submarine will operate MFA sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

1.3.10 If the need for power-down should arise, as detailed in ―Safety Zones (above), Navy staff would follow the requirements as though they were operating at 235 dB - the normal operating level (i.e., the first power-down would be to 229 dB, regardless of the level above 235 db the sonar was being operated).

1.3.11 Prior to start up or restart of active sonar, operators would check that the safety zone radius around the sound source is clear of marine mammals.

1.3.12 Sonar levels (generally) – The Navy would operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

1.3.13 Helicopters would observe/survey the vicinity of an ASW exercise for 10 minutes before the first deployment of active (dipping) sonar in the water.

1.3.14 Helicopters would not dip their sonar within 183 m (200 yd) of a marine mammal and would cease pinging if a marine mammal closes within 183 m (200 yd) after pinging has begun.

1.3.15 Submarine sonar operators would review detection indicators of close-aboard marine mammals prior to the commencement of ASW operations involving active mid-frequency sonar.

2.0 *Mitigation measures associated with events using IEER/AEER Sonobuoys*

a. Pattern Deployment:

- Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 1500 feet (ft) at a slow speed when operationally feasible and weather conditions permit. In dual aircraft operations, crews may conduct coordinated area clearances.

- Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post (source/receiver sonobuoy pair) detonation (AN/SSQ-110 only) or activated (AN/SSQ-125). This 30 minute observation period may include pattern deployment time.

- For any part of the briefed pattern where a post will be deployed within 1000 yards (yds) of observed marine mammal activity, crews will deploy the receiver only and monitor while conducting a visual search. When marine mammals are no longer detected within 1000 yds of the intended post position, crews will collocate the AN/SSQ-110A sonobuoy (source) with the receiver.

- When operationally feasible, crews will conduct continuous visual and aural monitoring of marine mammal activity, including monitoring of their aircraft sensors from first sensor placement to checking off-station and out of RF range of the sensors.

b. Pattern Employment:

(i) Aural Detection:

- Aural detection of marine mammals cues the aircrew to increase the diligence of their visual surveillance.

- If, following aural detection, no marine mammals are visually detected, then the crew may continue multi-static active search.

(ii) Visual Detection:

- If marine mammals are visually detected within 1000 yds of the AN/SSQ-110A sonobuoy intended for use, then that payload shall not be detonated (AN/SSQ_110 only) or activated (AN/SSQ-125).

Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes or are observed to have moved outside the 1000 yd safety zone.

- Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1000 yd safety zone.

c. AN/SSQ-110A Scuttling Sonobuoys:

(i) Aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the "Payload 1 Release" command followed by the "Payload 2 Release" command (applies to SSQ-110 sonobuoys only; SSQ-125 sonobuoys do not contain an explosive charge). Aircrews shall refrain from using the "Scuttle" command when two payloads remain at a given post. Aircrews will ensure a 1000 yd safety zone, visually clear of marine mammals, is maintained around each post as is done during active search operations.

(ii) Aircrews shall only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary method or tertiary method.

Aircrews ensure all payloads are accounted for. Sonobuoys that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne and, upon landing, via Naval message.

(iii) Mammal monitoring shall continue until out of their aircraft sensor range.

3.0 *Special Conditions Applicable to Bow-riding Dolphins*

If, after conducting an initial maneuver to avoid close quarters with dolphins, the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel‘s bow wave, no further mitigation actions would be necessary because dolphins are out of the main transmission axis of the active sonar while in the shallow-wave area of the vessel bow.

4.0 *Planning Awareness Areas*

The Navy has designated several Planning Awareness Areas (PAAS) based on areas of high productivity that have been correlated with high concentrations of marine mammals (such as persistent oceanographic features like upwellings associated with the Gulf Stream front where it is deflected off the east coast near the Outer Banks), and areas of steep bathymetric contours that are frequented by deep diving marine mammals such as beaked whales and sperm whales. In developing the PAAS, U.S. Fleet Forces (USFF) was able to consider these factors because of geographic flexibility in conducting ASW training. USFF is not tied to a specific range support structure for the majority of the training for AFAST. Additionally, the topography and bathymetry along the East Coast and in the Gulf of Mexico is unique in that there is a wide continental shelf leading to the shelf break affording a wider range of training opportunities.

4.1 The Navy shall avoid planning major exercises in the specified PAAS where feasible. Should national security require the conduct of more than four major exercises (Composite Training Unit Exercise [COMPTUEX], Joint Task Force Exercise [JTFEX], Southeastern ASW Integrated Training Initiative [SEASWITI], or similar scale event) in these areas (meaning all or a portion of the exercise) per year the Navy shall provide NMFS with prior notification and include the information in any associated after-action or monitoring reports.

4.2 To the extent operationally feasible, the Navy plans to conduct no more than one of the four above-mentioned major exercises (COMPTUEX, JTFEX, SEASWITI, or similar scale event) per year in the Gulf of Mexico. Based on operational requirements, the exercise area for this one exercise may include the De Soto Canyon. If national security needs require more than one major exercise to be conducted in the PAAS which includes portions of the DeSoto Canyon, the Navy would provide NMFS with prior notification and include the information in any associated after-action or monitoring reports.

4.3 The PAAS will be included in the Navy's Protective Measures Assessment Protocol (PMAP) (implemented by the Navy for use in the protection of the marine environment) for unit level situational awareness (i.e., exercises other than COMPTUEX, JTFEX, SEASWITI). The goal of PMAP is to raise awareness in the fleet and ensure common sense and informed oversight is injected into planning processes for testing and training evolutions.

4.4 Helicopter Dipping Sonar in southeast habitat identified for North Atlantic right whale calving

4.4.1 Helicopter Dipping Sonar is one of the two activity types that have been identified as planned to occur in the southern North Atlantic right whale calving areas. Historically, only maintenance of helicopter dipping sonars occurs within a portion of the North Atlantic right whale calving areas. Tactical training with helicopter dipping sonar does not typically occur in the North Atlantic right whale calving areas at any time of the year. The calving areas are used on occasion for post maintenance operational checks and equipment testing due to its proximity to shore. Unless otherwise dictated by national security needs, the Navy will minimize helicopter dipping sonar maintenance within the southeast North Atlantic right whale calving habitat from November 15 to April 15.

4.5 Object Detection Exercises in North Atlantic right whale calving areas

4.5.1 Object detection training requirements are another type of activity that has been identified as planned to occur in the southern North Atlantic right whale calving areas. The Navy recognizes the significance of the North Atlantic right whale calving area and has explored ways of effecting the least practicable impact (which includes a consideration of practicality of implementation and impacts to training fidelity) to right whales. Navy units will incorporate data from the Early Warning System (EWS) into exercise pre-planning efforts. The USFF contributes more than $150,000 annually for aerial surveys that support the EWS, a communication network that assists afloat commands to avoid interactions with right whales. Fleet Area Control and Surveillance Facility, Jacksonville (FACSFAC JAX) houses the Whale Fusion Center, which disseminates the latest right whale sighting information to Navy ships, submarines, and aircraft. Through the

Fusion Center, FACSFAC JAX coordinates ship and aircraft movement into the right whale calving area and the surrounding operating areas based on season, water temperature, weather conditions, and frequency of whale sightings and provides right whale reports to ships, submarines and aircraft, including coast guard vessels and civilian shipping. The Navy proposes to:

4.5.2 Reduce the time spent conducting object detection exercises in the North Atlantic right whale calving areas.

4.5.3 Prior to conducting surface ship object detection exercises in the southeast North Atlantic right whale calving areas during the time of November 15 to April 15, ships will contact FACSFAC JAX to obtain the latest right whale sighting information. The FACSFAC JAX will advise ships of all reported whale sightings in the vicinity of the calving areas and Associated Area of Concern. To the extent operationally feasible, ships will avoid conducting training in the vicinity of recently sighted right whales. Ships will maneuver to maintain at least 457 m (500 yd) separation from any observed whale, consistent with the safety of the ship.

5.0 *Mitigation Measures Related To Vessel Transit and North Atlantic Right Whales*

In 1999, a Mandatory Ship Reporting System was implemented by the U.S. Coast Guard, which requires vessels larger than 300 gross registered tons (Department of the Navy ships are exempt) to report their location, course, speed, and destination upon entering the nursery and feeding areas of the right whale. At the same time, ships receive information on locations of right whale sightings, in order to avoid collisions with the animals. In the south-eastern United States, the reporting system is from November 15 through April 15 of each year; the geographical boundaries include coastal waters within roughly 46 kilometers (25 nautical miles of shore along a 167 km (90 nm) stretch of the Atlantic coast in Florida and Georgia. In the northeastern United States, the reporting system is year-round and the geographical boundaries include the waters of Cape Cod Bay, Massachusetts Bay, and the Great South Channel east and southeast of Massachusetts; it includes all of Stellwagen Bank National Marine Sanctuary; a portion of the Boston OPAREA falls within these boundaries. Specific naval mitigation measures for each region of the AFAST Study Area are discussed in the following subsections.

5.1 Mid-Atlantic, Offshore of the Eastern United States

For purposes of these measures, the mid-Atlantic is defined broadly to include ports south and east of Block Island Sound southward to South Carolina. The procedure described below would be established as mitigation measures for Navy vessel transits during Atlantic right whale migratory seasons near ports located off the western North Atlantic, offshore of the eastern United States. The mitigation measures would apply to all Navy vessel transits, including those vessels that would transit to and from East Coast ports and OPAREAS. Seasonal migration of right whales is generally described by NMFS as occurring from October 15th through April 30th, when right whales migrate between feeding grounds farther north and calving grounds farther south. The Navy mitigation measures have been established in accordance with rolling dates identified by NMFS consistent with these seasonal patterns. NMFS has identified ports located in the western Atlantic Ocean, offshore of the southeastern United States, where vessel transit during right whale migration is of highest concern for potential ship strike. The ports include the Hampton Roads entrance to the Chesapeake Bay, which includes the concentration of Atlantic Fleet vessels in Norfolk, Virginia. Navy vessels are required to use extreme caution and operate at a slow, safe speed consistent with mission and safety during the months (indicated in Table 5-1 of the Final EIS for Atlantic Fleet Active Sonar Training) and within a 37 kilometer (20 nautical mile) arc (except as noted) of the specified reference points.

During the indicated months, Navy vessels would practice increased vigilance with respect to avoidance of vessel-whale interactions along the mid-Atlantic coast, including transits to and from any mid-Atlantic ports not specifically identified above. All surface(d) units transiting within 56 km (30 nm) of the coast in the mid-Atlantic would ensure at least two watchstanders are posted, including at least one lookout that has completed required MSAT training. Furthermore, Navy vessels would not knowingly approach any whale head on and would maneuver to keep at least 457 m (500 yd) away from any observed whale, consistent with vessel safety.

5.2 Southeast Atlantic, Offshore of the Eastern United States

For purposes of these measures, the southeast encompasses sea space from Charleston, South Carolina, southward to Sebastian Inlet, Florida, and from the coast seaward to 148 km (80 nm) from shore. The mitigation measures described in this section were developed specifically to protect the North Atlantic right whale during its calving season (Typically from November 15 through April 15). During this period, North Atlantic right whales give birth and nurse their calves off the coast of Georgia and Florida.

This habitat is the area from 31-15N to 30-15N extending from the coast out to 28 km (15 nm), and the area from 28-00N to 30-15N from the coast out to 9 km (5 nm). All mitigation measures that apply to the calving areas also apply to an associated area of concern which extends 9 km (5 nm) seaward of the designated boundaries. Prior to transiting or training in an area of concern, ships will contact Fleet Area Control and Surveillance Facility, Jacksonville, to obtain latest whale sighting and other information needed to make informed decisions regarding safe speed and path of intended movement. Subs shall contact Commander, Submarine Group Ten for similar information. Specific mitigation measures related to activities occurring within an area of concern include the following:

5.2.1 When transiting within an area of concern, vessels will exercise extreme caution and proceed at a slow safe speed. The speed will be the slowest safe speed that is consistent with mission, training and operations.

5.2.2 Speed reductions (adjustments) are required when a whale is sighted by a vessel or when the vessel is within 9 km (5 nm) of a reported new sighting less than 12 hours old.

5.2.3 Additionally, circumstances could arise where, in order to avoid North Atlantic right whale(s), speed reductions could mean a vessel must reduce speed to a minimum at which it can safely keep on course or vessels could come to an all stop.

5.2.4 Vessels will avoid head-on approach to North Atlantic right whale(s) and will maneuver to maintain at least 457 m (500 yd) of separation from any observed whale if deemed safe to do so. These requirements do not apply if a vessel‘s safety is threatened, such as when change of course would create an imminent and serious threat to person, vessel, or aircraft, and to the extent vessels are restricted in the ability to maneuver.

5.2.5 Ships shall not transit through an area of concern in a North-South direction.

5.2.6 Ship, surfaced subs, and aircraft will report any whale sightings to Fleet Area Control and Surveillance Facility, Jacksonville, by most convenient and fast means. Sighting report will include the time, latitude/longitude, direction of movement and number and description of whale (i.e., adult/calf).

5.3 Northeast Atlantic, Offshore of the Eastern United States

The protective measures described in this section apply to aircraft operating in the Boston OPAREA (Warning Areas W-102, W-103, and W-104), as well as ships operating within the entire Atlantic Fleet area of responsibility (AOR), except those areas off the southeastern U.S. already covered in previous discussion.

Prior to transiting the Great South Channel or Cape Cod Bay feeding areas, ships will obtain the latest right whale sightings and other information needed to make informed decisions regarding safe speed. The Great South Channel feeding area is defined by the following coordinates: 41-00N, 69-05W; 41-45N, 69-45W; 42-10N, 68-31W; 41-38N, 68-13W. The Cape Cod Bay feeding areas are defined by the following coordinates: 42-04.8N, 70-10W; 42-12N, 70-15W; 42-12N, 70-30W; 41-46.8N, 70-30W. Ships, surfaced subs, and aircraft will report any North Atlantic right whale sightings (if the whale is identifiable as a right whale) off the northeastern U.S. to Patrol and Reconnaissance Wing (COMPATRECONWING). The report will include the time of sighting, lat/long, direction of movement (if apparent) and number and description of the whale(s). In addition, vessels or aircraft that observe whale carcasses will record the location and time of the sighting and report this information as soon as possible to the regional environmental coordinator. All whale strikes must be reported. Report will include the date, time, and location of the strike; vessel course and speed; operations being conducted by the vessel; weather conditions, visibility, and sea state; description of the whale; narrative of incident; and indication of whether photos/videos were taken. Units are encouraged to take photos whenever possible. Specific mitigation measures related to activities occurring within an area of concern include the following:

5.3.1 Vessels will avoid head-on approach to North Atlantic right whale(s) and will maneuver to maintain at least 457 m (500 yd) of separation from any observed whale if deemed safe to do so. These requirements do not apply if a vessel‘s safety is threatened, such as when change of course would create an imminent and serious threat to person, vessel, or aircraft, and to the extent vessels are restricted in the ability to maneuver.

5.3.2 When transiting within an area of concern, vessels shall use extreme caution and operate at a safe speed so as to be able to avoid collisions with North Atlantic right whales and other marine mammals, and stop within a distance appropriate to the circumstances and conditions.

5.3.3 Speed reductions (adjustments) are required when a whale is sighted by a vessel or when the vessel is within 9 km (5 NM) of a reported new sighting less than one week old.

5.3.4 Ships transiting in the Cape Cod Bay and Great South Channel feeding areas will obtain information on recent whale sightings in the vicinity of the feeding areas. Any vessel operating in the vicinity of a North Atlantic right whale shall consider additional speed reductions as per Rule 6 of International Navigational Rules.

5.4 Additional Mitigation for Torpedo Exercises (TORPEXs) in the Northeast North Atlantic right whale feeding areas. Any TORPEXs in locations other than the Northeast will utilize the measures described in Section 5.1. TORPEXs conducted in the five TORPEXs training areas off of Cape Cod, which may occur in right whale feeding areas, will implement the following measures:

5.4.1 All torpedo-firing operations shall take place during daylight hours.

5.4.2 During the conduct of each test, visual surveys of the test area shall be conducted by all vessels and aircraft involved in the exercise to detect the presence of marine mammals. Additionally, trained observers shall be placed on the submarine, spotter aircraft, and the surface support vessel. All participants will be required to report sightings of any marine mammals, including negative reports, prior to torpedo firings. Reporting requirements will be outlined in the test plans and procedures written for each individual exercise, and will be emphasized as part of pre-exercise briefings conducted with all participants.

5.4.3 Observers shall receive NMFS -approved training in field identification, distribution, and relevant behaviors of marine mammals of the western north Atlantic. Currently, this training is provided by a professor at the University of Rhode Island, Graduate School of Oceanography. Observers shall fill out Standard Sighting Forms and the data will be housed at the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT). Any sightings of North Atlantic right whales shall be immediately communicated to the Sighting Advisory System (SAS). All platforms shall have onboard a copy of the following:

5.4.4 The Guide to Marine Mammals and Turtles of the U.S. Atlantic and Gulf of Mexico (Wynne and Schwartz. 1999).

5.4.5 The NMFS Critical Sightings Program placard.

5.4.6 Right Whales, Guidelines to Mariners placard.

5.4.7 In addition to the visual surveillance discussed above, dedicated aerial surveys shall be conducted utilizing a fixed-wing aircraft. An aircraft with an overhead wing (i.e., Cessna Skymaster or similar) will be used to facilitate a clear view of the test area. Two trained observers, in addition to the pilot, shall be embarked on the aircraft. Surveys will be conducted at an approximate altitude of 305 m (1,000 feet [ft]) flying parallel track lines at a separation of 1.85 km (1 nm), or as necessary to facilitate good visual coverage of the sea surface. While conducting surveillance, the aircraft shall maintain an approximate speed of 185 kilometers per hour (km/hr) (100 knots [kn]). Since factors that affect visibility are highly dependent on the specific time of day of the survey, the flight operator will have the flexibility to adjust the flight pattern to reduce glare and improve visibility. The entire test site will be surveyed initially, but once preparations are being made for an actual test launch, survey effort will be concentrated over the vicinity of the individual test location. Further, for approximately ten minutes immediately prior to launch, the aircraft will racetrack back and forth between the launch vessel and the target vessel.

5.4.8 Commencement of an individual torpedo test scenario shall not occur until observers from all vessels and aircraft involved in the exercise have reported to the Officer in Tactical Command (OTC) and the OTC has declared that the range is clear of marine mammals. Should protected animals be present within or seen moving toward the test area, the test shall be either delayed or moved as required to avoid interference with the animals.

5.4.9 The TORPEX will be suspended if the Beaufort Sea State exceeds 3 or if visibility precludes safe operations.

5.4.10 Vessel speeds:

- During transit through the North Atlantic right whale feeding areas, surface vessels and submarines shall maintain a speed of no more than 19 km/hr (10 km) while not actively engaged in the exercise procedures.
- During TORPEX operations, a firing vessel will likely not exceed 19 km/hr (10 km). When a submarine is used as a target, vessel speeds would not likely exceed 33 km/hr (18 km). However, on occasion, when surface vessels are used as targets, the vessel may exceed 33 km/hr (18 km) in order to fully test the functionality of the torpedoes. This increased speed would occur for a short period of time (e.g., 10 to 15 minutes) to evade the torpedo when fired upon.
- In the event of an animal strike, or if an animal is discovered that appears to be in distress, a report will immediately be promulgated through the appropriate Navy chain of Command.

2.6 Mitigation Requirements of the MMPA Letter of Authorization

When the U.S. Navy conducts the training activities identified in the Permit Division's Letter of Authorization, the final regulations and draft LOA that NMFS' Permits Division proposes to issue require the U.S. Navy to implement mitigation measures that include (but are not limited to) the following:

2.6.1 Mitigation

The Holder of this Authorization, and any person(s) operating under his authority, must implement the following mitigation measures when conducting activities identified in 50 CFR § 216.240(c) and Condition 4(a) of this Authorization: [3]

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[3] The outline scheme of this section is consistent with the proposed LOA rather than following the numbering outline of this document

(a) Mitigation Measures for ASW and MIW training:

(i) All Lookouts onboard platforms involved in ASW training events shall review the NMFS-approved Marine Species Awareness Training (MSAT) material prior to use of mid-frequency active sonar.

(ii) All Commanding Officers, Executive Officers, and officers standing watch on the Bridge shall review the MSAT material prior to a training event employing the use of mid- or high-frequency active sonar.

(iii) Navy Lookouts shall undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (NAVEDTRA, 12968-D).

(iv) Lookout training shall include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, Lookouts shall complete the Personal Qualification Standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects).

(v) Lookouts shall be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of mitigation measures if marine mammals are spotted.

(vi) On the bridge of surface ships, there shall always be at least three people on watch whose duties include observing the water surface around the vessel.

(vii) All surface ships participating in ASW exercises shall, in addition to the three personnel on watch noted previously, have at all times during the exercise at least two additional personnel on watch as lookouts.

(viii) Personnel on lookout and officers on watch on the bridge shall have at least one set of binoculars available for each person to aid in the detection of marine mammals.

(ix) On surface vessels equipped with MFAS, pedestal-mounted “Big Eye” (20x110) binoculars shall be present and in good working order.

(x) Personnel on lookout shall employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D). Surface lookouts should scan the water from the ship to the horizon and be responsible for all contacts in their sector. In searching the assigned sector, the lookout should always start at the forward part of the sector and search aft (toward the back). To search and scan, the lookout should hold the binoculars steady so the horizon is in the top third of the field of vision and direct the eyes just below the horizon. The lookout should scan for approximately five seconds in as many small steps as possible across the field seen through the binoculars. They should search the entire sector in approximately five-degree steps, pausing between steps for approximately five seconds to scan the field of view. At the end of the sector search, the glasses should be lowered to allow the eyes to rest for a few seconds, and then the lookout should search back across the sector with the naked eye.

(xi) After sunset and prior to sunrise, lookouts shall employ Night Lookout Techniques in accordance with the Lookout Training Handbook. At night, lookouts should not sweep the horizon with their eyes because this method is not effective when the vessel is moving. Lookouts should scan the horizon in a series of movements that should allow their eyes to come to periodic rests as they scan the sector. When visually searching at night, they should look a little to one side and out of the corners of their eyes, paying attention to the things on the outer edges of their field of vision.

(xii) Personnel on lookout shall be responsible for informing the Officer of the Deck of all objects or anomalies sighted in the water (regardless of the distance from the vessel), since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided as warranted.

(xiii) Commanding Officers shall make use of marine mammal detection cues and information to limit interaction with marine mammals to the maximum extent possible consistent with safety of the ship.

(xiv) All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) shall monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.

(xv) Units shall use training lookouts to survey for marine mammals prior to commencement and during the use of active sonar.

(xvi) During operations involving sonar, personnel shall utilize all available sensor and optical systems (such as Night Vision Goggles) to aid in the detection of marine mammals.

(xvii) Navy aircraft participating in exercises at sea shall conduct and maintain, when operationally feasible and safe, surveillance for marine mammals as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

(xviii) Aircraft with deployed sonobuoys shall use only the passive capability of sonobuoys when marine mammals are detected within 200 yards (183 m) of the sonobuoy.

(xix) Marine mammal detections shall be reported immediately to assigned Aircraft Control Unit (if participating) for further dissemination to ships in the vicinity of the marine mammals. This action shall occur when it is reasonable to conclude that the course of the ship will likely close the distance between the ship and the detected marine mammal.

(xx) Safety Zones - When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmission levels are limited to at least 6 dB below normal operating levels if any detected marine mammals are within 1,000 yards (914 m) of the sonar dome (the bow).

> (A) Ships and submarines shall continue to limit maximum transmission levels by this 6-dB factor until the marine mammal has been seen to leave the 1,000-yd safety zone, has not been detected

for 30 minutes, or the vessel has transited more than 2,000 yards (1829 m) beyond the location of the last detection.

(B) When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmission levels are limited to at least 10 dB below normal operating levels if any detected marine mammals are within 500 yards (457 m) of the sonar dome (the bow). Ships and submarines shall continue to limit maximum ping levels by this 10-dB factor until the marine mammal has been seen to leave the 500-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards (1829 m) beyond the location of the last detection.

(C) When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmissions cease if any detected marine mammals are within 200 yards (183 m) of the sonar dome (the bow). Sonar shall not resume until the marine mammal has been seen to leave the 200-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards (1829 m) beyond the location of the last detection.

(D) If the need for power-down should arise as detailed in this section, Navy shall follow the requirements as though they were operating at 235 dB – the normal operating level (i.e., the first power-down shall be to 229 dB, regardless of at what level above 235 sonar was being operated).

(xxi) Prior to start up or restart of active sonar, operators shall check that the Safety Zone radius around the sound source is clear of marine mammals.

(xxii) Sonar levels (generally) – The Navy shall operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

(xxiii) Helicopters shall observe/survey the vicinity of an ASW Operation for 10 minutes before the first deployment of active (dipping) sonar in the water.

(xxiv) Helicopters shall not dip their sonar within 200 yards (183 m) of a marine mammal and shall cease pinging if a marine mammal closes within 200 yards (183 m) of the helicopter after pinging has begun.

(xxv) Submarine sonar operators shall review detection indicators of close-aboard marine mammals prior to the commencement of ASW training activities involving active sonar.

(xxvi) Night vision devices shall be available to all ships and air crews, for use as appropriate.

(xxvii) Dolphin bowriding - if, after conducting an initial maneuver to avoid close quarters with dolphins, the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave, no further mitigation actions would be necessary because dolphins are out of the main transmission axis of the active sonar while in the shallow-wave area of the vessel bow.

(xxviii) TORPEXs conducted in the North Atlantic right whale (NARW) Great South Channel or Cape Cod Bay critical habitats (previously referred to as northeastern NARW feeding habitat) shall implement the following measures. The Great South Channel NARW critical habitat is defined as follows: The area bounded by 41deg.40' N/69 deg.45' W; 41 deg.00' N/69 deg.05' W; 41 deg.38' N/68 deg.13' W; and 42 deg.10' N/68 deg.31' W. The Cape Cod Bay NARW critical habitat is defined as follows: the area bounded by 42 deg. 04.8' N/70 deg.10' W; 42 deg 12' N/70 deg.15' W; 42 deg.12' N/70 deg.30' W; 41 deg.46.8' N/70 deg.30' W and on the south and east by the interior shore line of Cape Cod, Massachusetts.

(A) All torpedo-firing operations shall take place during daylight hours.

(B) During the conduct of each test, visual surveys of the test area shall be conducted by all vessels and aircraft involved in the exercise to detect the presence of marine mammals. Additionally, trained observers shall be placed on the submarine, spotter aircraft, and the surface support vessel. All participants shall report sightings of any marine mammals, including negative reports, prior to torpedo firings. Reporting requirements shall be outlined in the test plans and procedures written for each individual exercise, and shall be emphasized as part of pre-exercise briefings conducted with all participants.

(C) Observers shall receive NMFS-approved training in field identification, distribution, and relevant behaviors of marine mammals of the western north Atlantic. Observers shall fill out Standard Sighting Forms and the data shall be housed at the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT). Any sightings of North Atlantic right whales shall be immediately communicated to the Sighting Advisory System (SAS). All platforms shall have onboard a copy of:

(1) The Guide to Marine Mammals and Turtles of the US Atlantic and Gulf of Mexico (Wynne and Schwartz 1999)

(2) The NMFS Critical Sightings Program placard

(3) Right Whales, Guidelines to Mariners placard

(D) In addition to the visual surveillance discussed above, dedicated aerial surveys shall be conducted utilizing a fixed-wing aircraft. An aircraft with an overhead wing (i.e., Cessna Skymaster or similar) shall be used to facilitate a clear view of the test area. Two trained observers, in addition to the pilot, shall be embarked on the aircraft. Surveys shall be conducted at an approximate altitude of 1000 ft (305 m) flying parallel track lines at a separation of 1 nmi (1.85 km), or as necessary to facilitate good visual coverage of the sea surface. While conducting surveillance, the aircraft shall maintain an approximate speed of 100 knots (185 km/hr). Since factors that affect visibility are highly dependent on the specific time of day of the survey, the flight operator will have the flexibility to adjust the flight pattern to reduce glare and improve visibility. The entire test site shall be surveyed initially, but once preparations are being made for an actual test launch, survey effort shall be concentrated over the vicinity of the individual test location. Further, for approximately ten minutes immediately prior to launch, the aircraft shall racetrack back and forth between the launch vessel and the target vessel.

(E) Commencement of an individual torpedo test scenario shall not occur until observers from all vessels and aircraft involved in the exercise have reported to the Officer in Tactical Command (OTC) and the OTC has declared that the range is clear of marine mammals. Should marine mammals be present within or seen moving toward the test area, the test shall be either delayed or moved as required to avoid interference with the animals.

(F) The TORPEX shall be suspended if the Beaufort Sea State exceeds 3 or if visibility precludes safe operations.

(G) Vessel speeds:

(1) During transit through the NARW Great South Channel or Cape Cod Bay critical habitats, surface vessels and submarines shall maintain a speed of no more than 10 knots (19 km/hr) while not actively engaged in the exercise procedures.

(2) During TORPEX operations, a firing vessel should, where feasible, not exceed 10 knots. When a submarine is used as a target, vessel speeds should, where feasible, not exceed 18 knots. However, on occasion, when surface vessels are used as targets, the vessel may exceed 18 kts in order to fully test the functionality of the torpedoes. This increased speed would occur for a short period of time (e.g., 10-15 minutes) to evade the torpedo when fired upon.

(H) In the event of an animal strike, or if an animal is discovered that appears to be in distress, the Navy shall immediately report the discovery through the appropriate Navy Chain of Command.

(xxix) The Navy shall abide by the following additional measures:

(A) The Navy shall avoid planning major exercises in the specified planning awareness areas (PAAs - see Figure 2 in 50 CFR 216 Subpart V) where feasible. Should national security require the conduct of more than four major exercises (C2X, JTFEX, SEASWITI, or similar scale event) in these areas (meaning all or a portion of the exercise) per year the Navy shall provide NMFS with prior notification and include the information in any associated after-action or monitoring reports.

(B) The Navy shall conduct no more than one of the four above-mentioned major exercises (COMPTUEX, JTFEX, SEASWITI or similar scale event) per year in the Gulf of Mexico to the extent operationally feasible. If national security needs require more than one major exercise to be conducted in the Gulf of Mexico PAAs, the Navy shall provide NMFS with prior notification and include the information in any associated after-action or monitoring reports.

(C) The Navy shall include the PAAs in the Navy's Protective Measures Assessment Protocol (PMAP) (implemented by the Navy for use in the protection of the marine environment) for unit level situational awareness (i.e., exercises other than COMPTUEX, JTFEX, SEASWITI) and planning purposes.

(D) Helicopter Dipping Sonar - Unless otherwise dictated by national security needs, the Navy shall minimize helicopter dipping sonar activities within the NARW critical habitat (previously referred to as southeastern NARW calving habitat) from November 15 – April 15. NARW critical habitat is defined as follows: The coastal waters between 31 deg.15' N and 30 deg.15' N from the coast out 15 nautical miles; and the coastal waters between 30 deg.15' N and 28 deg.00' N from the coast out 5 nautical miles. All mitigation measures described in this LOA that apply to the critical habitat are in effect from November 15 – April 15 and also apply to an associated area of concern which extends 9 km (5 nm) seaward of the designated critical habitat boundaries.

(E) Object Detection Exercises – The Navy shall implement the following measures regarding object detection activities in the North Atlantic right whale critical habitat:

(1) The Navy shall reduce the time spent conducting object detection exercises in the NARW critical habitat;

(2) Prior to conducting surface ship object detection exercises in the NARW critical habitat during the time of November 15 – April 15, ships shall contact FACSFACJAX to obtain the latest North Atlantic right whale sighting information. FACSFACJAX shall advise ships of all reported whale sightings in the vicinity of the NARW critical habitat and associated areas of concern (which extend 9 km (5 nm) seaward of the critical habitat boundaries). To the extent operationally feasible, ships shall avoid conducting training in the vicinity of recently sighted North Atlantic right whales. Ships shall maneuver to maintain at least 500 yards (457 m) separation from any observed whale, consistent with the safety of the ship.

(xxx) The Navy shall abide by the letter of the “Stranding Response Plan for Major Navy Training Exercises in the AFAST Study Area” (attached), to include the following measures:

(A) Shutdown Procedures – When an Uncommon Stranding Event (USE – defined in 50 CFR § 216.241) occurs during a Major Training Exercise (MTE, including SEASWITI, IAC, Group Sails, JTFEX, or COMPTUEX) in the AFAST Study Area, the Navy shall implement the procedures described below.

(1) The Navy shall implement a Shutdown (as defined 50 CFR § 216.241) when advised by a NMFS Office of Protected Resources Headquarters Senior Official designated in the AFAST Stranding Communication Protocol that a USE involving live animals has been identified and that at least one live animal is located in the water. NMFS and Navy shall communicate, as needed, regarding the identification of the USE and the potential need to implement shutdown procedures.

(2) Any shutdown in a given area shall remain in effect in that area until NMFS advises the Navy that the subject(s) of the USE at that area die or are euthanized, or that all live animals involved in the USE at that area have left the area (either of their own volition or herded).

(3) If the Navy finds an injured or dead animal of any species other than a North Atlantic right whale floating at sea during an MTE, the Navy shall notify NMFS immediately or as soon as operational security considerations allow. The Navy shall provide NMFS with species or description of the animal(s), the condition of the animal(s), (including carcass condition if the animal(s) is/are dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). Based on the information provided, NMFS shall determine if, and advise the Navy whether a modified shutdown is appropriate on a case-by-case basis.

(4) If the Navy finds an injured (or entangled) North Atlantic right whale floating at sea during an MTE, the Navy shall implement shutdown procedures (14 nm off Atlantic coast or 17 nm in Gulf of Mexico, as defined below) around the animal immediately (without waiting for notification from NMFS). The Navy shall then notify NMFS (pursuant to the AFAST Communication Protocol) immediately or as soon as operational security considerations allow. The Navy shall provide NMFS with species or description of the animal(s), the condition of the animal(s) including location, time of first discovery, observed behaviors (if alive), and photo or video (if available). Subsequent to the discovery of the injured whale, any Navy platforms in the area shall report any North Atlantic right whale sightings to NMFS (or to a contact that can alert NMFS as soon as possible). Based on the information provided, NMFS may initiate/organize an aerial survey (which may include Navy's assistance in accordance with the Memorandum of Understanding (MOU) or by other available means) to see if other North Atlantic right whales are in the vicinity. Based on the information provided by the Navy and, if necessary, the outcome of the aerial surveys, NMFS shall determine whether a continued shutdown is appropriate on a case-by-case basis. Though it will be determined on a case-by-case basis after Navy/NMFS discussion of the situation, NMFS anticipates that the shutdown will continue within 14 or 17 nm of a live, injured/entangled North Atlantic right whale until the animal dies or has not been seen for at least 3 hours (either by NMFS staff attending the injured animal or Navy personnel monitoring the area around where the animal was last sighted).

(5) If the Navy finds a dead North Atlantic right whale floating at sea during an MTE, the Navy shall notify NMFS (pursuant to AFAST Stranding Communication Protocol) immediately or as soon as operational security considerations allow. The Navy shall provide NMFS with species or description of the animal(s), the condition of the animal(s), (including carcass condition if the animal(s) is/are dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). Subsequent to the discovery of the dead whale, if the Navy is operating sonar in the area they shall use

increased vigilance (in looking for North Atlantic right whales) and all platforms in the area shall report sightings of North Atlantic right whales to NMFS as soon as possible. Based on the information provided, NMFS may initiate/organize an aerial survey (which may include Navy's assistance in accordance with the Memorandum of Understanding (MOU) or by other available means) to see if other North Atlantic right whales are in the vicinity. Based on the information provided by the Navy and, if necessary, the outcome of the aerial surveys, NMFS will determine whether any additional mitigation measures are necessary on a case-by-case basis.

(6) In the event, following a USE, that: a) qualified individuals are attempting to herd animals back out to the open ocean and animals are not willing to leave, or b) animals are seen repeatedly heading for the open ocean but turning back to shore, NMFS and the Navy should coordinate (including an investigation of other potential anthropogenic stressors in the area) to determine if the proximity of MFAS/HFAS training activities or explosive detonations, though farther than 14 nm (off Atlantic coast) or 17 nm (in Gulf of Mexico) from the distressed animal(s), is likely decreasing the likelihood that the animals return to the open water. If so, NMFS and the Navy shall further coordinate to determine what measures are necessary to further minimize that likelihood and implement those measures as appropriate.

(B) Within 72 hours of NMFS notifying the Navy of the presence of a USE, the Navy shall provide available information to NMFS (per the AFAST Communication Protocol) regarding the location, number and types of acoustic/explosive sources, direction and speed of units using MFAS/HFAS, and marine mammal sightings information associated with training activities occurring within 80 nm (148 km) and 72 hours prior to the USE event. Information not initially available regarding the 80 nm (148 km), 72 hours period prior to the event shall be provided as soon as it becomes available. The Navy shall provide NMFS investigative teams with additional relevant unclassified information as requested, if available.

(b) Mitigation for IEER/AEER

The following mitigation measures shall be used with the employment of Improved Extended Echo Ranging/Advanced Extended Echo Ranging (IEER/AEER) sonobuoys.

(i) Navy crews shall conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 500 yards (457 m) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft training activities, crews are allowed to conduct coordinated area clearances.

(ii) For IEER (AN/SSQ-110A), Navy crews shall conduct a minimum of 30 minutes of visual and acoustic monitoring of the search area prior to commanding the first post (source/receiver sonobuoy pair) detonation. This 30-minute observation period may include pattern deployment time.

(iii) For any part of the intended sonobuoy pattern where a post (source/receiver sonobuoy pair) will be deployed within 1,000 yards (914 m) of observed marine mammal activity, deploy the receiver ONLY (i.e., not the source) and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yards (914 m) of the intended post position, the source sonobuoy (AN/SSQ-110A/SSQ-125) will be co-located with the receiver.

(iv) When operationally feasible, Navy crews shall conduct continuous visual and aural monitoring of marine mammal activity. This shall include monitoring of aircraft sensors from the time of the first sensor placement until the aircraft have left the area and are out of RF range of these sensors.

(v) Aural Detection: If the presence of marine mammals is detected aurally, then that should cue the aircrew to increase the diligence of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the Navy crew may continue multi-static active search.

(vi) Visual Detection:

> (A) If marine mammals are visually detected within 1,000 yards (914 m) of the explosive source sonobuoy (AN/SSQ-110A/SSQ-125) intended for use, then that payload shall not be activated.
>
> (B) Navy Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes, or are observed to have moved outside the 1,000 yards (914 m) safety buffer.
>
> (C) Navy Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1,000 yards (914 m) safety buffer.

(vii) For IEER (AN/SSQ-110A), Navy Aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the “Payload 1 Release” command followed by the “Payload 2 Release” command. Aircrews shall refrain from using the “Scuttle” command when two payloads remain at a given post. Aircrews shall ensure that a 1,000 yard (914 m) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.

(viii) Navy Aircrews shall only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary or tertiary method.

(ix) The Navy shall ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ-110A) that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message.

(x) Marine mammal monitoring shall continue until out of own-aircraft sensor range.

(c) Mitigation Measures related to Vessel Transit and North Atlantic Right Whales

(i) Mid-Atlantic, Offshore of the Eastern United States

(A) All Navy vessels are required to use extreme caution and operate at a slow, safe speed consistent with mission and safety during the months indicated below and within a 37 km (20 nm) arc (except as noted) of the specified associated reference points:

(1) South and East of Block Island (37 km (20 nm) seaward of line between 41-4.49 deg. N. lat. 071-51.15 deg.W. long. and 41-18.58 deg.N. lat. 070-50.23 deg.W. long): Sept-Oct and Mar-Apr.

(2) New York / New Jersey (40-30.64 deg.N. lat. 073-57.76 deg.W. long.): Sep–Oct and Feb-Apr.

(3) Delaware Bay (Philadelphia) (38-52.13 deg.N. lat. 075-1.93 deg.W. long.): Oct–Dec and Feb–Mar.

(4) Chesapeake Bay (Hampton Roads and Baltimore) (37-1.11 deg. N.lat. 075-57.56 ° W. long.): Nov-Dec and Feb–Apr.

(5) North Carolina (34-41.54 deg.N. lat. 076-40.20 deg.W. long.): Dec-Apr.

(6) South Carolina (33-11.84 deg.N. lat. 079-8.99 deg.W. long. and 32-43.39 deg.N. lat. 079-48.72 deg.W. long.): Oct-Apr.

(B) During the months indicated in paragraph (c)(i)(A), above, Navy vessels shall practice increased vigilance with respect to avoidance of vessel-whale interactions along the mid-Atlantic coast, including transits to and from any mid-Atlantic ports not specifically identified in paragraph (c)(i)(A), above.

(C) All surface units transiting within 56 km (30 nm) of the coast in the mid-Atlantic shall ensure at least two watchstanders are posted, including at least one lookout who has completed required MSAT training.

(D) Navy vessels shall not knowingly approach any whale head on and shall maneuver to keep at least 1,500 ft (457 m) away from any observed whale, consistent with vessel safety.

(ii) Southeast Atlantic, Offshore of the Eastern United States – for the purposes of the measures below (within (ii)), the "southeast" encompasses sea space from Charleston, South Carolina, southward to Sebastian Inlet, Florida, and from the coast seaward to 148 km (80 nm) from shore.

(A) Prior to transiting or training in the NARW critical habitat or associated area of concern, ships shall contact Fleet Area Control and Surveillance Facility, Jacksonville, to obtain latest whale sighting and other information needed to make informed decisions regarding safe speed and path of intended movement. Subs shall contact Commander, Submarine Group Ten for similar information.

(B) The following specific mitigation measures apply to activities occurring within the NARW critical habitat and an associated area of concern which extends 9 km (5 nm) seaward of the NARW critical habitat boundaries:

(1) When transiting within the NARW critical habitat or associated area of concern, vessels shall exercise extreme caution and proceed at a slow safe speed. The speed shall be the slowest safe speed that is consistent with mission, training and operations.

(2) Speed reductions (adjustments) are required when a whale is sighted by a vessel or when the vessel is within 9 km (5 nm) of a reported new sighting less than 12 hours old. Circumstances could arise where, in order to avoid North Atlantic right whale(s), speed reductions could mean a vessel must reduce speed to a minimum at which it can safely keep on course or vessels could come to an all stop.

(3) Vessels shall avoid head-on approaches to North Atlantic right whale(s) and shall maneuver to maintain at least 457 m (500 yd) of separation from any observed whale if deemed safe to do so. These requirements do not apply if a vessel's safety is threatened, such as when a change of course would create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver.

(4) Ships shall not transit through the NARW critical habitat or associated area of concern in a North-South direction.

(5) Ships, surfaced subs, and aircraft shall report any whale sightings to Fleet Area Control and Surveillance Facility, Jacksonville, by the quickest and most practicable means. The sighting report shall include the time, latitude/longitude, direction of movement and number and description of whales (i.e., adult/calf).

(iii) Northeast Atlantic, Offshore of the Eastern United States

(A) Prior to transiting the NARW Great South Channel or Cape Cod Bay critical habitat, ships shall obtain the latest North Atlantic right whale sightings and other information needed to make informed decisions regarding safe speed.

(B) Ships, surfaced subs, and aircraft shall report any North Atlantic right whale sightings (if the whale is identifiable as a right whale) off the northeastern U.S. to the Northeast right whale sighting advisory system at (978) 585-8473 or to the US Coast Guard via Channel 16. The report shall include the time of sighting, lat/long, direction of movement (if apparent) and number and description of the whale(s).

(C) Vessels or aircraft that observe whale carcasses shall record the location and time of the sighting and report this information as soon as possible through Navy's special incident reporting procedures for marine mammals. All whale strikes must be reported. This report shall include: the date, time, and location of the strike; vessel course and speed; operations being conducted by the vessel; weather conditions, visibility, and sea state; description of the whale; narrative of incident; and indication of whether photos/videos were taken. Navy personnel are encouraged to take photos whenever possible.

(D) Specific mitigation measures related to activities occurring within the NARW Great South Channel or Cape Cod Bay critical habitat include the following:

(1) Vessels shall avoid head-on approaches to North Atlantic right whale(s) and shall maneuver to maintain at least 500 yd (457 m) of separation from any observed whale if deemed safe to do so. These requirements do not apply if a vessel's safety is threatened, such as when change of course would create an imminent and serious threat to person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver.

(2) When transiting within the NARW Great South Channel or Cape Cod Bay critical habitat or the NARW Southeast U.S. critical habitat or associated area of concern, vessels shall use extreme caution and operate at a safe speed so as to be able to avoid collisions with North Atlantic right whales and other marine mammals, and stop within a distance appropriate to the circumstances and conditions.

(3) Speed reductions (adjustments) are required when a whale is sighted by a vessel or when the vessel is within 9 km (5 nm) of a reported new sighting less than one week old.

(4) Ships transiting in the NARW Cape Cod Bay and Great South Channel critical habitats shall obtain information on recent whale sightings in the vicinity of the feeding habitat. Any vessel operating in the vicinity of a North Atlantic right whale shall consider additional speed reductions per Rule 6 of International Navigational Rules.

2.6.2 Monitoring and Reporting

When conducting operations identified in 50 CFR § 216.240(c) and Condition 4(a), the Holder of the Authorization and any person(s) operating under his authority must implement the following monitoring and reporting measures. All reports should be submitted to the Director, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring MD 20910 and copies provided to the Assistant Regional Administrator for Protected Resources, Southeast Regional Office, National Marine Fisheries Service, 263 13th Avenue South, Saint Petersburg, Florida, 33701 and to the Assistant Regional Administrator for Protected Resources, Northeast Regional Office, 55 Great Republic Drive, Gloucester, Massachusetts, 09130-2298.

(a) As outlined in the AFAST Stranding Communication Plan, the Navy must notify NMFS immediately (or as soon as clearance procedures allow) if the specified activity identified in 50 CFR § 216.240(c) is thought to have resulted in the mortality or injury of any marine mammals, or in any take of marine mammals not identified in § 50 CFR 216.242(c).

(b) The Navy must implement the AFAST Monitoring Plan.

(c) The Navy shall continue to comply with the Integrated Comprehensive Monitoring Program (ICMP) Plan and continue to improve the program in consultation with NMFS.

(d) General Notification of Injured or Dead Marine Mammals - Navy personnel shall ensure that NMFS (regional stranding coordinator) is notified immediately (or as soon as clearance procedures allow) if an injured or dead marine mammal is found during or shortly after, and in the vicinity of, any Navy training exercise utilizing MFAS, HFAS, or underwater explosive detonations. The Navy shall provide NMFS with species or description of the animal(s), the condition of the animal(s) (including carcass condition if the animal is dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). The Navy shall consult the Stranding Response Plan to obtain more specific reporting requirements for specific circumstances.

(e) Annual AFAST Monitoring Plan Report - The Navy shall submit reports annually on October 1, 2012 and October 1, 2013, describing the implementation and results (through August 1 of the reporting year) of the AFAST Monitoring Plan. The report will also include any analysis conducted or conclusions reached based on the previous year's data that were not completed in time for the previous year's monitoring report. Data collection methods will be standardized across range complexes to allow for comparison in different geographic locations. Although additional information will also be gathered, the marine mammal observers (MMOs) collecting marine mammal data pursuant to the AFAST Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in 50 CFR § 216.245(f)(1). The AFAST Monitoring Plan Report may be provided to NMFS within a larger report that includes the required Monitoring Plan Reports from AFAST and multiple Range Complexes.

(f) Annual AFAST Exercise Report - The Navy shall submit the Annual AFAST Exercise Reports on October 1, 2012 and October 1, 2013 (covering data gathered through August 1 of the reporting year). This report shall contain information identified in 50 CFR §§ 216.245(f)(1) – (f)(3).

> (1) MFAS/HFAS Major Training Exercises - This section shall contain the following information for the major training exercises for reporting (MTERs), which include the Southeastern ASW Integrated Training Initiative (SEASWITI), Integrated ASW Course (IAC), Composite Training Unit Exercises (COMPTUEX), and Joint Task Force Exercises (JTFEX) conducted in the AFAST Study Area:
>
> > (i) Exercise Information (for each MTER):
> >
> > > (A) Exercise designator
> > > (B) Date that exercise began and ended
> > > (C) Location
> > > (D) Number and types of active sources used in the exercise
> > > (E) Number and types of passive acoustic sources used in exercise
> > > (F) Number and types of vessels, aircraft, etc., participating in exercise
> > > (G) Total hours of observation by watchstanders
> > > (H) Total hours of all active sonar source operation

(I) Total hours of each active sonar source (along with explanation of how hours are calculated for sources typically quantified in alternate way (buoys, torpedoes, etc.)).

(J) Wave height (high, low, and average during exercise)

(ii) Individual marine mammal sighting info (for each sighting in each MTER)

(A) Location of sighting

(B) Species (if not possible – indication of whale/dolphin/pinniped)

(C) Number of individuals

(D) Calves observed (y/n)

(E) Initial Detection Sensor

(F) Indication of specific type of platform observation made from (including, for example, what type of surface vessel, i.e., FFG, DDG, or CG)

(G) Length of time observers maintained visual contact with marine mammal

(H) Wave height (in feet)

(I) Visibility

(J) Sonar source in use (y/n).

(K) Indication of whether animal is < 200 yd, 200-500 yd, 500-1000 yd, 1000-2000 yd, or > 2000 yd from sonar source in paragraph (f)(1)(ii)(J) of this section.

(L) Mitigation Implementation – Whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was.

(M) If source in use (i.e., in paragraph (f)(1)(ii)(J) of this section) is hull-mounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel)

(N) Observed behavior – Watchstanders shall report, in plain language and without trying to categorize in any way, the observed behavior of the animals (such as animal closing to bow ride, paralleling course/speed, floating on surface and not swimming, etc.)

(iii) An evaluation (based on data gathered during all of the MTERs) of the effectiveness of mitigation measures designed to avoid exposing marine mammals to MFAS. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

(2) ASW Summary - This section shall include the following information as summarized from both MTERs and non-major training exercises:

(i) Total annual hours of each type of sonar source (along with explanation of how hours are calculated for sources typically quantified in alternate way (buoys, torpedoes, etc.))

(ii) Cumulative Impact Report - To the extent practicable, the Navy, in coordination with NMFS, shall develop and implement a method of annually reporting non-major (i.e., other than MTERs) training exercises utilizing hull-mounted sonar. The report shall present an annual (and seasonal, where practicable) depiction of non-major training exercises geographically across the AFAST Study Area. To the extent practicable, this report will also include the total number of sonar hours (from helicopter dipping sonar and object detection exercises) conducted within the NARW Southeast U.S.critical habitat plus 5 nm buffer area). The Navy shall include (in the AFAST annual report) a brief annual progress update on the status of the development of an effective and unclassified method to report this information until an agreed-upon (with NMFS) method has been developed and implemented.

(3) IEER/AEER Summary - This section shall include an annual summary of the following IEER and AEER information:

(i) Total number of IEER and AEER events conducted in the AFAST Study Area

(ii) Total expended/detonated rounds (buoys)

(iii) Total number of self-scuttled IEER rounds

(g) Sonar Exercise Notification - The Navy shall submit to the NMFS HQ Office of Protected Resources (Chiefs, Endangered Species Division and Division of Permits, Conservation and Education) either an electronic (preferably) or verbal report within fifteen calendar days after the completion of any MTER indicating:

(1) Location of the exercise

(2) Beginning and end dates of the exercise

(3) Type of exercise (e.g, COMPTUEX or SEASWITI)

(h) AFAST 5-yr Comprehensive Report - The Navy shall submit to NMFS a draft report that analyzes and summarizes all of the multi-year marine mammal information gathered during ASW, MIW and IEER/AEER exercises for which annual reports are required (Annual AFAST Exercise Reports and AFAST Monitoring Plan Reports). This report will be submitted at the end of the fourth year of the rule (November 2012), covering activities that have occurred through June 1, 2012.

(i) Comprehensive National ASW Report - By June, 2014, the Navy shall submit a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through January 1, 2014) from the watchstanders and pursuant to the implementation of the Monitoring Plans for AFAST, SOCAL, the HRC, the Marianas Range Complex, the Northwest Training Range, and the Gulf of Alaska.

(j) The Navy shall respond to NMFS comments and requests for additional information or clarification on the AFAST Comprehensive Report, the Comprehensive National ASW report, the Annual AFAST Exercise Report, or the Annual AFAST Monitoring Plan Report (or the multi-Range Complex Annual Monitoring Plan Report, if that is how the Navy chooses to submit the information) if submitted within 3 months of receipt. These reports will be considered final after the Navy has addressed NMFS' comments or provided the requested information, or three months after the submittal of the draft if NMFS does not comment by then.

(k) In 2012 and 2013, the Navy shall convene Monitoring Workshops in which the Monitoring Workshop participants will be asked to review the Navy's Monitoring Plans and monitoring results and make individual recommendations (to the Navy and NMFS) of ways of improving the Monitoring Plans. The recommendations shall be reviewed by the Navy, in consultation with NMFS, and modifications to the Monitoring Plan shall be made, as appropriate.

3 APPROACH TO THE ASSESSMENT

NMFS uses a series of sequential analyses to assess the effects of federal actions on endangered and threatened species and designated critical habitat. The first analysis identifies those physical, chemical, or biotic aspects of proposed actions that are likely to have individual, interactive, or cumulative direct and indirect effect on the environment (we use the term "potential stressors" for these aspects of an action). As part of this step, we identify the spatial extent of any potential stressors and recognize that the spatial extent of those stressors may change with time (the spatial extent of these stressors is the "action area" for a consultation).

The second step of our analyses starts by determining whether endangered species, threatened species, or designated critical habitat are likely to occur in the same space and at the same time as these potential stressors. If we conclude that such co-occurrence is likely, we then try to estimate the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action's effects and the populations or subpopulations those individuals represent.

Once we identify which listed resources (endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, in the third step of our analyses we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*). The final steps of our analyses — establishing the risks those responses pose to listed resources — are different for listed species and designated critical habitat (these represent our *risk analyses*).

Risk analyses for endangered and threatened species. Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to an Action's effects on the environment (which we identify in our *response analyses*) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Stearns 1992). Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. Therefore, when listed plants or animals exposed to an Action's effects are *not* expected to experience reductions in fitness, we would not expect that Action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (for example, (see Anderson 2000; Mills and Beatty 1979; Sterns 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment because an Action that is not likely to affect the fitness of individuals is not likely to jeopardize the continued existence of listed species.

If, however, we conclude that listed plants or animals are likely to experience reductions in their fitness, our assessment tries to determine if those fitness reductions are likely to be sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference. Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this Opinion) as our point of reference.

Biological opinions, then, distinguish among different kinds of "significance" (as that term is commonly used for NEPA analyses). First, we focus on potential physical, chemical, or biotic stressors that are "significant" in the sense of "salient" in the sense of being distinct from ambient or background. We then ask if (a) exposing individuals to those potential stressors is likely to (a) represent a "significant" adverse experience in the life of individuals that have been exposed; (b) exposing individuals to those potential stressors is likely to cause the individuals to experience "significant" physical, chemical, or biotic responses; and (c) any "significant" physical, chemical, or biotic response are likely to have "significant" consequence for the fitness of the individual animal. In the latter two cases (items (b) and (c)), the term "significant" means "clinically or biotically significant" rather than statistically significant.

For populations (or sub-populations, demes, etc.), we are concerned about whether the number of individuals that experience "significant" reductions in fitness and the nature of any fitness reductions are likely to have a "significant" consequence for the viability (= probability of demographic, ecological, or genetic extinction) of the population(s) those individuals represent. Here “significant” also means “clinically or biotically significant” rather than statistically significant.

For “species” (the entity that has been listed as endangered or threatened, not the biological species concept), we are concerned about whether the number of populations that experience “significant” reductions in viability (= increases in their extinction probabilities) and the nature of any reductions in viability are likely to have “significant” consequence for the viability (= probability of demographic, ecological, or genetic extinction) of the “species” those population comprise. Here, again, “significant” also means “clinically or biotically significant” rather than statistically significant.

3.1 Application of this Approach in this Consultation

The primary stressors the Atlantic Fleet Active Sonar Training exercises the U.S. Navy plans to undertake along the Atlantic Coast of the United States and the Gulf of Mexico consist of:

1. the active sonar systems that would be employed during these training activities;
2. disturbance associated with proximity to the vessels involved in the training activities the U.S. Navy plans to conduct; and
3. the risk of collisions associated with proximity to the vessels involved in the training activities the U.S. Navy plans to conduct.

Our section 7 consultation considered the number of endangered or threatened marine animals (that is, those marine animals that are under the jurisdiction of the National Marine Fisheries Service) that might be exposed to these different stressors, the nature of those exposures, the animal’s probable responses upon being exposed, and the risks those responses might pose to individual animals, the populations those individuals represent, and the species those populations comprise.

3.1.1 Exposure Analyses

As discussed in the introduction to this section of this Opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. Our exposure analyses are designed to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action’s effects and the populations or subpopulations those individuals represent.

For our exposure analyses, NMFS generally relies on an action agency’s estimates of the number of marine mammals that might be “taken” (as that term is defined for the purposes of the MMPA). In a small number of consultations, however, NMFS has conducted separate analyses to estimate the number of endangered or threatened marine animals that might be exposed to stressors produced by a proposed action to assess the effect of assumptions in an action agency’s model on model estimates. For example, NMFS used a model based on components of Hollings’ disc equation (1959) (NMFS 2008c) to independently estimate the number of marine mammals that might be exposed to U.S. Navy training activities in a few recent consultations that satisfied the following conditions:

1 the sole or primary stressor was hull-mounted mid-frequency active sonar and

2 data were available on (2a) the density of endangered or threatened animals in an action area, (2b) the ship's speed, (2c) the radial distance at which different received levels would be detected from a source given sound speed profiles, and (2d) the duration of specific training exercises.

These conditions have been met in several of the more than 23 consultations NMFS has completed on U.S. Navy training since 2002 (for example, opinions on anti-submarine warfare training on the U.S. Navy's Hawai'i Range Complex and Southern California Range Complex) so NMFS conducted independent exposure analyses and included the results of those analyses in biological opinions on those actions. In the remaining opinions, hull-mounted mid-frequency active sonar was not the primary stressor associated with proposed training or the data for one of the model's variables were not available.

Although the primary stressor is hull-mounted mid-frequency active sonar in this consultation, data were not available on (a) the density of endangered or threatened animals in an action area, (b) the radial distance at which different received levels would be detected from a source given sound speed profiles, and (c) the duration of specific training exercises, so we could not run the exposure models we had developed. Nevertheless, because the U.S. Navy's "take" estimates do not appear to be disproportionately high or low given the data available on animal densities, we had no reason to conduct our own exposure analyses. As a result, we relied solely on the results of acoustic models the U.S. Navy used to prepare its NEPA compliance documents and to request permits from NMFS' Permits and Conservation Division.

The U.S. Navy's model focuses on a suite of representative provinces based on sound velocity profiles, bathymetries, and bottom types. Within each of these provinces, the U.S. Navy modeled transmission losses in five meter increments and used the results to build sound fields (based on maximum sound pressure levels). The U.S. Navy then calculates an "impact volume," which is the volume of water in which an acoustic metric exceeds a specified threshold; in this case, the Navy used one of three acoustic metrics: energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. By multiplying these "impact volumes" by estimates of animal densities in three dimensions (densities distributed by area and depth), the U.S. Navy estimated the expected number of animals that might be exposed to an acoustic metric (energy flux density, peak pressure, or positive impulse) at levels that exceed thresholds that had been specified in advance. Specifically, the U.S. Navy calculated impact volumes for sonar operations (using energy flux density to estimate the probability of injury), peak pressure, and a Goertner modified positive impulse (for onset of slight lung injury associated with explosions).

To calculate "impact volumes," the U.S. Navy used a "risk continuum" or a curve that the U.S. Navy and NMFS developed that relates the probability of a behavioral response given exposure to a received level that is generally represented by sound pressure level, but included sound exposure level to deal with threshold shifts. The risk continuum, which the U.S. Navy and NMFS Permits Division adapted from a mathematical model presented in Feller (1968) (Navy 2008b), was estimated using three data sources: (1) data from controlled experiments conducted at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (Finneran et al. 2001; Finneran et al. 2003; Finneran et al. 2005; Finneran and Schlundt. 2004; Schlundt et al. 2000c), (2) data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromme 2004), and (3) a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek et al. 2004a). The U.S. Navy and NMFS Permits Division estimated the proportion of a population that would be expected to exhibit behavioral responses that NMFS would classify as "take" (as that term is defined by the MMPA) by multiplying the different "impact volumes" at particular received levels by the "risk continuum."

Based on our evaluation of the U.S. Navy's model, we are satisfied that the model would tend to overestimate the number of marine mammals that might be exposed, because the model assumes that marine mammals would not move away from sound stimuli, when in fact, marine mammals are highly mobile and are likely to use their mobility to avoid stimuli like active sonar, just as they avoid vessel traffic. Consequently, the results of these models would tend to provide the benefit of uncertainty to endangered or threatened species by overestimating their likelihood of being exposed and exhibiting adverse responses given exposure to military readiness activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico.

3.1.2 Response Analyses

As discussed in the introduction to this section of this Opinion, once we identified which listed resources were likely to be exposed to active sonar associated with the proposed training activities and the nature of that exposure, we examined the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (Figure 1). Prior to this consultation, we developed a conceptual model which we subsequently modified based on a model of animal behavior and behavioral decision-making, which incorporates the cognitive processes involved in behavioral decisions; earlier versions of this model ignored critical components of animal behavior and behavioral decision-making. As a result, our revised model assumes that Navy training activities primarily affect endangered and threatened species by changing their behavior, although we continue to recognize the risks of physical trauma and noise-induced losses in hearing sensitivity (threshold shift). Second, we incorporated a more expansive concept of "hearing" that includes cognitive processing of auditory cues, rather than a focus solely on the mechanical processes of the ear and auditory nerve. Third, our revised model incorporates the primary mechanisms by which behavioral responses affect the longevity and reproductive success of animals: changing an animal's energy budget, changing an animal's time budget (which is related to changes in an animal's energy budget), forcing animals to make life history trade-offs (for example, engaging in evasive behavior such as deep dives that involve short-term risks while promoting long-term survival), or changes in social interactions among groups of animals (for example, interactions between a cow and her calf).

Like our earlier conceptual models (presented in Southall et al. 2007), this conceptual model begins with acoustic stimuli we focus on in an assessment (Box 1 in Figure 1). In this case, we treat the active sonar and any shock waves or sound fields associated with underwater detonations as separate focal stimuli. The preceding section of our *Approach* described how we estimated the number of animals that are likely to be exposed to those acoustic stimuli associated with the proposed training activities and the nature of that exposure.

The potential stressors associated with the training exercises the U.S. Navy proposes to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico are likely to consist of two general classes: *processive stressors*, which require high-level cognitive processing of sensory information, and *systemic stressors*, which usually elicit direct physical or physiological responses and, therefore, do not require high-level cognitive processing of sensory information (Anisman and Merali 1999; Herman and Cullinan 1997). Disturbance from surface vessels and active sonar would be examples of processive stressors while ship strikes and shock waves associated with underwater detonations would be examples of systemic stressors (the sound field produced by an underwater detonation would be a systemic stressor close to the explosion and a processive stressor further away).

As a result, exposures resulting from the proposed training exercises are likely to result in two general classes of responses:

1. Responses that are influenced by an animal's assessment of whether a potential stressor poses a threat or risk (see Figure 1: Behavioral Response).

2. Responses that are not influenced by the animal's assessment of whether a potential stressor poses a threat or risk (see Figure 1: Physical Damage).

Unlike our earlier conceptual model, our revised model explicitly acknowledges the existence of other acoustic and non-acoustic stimuli in an animal's environment that might diminish the focal stimulus' salience (the line connecting Box 2b. to Box 2) or that might compete for the animal's finite attentional resources, which would affect the salience of the focal stimulus as perceived by the animal (the line connecting Box 2b to Box B1)[4]. Absent information to the contrary, our assessment assume the focal stimulus remains salient regardless of competing stimuli and the limited attentional resources of animals. By extension, we assume that any behavioral change we might observe in an animal would have been caused by the focal stimulus rather than competing stimuli.

If we conclude (or if we assume) that an acoustic stimulus, such as mid-frequency active sonar, was salient, we would then ask how an animal might classify the stimulus as a cue about its environment (Box B2) because an animal's response to a stimulus in its environment will depend upon whether and how the animal converts the stimulus into some information about its environment (Blumstein and Bouskila 1996; Yost 2007). For example, if an animal classifies a stimulus as a "predatory cue," that classification will invoke a suite of candidate physical, physiological, or behavioral responses that are appropriate to being confronted by a predator (this would occur regardless of whether a predator is, in fact, present).

Our revised conceptual model, by adopting a more expansive concept of "hearing." departs from our earlier model and other models employed by the U.S. Navy in consultation with NMFS. Most existing models have treated hearing simply. These initial models of hearing also led to a focus on received level as simple, easily understood, and consistent assessment metric with noise-induced hearing loss as an assessment endpoint.

This conceptual model expands the conception of "hearing" to include mechanical-cognitive-perceptual processes. That is, we have expanded our concept of "hearing" to include the mental processes an animal employs when it analyzes acoustic impulses (see Blumstein and Bouskila 1996; Bregman 1990; Hudspeth 1997; Pickles 1982; Yost 2007), which includes the processes animals employ to integrate and segregate sounds and auditory streams and the circumstances under which they are likely to devote attentional resources to an acoustic stimulus. As a result of this shift in focus, we have to consider more than the received level of a particular low- or mid-frequency wave form and its effects on the sensitivity of an animal's ear structure, we also have to distinguish between different auditory scenes; for example, animals will distinguish between sounds from a source that is moving away versus a sound

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[4] See Blumstein and Bouskila Blumstein, D. T., and A. Bouskila. 1996. Assessment and decision making in animals: A mechanistic model underlying behavioural flexibility can prevent ambiguity. Oikos 77(3):569-576. for more extensive reviews of the literature on how animals process and filter sensory information, which affects the subjective salience of sensory stimuli. See Crick (1984), Dukas Dukas, R. 2002. Behavioural and ecological consequences of limited attention. Philosophical Transactions of the Royal Society B-Biological Sciences 357(1427):1539-1547., Dukas and Real (1993), and Roitblat (1987) for more extensive reviews of the literature on attentional processes and the consequences of limited attentional resources.

produced by a source that is approaching them, sounds from multiple sources that are all approaching, and sounds from multiple sources that appear to be moving at random, etc.

Animals would then combine their perception of the acoustic stimulus with their assessment of the auditory scene (which include other acoustic stimuli), their awareness of their behavioral state, physiological state, reproductive condition, and social circumstances to assess whether the acoustic stimulus poses a risk and the degree of risk it might pose, whether it is impairing their ability to communicate with conspecifics, whether it is impairing their ability to detect predators or prey, etc. We assume that animals would classify an acoustic source differently if the source is moving towards its current position (or projected position), moving away from its current position, moving tangential to its current position, if the source is stationary, or if there are multiple acoustic sources it its auditory field.

This process of “classifying a stimulus” (Box B2) lends meaning to the stimulus and places the animal in a position to decide whether and how to respond to the stimulus (Blumstein and Bouskila 1996). How an animal classifies a stimulus will determine the set of candidate responses that are appropriate. That is, we assume that animals that classified a stimulus as a “predatory cue” would invoke candidate responses that consisted of anti-predator behavior rather than foraging behavior (Blumstein and Bouskila 1996). We then assume that animals apply one or more behavioral decision rules to the set of candidate responses that are appropriate to the acoustic stimulus as it has been classified (Box B3 Our use of the term “behavioral decision rule” follows Blumstein and Bouskila (1996), McFarland (1982), and Lima and Dill (1990) and is synonymous with the term “behavioral policy” of McNamara and Houston (1986): the process an animal applies to determine which specific behavior it will select from the set of behaviors that are appropriate to the auditory scene, given its physiological and behavioral state when exposed and its experience. Because we would never know the behavioral policy of an individual, free- ranging animal, we treat this policy as a probability distribution function that matches the vector of candidate behavioral responses.

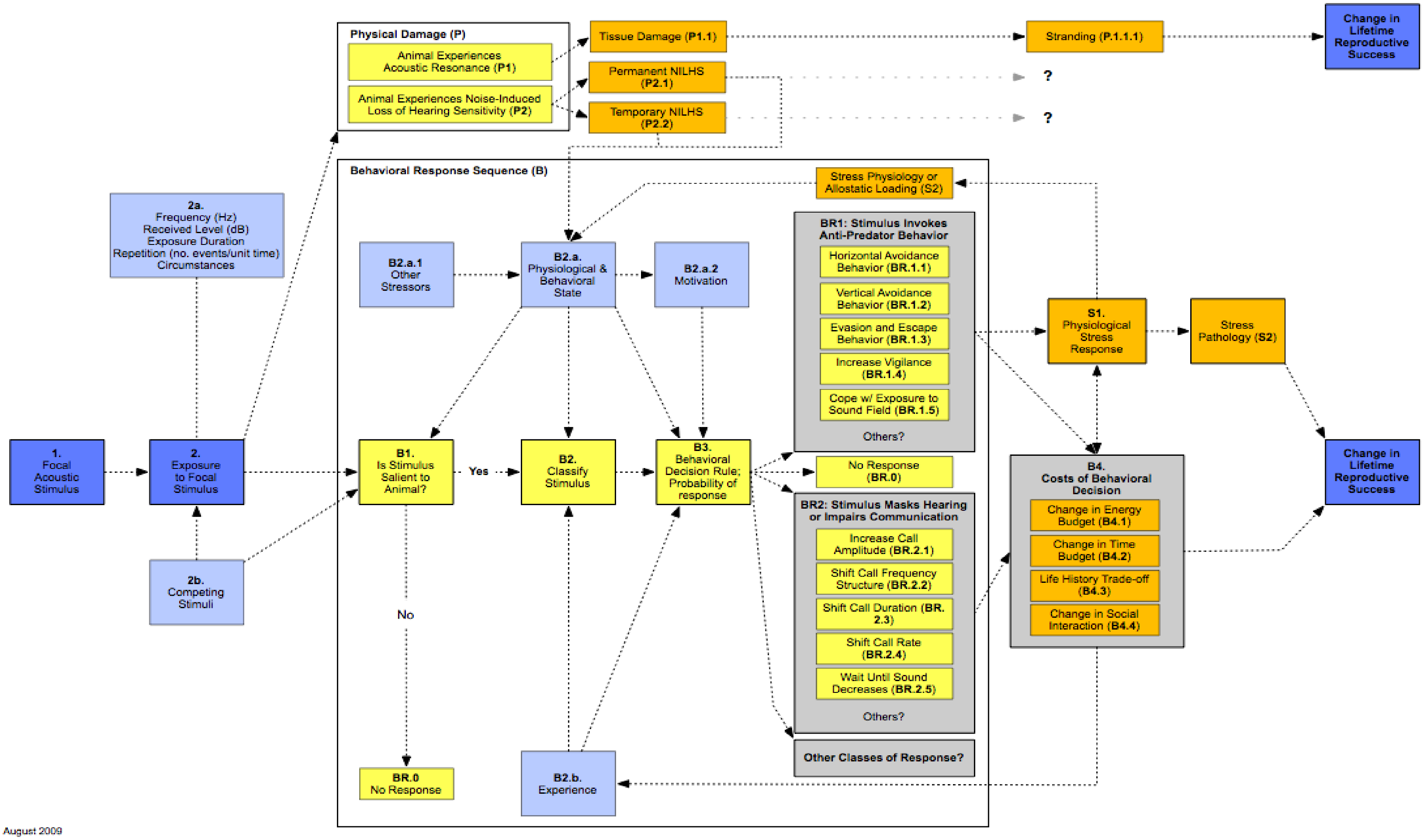
Once an animal selects a behavioral response from a set of candidate behaviors, we would assume that any change in behavior would represent a shift from an optimal behavioral state (or behavioral act) to a sub-optimal behavioral state (or behavioral act) and that the selection of the sub-optimal behavioral state or act would be accompanied by *canonical costs*, which are reductions in the animal’s expected future reproductive success that would occur when an animal engages in suboptimal behavioral acts (McNamara and Houston 1986). Specifically, canonical costs represent a reduction in current and expected future reproductive success (which integrates survival and longevity with current and future reproductive success) that would occur when an animal engages in a sub-optimal rather than an optimal sequence of behavioral acts; given the pre-existing physiological state of the animal in a finite time interval (Houston et al. 1993; McFarland and Sibly 1975; McNamara and Houston 1982; McNamara 1993; McNamara and Houston 1986; Nonacs 2001). Canonical costs would generally result from changes in animals’ energy budgets (McEwen and Wingfield 2003; Moberg 2000; Romero 2004; Sapolsky 1997), time budgets (Frid and Dill 2002; Sutherland 1996), life history trade-offs (Cole 1954; Stearns 1992), changes in social interactions (Sutherland 1996), or combinations of these phenomena (see Box B4 of Figure 1). We assume that an animal would not incur a canonical cost if they adopted an optimal behavioral sequence (see McNamara and Houston 1986 for further treatment and discussion).

This conceptual model does not require us to assume that animals exist in pristine environments; in those circumstances in which animals are regularly or chronically confronted with stress regimes that animals would adopt to by engaging in sub-optimal behavior, we would assume that a change in behavior that resulted from exposure to a particular stressor or stress regime would either contribute to their sub-optimal behavior or would force them to engage in behavior that is even further from optimal.

We used empirical Bayesian analysis to estimate the probability of one or more of the proximate responses identified in Figure 1 given an exposure event from the data that were available. Bayes' rule (also called Bayes' theorem) calculates the probability of an event given prior knowledge of the event's probability using the equation:

$$\mathrm{Prob}(R_i|D) = [\mathrm{Pr}(D|R_i) \times \mathrm{Pr}(R_i)]/\Sigma[\mathrm{Pr}(D|R_j) \times \mathrm{Pr}(R_j)]$$

Where *R* represents the set of mutually exclusive and exhaustive physical, physiological, and behavioral responses to an exposure with probabilities, $\mathrm{Pr}(R_i)$, $\mathrm{Pr}(R_j)$ represents alternatives to that particular response, and D represents the data on responses. In this formulation, Pr(Ri) in the numerator, represents the prior probability of a response which we derived from (1) the number of reports in the literature, that is, the number of papers that reported a particular response (here we distinguished between the number of reports for all cetaceans, the number of reports for all odonotocetes, and the number of reports for all mysticetes) and (2) an uninformed prior, which assumed that all responses that had non-zero values were equally probable.



Version 21 August 2009

Figure 1. Conceptual model of the potential responses of endangered and threatened species upon being exposed to active sonar and the pathways by which those responses might affect the fitness of individual animals that have been exposed. See text in “Application of this Approach” and “Response Analyses” for an explanation of the model and supporting literature.

To apply this procedure to our response analyses, we formed the set of potential responses using the "proximate responses" identified in Figure 1 (see Table 2). Then we identified the number of instances in which animals were reported to have exhibited one or more of those proximate responses based on published studies or studies available as gray literature. For example, Nowacek et al. (2004a) reported one instance in which North Atlantic right whales exposed to alarm stimuli did not respond to the stimulus and several instances in which right whales exhibited "disturbance" responses. We coded these two responses (no response and disturbance response) separately. We used the resulting posterior probabilities to identify the kind of responses that would be represented by the "take" estimates that were produced by the models the U.S. Navy and the Permits Division used.

Table 2. Grouping of proximate responses (identified in Figure 1) into categories for response analyses.

	Proximate Response	Grouping for Bayesian Analyses
1	No response	No Response
2	Acoustic resonance	Physical Trauma
3	Noise-induced hearing loss (P)	Not used for formal analyses
4	Noise-induced hearing loss (T)	Not used for formal analyses
5	Reduced auditory field (reduced active space)	Not used for formal analyses
6	Signal masking	Not used for formal analyses
7	Increase call amplitude of vocalizations	Vocal Adjustments
8	Shift frequency structure of vocalizations	
9	Shift call duration of vocalizations	
10	Shift call rate of vocalizations	
11	Shift timing of vocalizations	
12	Physiological stress	Not used for formal analyses
13	Avoid sound field	Avoidance Response
14	Avoid received levels in sound field	
15	Abandon area of exercise	Evasive Response
16	Increase vigilance	Not used for formal analyses
17	Exhibit "disturbance" behavior	Behavioral Disturbance
18	Continue current behavior (coping)	No Response
19	Unspecified behavioral responses (adverse)	Unspecified behavioral responses (adverse)
20	Unspecified behavioral responses (not adverse)	Unspecified behavioral responses (not adverse)
21	Behaviors that cannot be classified	Not used for formal analyses

3.1.3 Risk Analyses

The final steps of our analyses — establishing the risks those responses pose to endangered and threatened species — begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to an Action's effects on the environment (which we identify in our response analyses) are likely to have consequences for the individual's fitness.

When individuals of a listed plant or animal population are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Sterns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to determine if the number of individuals that experience reduced fitness (or the magnitude of any reductions) is likely to be sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's probability of becoming demographically, ecologically, or genetically extinct in 10, 25, 50, or 100 years). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference.

Our risk analyses conclude by determining whether changes in the viability of one or more population is or is not likely to be sufficient to reduce the viability of the species (measured using probability of demographic, ecological, or genetic extinction in 10, 25, 50, or 100 years) those populations comprise. For these analyses, we combine our knowledge of the patterns that accompanied the decline, collapse, or extinction of populations and species that are known to have declined, collapsed, or become extinct in the past as well as a suite of population viability models.

When we conduct these analyses, our assessment is designed to establish that a decline, collapse, or extinction of an endangered or threatened species is not likely; we do not conduct these analyses to establish that such an outcome is likely. In this step of our analyses, we use the species' status (established in the Status of the Species section of this Opinion) as our point of reference.

3.2 Evidence Available for the Consultation

To conduct these analyses, we considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. Over the past decade, a considerable body of scientific information on anthropogenic sound and its effects on marine mammals and other marine life has become available. Many investigators have studied the potential responses of marine mammals and other marine organisms to human-generated sounds in marine environments or have integrated and synthesized the results of these studies (for example, Bowles 1994; Croll et al. 2001; Croll et al. 1999; Frankel and Clark 1998; Gisiner 1998; Norris 1994; Southall et al. 2007; Tyack 2007; Tyack and Clark. 2000; Wright et al. 2007).

Since we issued the opinion on the 2011 AFAST activities and LOA, the U.S. Navy provided NMFS with reports on the major training exercises that were conducted in the Action Area of our biological opinions on the AFAST, the results of their monitoring studies associated with those training activities, and a review of studies funded by the U.S. Navy's Office of Naval Research.

Thus far, none of this information reveals effects that we did not consider in either of our previous biological opinions or that would require us to reinitiate formal consultation on the U.S. Navy's AFAST activities or the Permits Division's MMPA actions.

Despite the information that has become available since our earlier opinions, this assessment continued to involve a large amount of uncertainty about the basic hearing capabilities of marine mammals; how marine mammals use sounds as environmental cues, how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of marine mammals; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of marine mammals, and the circumstances that are likely to produce outcomes that have adverse consequences for individual marine mammals and marine mammal populations (see NRC 2000 for further discussion of those unknowns).

3.3 Treatment of "Cumulative Impacts" (in the sense of NEPA)

Several organizations have argued that several of our previous biological opinions on the U.S. Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them. In each instance, we have had to explain how biological opinions consider "cumulative impacts" (in the NEPA sense of the term).

The U.S. Council on Environmental Quality defined "cumulative effects" (which we refer to as "cumulative impacts" to distinguish between NEPA and ESA uses of the same term) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR 1508.7). The effects analyses of biological opinions considered the "impacts" on listed species and designated critical habitat that result from the incremental impact of an action by identifying natural and anthropogenic stressors that affect endangered and threatened species throughout their range (the *Status of the Species*) and within an Action Area (the *Environmental Baseline*, which articulate the pre-existing *impacts* of activities that occur in an Action Area, including the past, contemporaneous, and future *impacts* of those activities). We assess the effects of a proposed action by adding their direct and indirect effects to the *impacts* of the activities we identify in an *Environmental Baseline* (50 CFR 402.02), in light of the impacts on the status of the listed species and designated critical habitat throughout their range; as a result, the results of our effects analyses are equivalent to those contained in the "cumulative impact" sections of NEPA documents.

3.4 A Brief Background on Sound

Sound is a wave of pressure variations propagating through a medium (for the sonar considered in this Opinion, the medium is marine water). Pressure variations are created by compressing and relaxing the medium. Sound measurements can be expressed in two forms: *intensity* and *pressure*. Acoustic intensity is the average rate of energy transmitted through a unit area in a specified direction and is expressed in watts per square meter (W/m^2). Acoustic intensity is rarely measured directly, it is derived from ratios of *pressures*; the standard reference pressure for underwater sound is 1 microPascal (μPa); for airborne sound, the standard reference pressure is 20 μPa (Richardson et al. 1995a).

Acousticians have adopted a logarithmic scale for sound intensities, which is denoted in decibels (dB). Decibel measurements represent the ratio between a measured pressure value and a reference pressure value (in this case 1 μPa or, for airborne sound, 20 μPa.). The logarithmic nature of the scale means that each 10 dB increase is a ten-fold increase in power (e.g., 20 dB is a 100-fold increase, 30 dB is a 1,000-fold increase). The term "sound pressure level" implies a decibel measure and a reference pressure that is used as the denominator of the ratio. Throughout this Opinion, we use 1 microPascal (denoted re: 1μPa) as a standard reference pressure unless noted otherwise.

It is important to note that decibels underwater and decibels in air are not the same and cannot be directly compared. Because of the different densities of air and water and the different decibel standards in water and air, a sound with the same intensity (i.e., power) in air and in water would be approximately 63 dB quieter in air.

Sound frequency is measured in cycles per second, or Hertz (abbreviated Hz), and is analogous to musical pitch; high-pitched sounds contain high frequencies and low-pitched sounds contain low frequencies. Natural sounds in the ocean span a huge range of frequencies: from earthquake noise at 5 Hz to harbor porpoise clicks at 150,000 Hz. These sounds are so low or so high in pitch that humans cannot even hear them; acousticians call these infrasonic and ultrasonic sounds, respectively. A single sound may be made up of many different frequencies together. Sounds made up of only a small range of frequencies are called "narrowband", and sounds with a broad range of frequencies are called "broadband"; airguns are an example of a broadband sound source and sonars are an example of a narrowband sound source.

When considering the influence of various kinds of noise on the marine environment, it is necessary to understand that different kinds of marine life are sensitive to different frequencies of sound. Most dolphins, for instance, have excellent hearing at very high frequencies between 10,000 and 100,000 Hz. Their sensitivity at frequencies below 1000 Hz; however, is quite poor. On the other hand, the hearing sensitivity of most sea turtles appears to be best at frequencies between about 200 Hz and 700 Hz. As a result, sea turtles might be expected to suffer more harmful effects from low frequency noise than would dolphins.

When sound travels away from its source, its loudness decreases as the distance traveled by the sound increases. Thus, the loudness of a sound at its source is higher than the loudness of that same sound a kilometer distant. Acousticians often refer to the loudness of a sound at its source as the *source level* and the loudness of sound elsewhere as the *received level*. For example, a humpback whale 3 kilometers from an airgun that has a source level of 230 dB may only be exposed to sound that is 160 dB loud. As a result, it is important not to confuse source levels and received levels when discussing the loudness of sound in the ocean.

As sound moves away from a source, its propagation in water is influenced by various physical characteristics, including water temperature, depth, salinity, and surface and bottom properties that cause refraction, reflection, absorption, and scattering of sound waves. Oceans are not homogeneous and the contribution of each of these individual factors is extremely complex and interrelated. The physical characteristics that determine the sound's speed through the water will change with depth, season, geographic location, and with time of day (as a result, in actual sonar operations, crews will measure oceanic conditions, such as sea water temperature and depth, to calibrate models that determine the path the sonar signal will take as it travels through the ocean and how strong the sound will be at given range along a particular transmission path).

Sound tends to follow many paths through the ocean, so that a listener may hear multiple, delayed copies of transmitted signals (Richardson et al. 1995a). Echoes are a familiar example of this phenomenon in air. In order to determine what the paths of sound transmission are, one rule is to seek paths that deliver the sound to the receiver the fastest. If the speed of sound were constant throughout the ocean, acoustic rays would consist of straight-line segments, with reflections off the surface and the bottom. However, because the speed of sound varies in the ocean, most acoustic rays do not follow a straight path.

Sound speed in seawater is generally about 1,500 meters per second (5,000 feet per second) although this speed varies with water density, which is affected by water temperature, salinity (the amount of salt in the water), and depth (pressure). The speed of sound increases as temperature and depth (pressure), and to a lesser extent, salinity, increase. The variation of sound speed with depth of the water is generally presented by a "sound speed profile," which varies with geographic latitude, season, and time of day.

As sound travels through the ocean, the intensity associated with the wave front diminishes, or attenuates. In shallow waters of coastal regions and on continental shelves, sound speed profiles become influenced by surface heating and cooling, salinity changes, and water currents. As a result, these profiles tend to be irregular and unpredictable, and contain numerous gradients that last over short time and space scales. This decrease in intensity is referred to as propagation loss, also commonly called transmission loss. In general, in a homogeneous lossless medium, sound intensity decreases as the square of the range due to simple spherical spreading. In other words, a source level of 235 dB will have decreased in intensity to a received level of 175 dB after about 914 meters (1,000 yards).

3.5 Action Area

The action area for this Opinion encompasses the marine and coastal waters along the Atlantic Coast of the United States and in the Gulf of Mexico (see **Figure 2**). Specifically, the action area includes waters within and adjacent to the Boston complex Operating Area, the Narragansett Operating Area, Atlantic City Operating Area, Virginia Capes operating Areas, Cherry Point Operating Area, Jacksonville-Charleston Operating Areas, Key West Operating Area, Pensacola-Panama City Operating Area, New Orleans Operating Area, and Corpus Christi Operating Area.

We assume that any activities that are likely to occur landward of the mean higher high water line — including activities that may affect threatened or endangered species of sea turtle landward of the mean higher high water line — are addressed in separate section 7 consultations with the U.S. Fish and Wildlife Service.

Figure 2. The action area for the U.S. Navy's Atlantic Fleet Active Sonar Training.

4 STATUS OF LISTED RESOURCES

NMFS has determined that fifteen species may occur within this action area for the proposed AFAST exercises (Table 3).

Table 3. Species listed under the Federal Endangered Species Act (ESA) under NMFS jurisdiction that may occur in the Action Area for the proposed Atlantic Fleet Active Sonar Training (AFAST) exercises.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus*)	E – 35 FR 18319	-- --	71 FR 38385
Humpback Whale (*Megaptera novaeangliae*)	E -– 35 FR 18319	-- --	55 FR 29646
North Atlantic Right Whale (*Eubalaena glacialis*)	E – 73 FR 12024	59 FR 28805	70 FR 32293
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	76 FR 43985
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18619	-- --	75 FR 81584
Sea Turtles			
Green Turtle (*Chelonia mydas*)	E – 43 FR 32800	63 FR 46693	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricate*)	E – 35 FR 8491	63 FR 46693	57 FR 38818
Kemp's Ridley Turtle (*Lepidochelys kempi*)	E – 35 FR 18319	-- --	75 FR 12496
Leatherback Turtle (*Dermochelys coriacea*)	E – 61 FR 17	44 FR 17710	63 FR 28359
Loggerhead Turtle (*Caretta caretta*)	E – 76 FR 58868	-- --	63 FR 28359
Fishes			
Shortnose sturgeon *(Acipenser brevirostrum)*	E – 32 FR4001	-- --	63 FR 69613
Atlantic salmon (*Salmo salar)*	E – 65 FR 69459	74 FR 29300	70 FR 75473
Smalltooth sawfish (*Pristis pectinata)*	E – 68 FR 15674	74 FR 45353	74 FR 3566
Gulf sturgeon (*Acipenser oxyrinchus desotoi)*	T – 56 FR 49653	68 FR 13370	09/1995

Critical habitat has been designated for the North Atlantic right whale in the Atlantic Ocean in Cape Cod Bay, Great South Channel, and off Georgia and Florida. Critical habitat for green sea turtles has been designated on Culebra Island, Puerto Rico, for hawksbill sea turtles on Mona and Monita Islands, Puerto Rico, and for leatherback sea turtles on Sandy Point on Saint Croix in the U.S. Virgin Islands. Atlantic salmon critical habitat was designated in June 2009; all of which is within the State of Maine. NMFS designated critical habitat for smalltooth sawfish in September 2009 in two units along the southwestern coast of Florida between Charlotte Harbor and Florida Bay. In

2003, NMFS and the USFWS jointly designated Gulf sturgeon critical habitat; 14 geographic areas from Florida and Louisiana were included encompassing spawning rivers and adjacent estuarine areas.

4.1 Species Not Considered Further in this Opinion

As described in the Approach to the Assessment, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the active sonar training the U.S. Navy proposes to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico from January 2012 to January 2014. The first criterion was *exposure* or some reasonable expectation of a co-occurrence between one or more potential stressor associated with the U.S. Navy's activities and a particular listed species or designated critical habitat: if we conclude that a listed species or designated critical habitat is not likely to be exposed to U.S. Navy's activities, we must also conclude that the species is not likely to be adversely affected and critical habitat is not likely to adversely modified or destroyed by those activities. The second criterion is the probability of a *response* given exposure, which considers *susceptibility*: species that may be exposed to sound transmissions from active sonar, for example, but are likely to be unaffected by the sonar (at sound pressure levels they are likely to be exposed to) are also not likely to be adversely affected by the sonar. We applied these criteria to the species listed at the beginning of this section; this subsection summarizes the results of those evaluations.

4.1.1 Shortnose Sturgeon

Shortnose sturgeon are an anadromous species that occurs along the Atlantic Coast of North America, from the St. John River in Canada to the St. John's River in Florida. The recovery plan for shortnose sturgeon recognized 19 distinct, wild populations: New Brunswick, Canada (1 population); Maine (2 populations); Massachusetts (1 population); Connecticut (1 population); New York (1 population); New Jersey and Delaware (1 population); Maryland and Virginia (1 population); North Carolina (1 population); South Carolina (4 populations); Georgia (4 populations); and Florida (2 populations). One partially-landlocked population occurs in Holyoke Pool of the Connecticut River. Another landlocked population may exist in Lake Marion on the Santee River in South Carolina. Because of their coastal distribution, shortnose sturgeon are not likely to be exposed to active sonar associated with the U.S. Navy's proposed AFAST exercises and, therefore, are not likely to be adversely affected by the proposed exercises.

4.1.2 Atlantic Salmon

The Atlantic salmon is an anadromous species that occurs in North American, European, and Baltic waters. The North American group generally ranges from Quebec to Long Island Sound. Atlantic salmon typically spend the first two to three years in fresh water, move to ocean habitats for the next two to three years, and then return to the natal river to spawn. Atlantic salmon originating in the U.S. are highly migratory between natal rivers and the northwest Atlantic Ocean. Movement into riverine habitat occurs from spring to fall, peaking in June. Historically, Atlantic salmon occurred in most major river systems north of the Hudson River. However, with the exception of a few populations, current distribution is limited to the eastern third of Maine‘s coast. The Atlantic salmon Gulf of Maine DPS is currently listed as endangered under the ESA. The DPS was defined in 2000 as extending from the lower Kennebec River to (but not including) the mouth of the St. Croix River. In September 2008, NMFS and USFWS expanded the DPS to include all naturally reproducing wild and conservation hatchery populations from the

Androscoggin River to the Dennys River. Atlantic salmon in Maine outside the Gulf of Maine DPS are designated as Species of Concern.

Adult returns of Atlantic salmon within the range of the Gulf of Maine DPS remain low relative to conservation escapement goals (Fay et al. 2006). Because of their current distribution, these Atlantic salmon might only co-occur with the training activities the U.S. Navy proposes to conduct on the Northeast Operating Areas. Because they tend to be distributed in waters off Canada and Greenland and because of their low population size and the relatively few exercises that would occur in the Northeast Operating Areas, these salmon are not likely to be exposed to the training activities the U.S. Navy proposed to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico.

4.1.3 Smalltooth Sawfish

The smalltooth sawfish was listed under the ESA on April 6, 2003 following NMFS announcement on April 1, 2003 of a final determination for this species (68 FR 15674). Smalltooth sawfish are tropical, marine and estuarine fish that inhabit shallow waters of inshore bars, mangrove edges, and seagrass beds, although they are occasionally found in deeper coastal waters (NMFS 2000). Historically, this species was common in the shallow waters of the Gulf of Mexico and along the eastern seaboard of the United States to North Carolina (rare sightings of this sawfish occurred as far north as New York). Their current range is limited to peninsular Florida, where they are only found with any regularity off the extreme southern portion of the peninsula (off Everglades National Park and Florida Bay). Because of their current distribution, smalltooth sawfish might only be exposed to the training activities the U.S. Navy proposes to conduct on the Jacksonville Range Complex, which remains north of the primary distribution. Therefore, smalltooth sawfish are not likely to be exposed to the training activities the U.S. Navy proposed to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico and, therefore, are not likely to be adversely affected by those exercises.

4.1.4 Gulf Sturgeon

Subadult and adult Gulf sturgeons may be found in the nearshore marine waters within close proximity to the boundary of the eastern Gulf of Mexico, particularly along the northern Gulf of Mexico. The Gulf sturgeon in this area has been observed 1.9 km (1 NM) from shore (Ross et al., 2002). Gulf sturgeons have been observed off the Suwannee River area as far as 16.7 km (9 NM) from shore (USFWS and NMFS, 2003). The Gulf sturgeon is not expected to be present in the training areas since it is a coastal inhabitant. The USFWS has designated critical habitat for the Gulf sturgeon in the Gulf of Mexico. This protected habitat encompasses coastal waters from the mean high water line and out to 1.9 km (1 NM) offshore. The units for critical habitat include the Pearl River system in eastern Louisiana; the Pascagoula River system in Mississippi; the Escambia, Yellow, Apalachicola, Choctawhatchee, and Suwannee river systems in northwestern Florida; the Pensacola, Apalachicola, and Choctawhatchee bays in northwestern Florida; the Lake Borgne, Mississippi Sound, and Lake Pontchartrain systems in Mississippi and Louisiana; the Santa Rosa and Suwannee sounds in northwestern Florida; and the Florida Nearshore Gulf of Mexico area that stretches from Escambia to Gulf counties (50 CFR Part 226). The AFAST Study Area is located outside the Gulf sturgeon‘s critical habitat. Therefore, gulf sturgeon are not likely to be exposed to the training activities the U.S. Navy proposed to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico and, therefore, are not likely to be adversely affected by those exercises.

4.2 Critical Habitat

Critical habitat for green sea turtles has been designated on Culebra Island, Puerto Rico (63 FR 46693), for hawksbill sea turtles on Mona and Monita Islands, Puerto Rico (63 FR 46693), and for leatherback sea turtles on Sandy Point on Saint Croix in the U.S. Virgin Islands (44 FR 17710).

Based on the best scientific and commercial data available, critical habitat that has been designated for green sea turtles, hawksbill sea turtles, and leatherback sea turtles is outside of the area that might be exposed to mid- or high-frequency active sonar associated with the AFAST exercises. As a result, we conclude that the proposed exercises will not affect designated critical habitat. Therefore, this critical habitat will not be considered further in this Opinion. We consider the critical habitat that has been designated for North Atlantic right whales further in this consultation.

4.3 Climate Change

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 2001a; Oreskes 2004). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat-waves, floods, storms, and wet-dry cycles. Threats posed by the direct and indirect effects of global climatic change are or will be common to all of the species we discuss in this Opinion. Because of this commonality, we present this narrative here rather than in each of the species-specific narratives that follow.

The Intergovernmental Panel on Climate Change (IPCC) estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). The IPCC reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the IPCC concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (IPCC 2001a; IPCC 2001b). Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001b). These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 4).

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Houghton 2001). The direct effects of climate change would result in increases in atmospheric temperatures, changes in sea surface temperatures, changes in patterns of precipitation, and changes in sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown.

Table 4. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from Campbell-Lendrum and Woodruff 2006; IPCC 2001a).

Phenomenon	**Confidence in Observed Changes (observed in the latter 20th Century)**	**Confidence in Projected Changes (during the 21st Century)**
Higher maximum temperatures and a greater number of hot days over almost all land areas	Likely	Very likely
Higher minimum temperatures with fewer cold days and frost days over almost all land areas	Very likely	Very likely
Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increased heat index over most land areas	Likely over many areas	Very likely over most areas
More intense precipitation events	Likely over many mid- to high-latitude areas in Northern Hemisphere	Very likely over many areas
Increased summer continental drying and associated probability of drought	Likely in a few areas	Likely over most mid-latitude continental interiors (projections are inconsistent for other areas)
Increase in peak wind intensities in tropical cyclones	Not observed	Likely over some areas
Increase in mean and peak precipitation intensities in tropical cyclones	Insufficient data	Likely over some areas

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for calving and rearing calves, the distribution and abundance of prey, and the distribution and abundance of competitors or predators. For example, variations in the recruitment of krill (*Euphausia superba*) and the reproductive success of krill predators have been linked to variations in sea-surface temperatures and the extent of sea-ice cover during the winter months. Although the IPCC (2001a) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20 percent since the 1950s.

The Antarctic Peninsula, which is the northern extension of the Antarctic continent, contains the richest areas of krill in the Southern Ocean. The extent of sea ice cover around this Peninsula has the highest degree of variability relative to other areas within the distribution of krill. Relatively small changes in climate conditions are likely to exert a strong influence on the seasonal pack-ice zone in the Peninsula area, which is likely to affect densities of krill in this region. Because krill are important prey for baleen whales or form a critical component of the food chains on which baleen whales depend, increasing the variability of krill densities or causing those densities to decline dramatically is likely to have adverse effect on populations of baleen whales in the Southern Ocean.

Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators that depend on krill for prey — Antarctic fur seals (*Arctocephalus gazella*), gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*), and black-browed albatrosses (*Thalassarche melanophrys*) — at South Georgia Island and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50 percent in the 1990s, although incidental mortalities in longline fisheries probably contributed to the decline of the albatross. These authors concluded, however, that these declines result, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older age classes, which lowers the number of predators this prey species can sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s.

Similarly, a study of relationships between climate and sea-temperature changes and the arrival of squid off southwestern England over a 20-year period concluded that veined squid (*Loligo forbesi*) migrate eastwards in the English Channel earlier when water in the preceding months is warmer, and that higher temperatures and early arrival correspond with warm phases of the North Atlantic Oscillation (Sims et al. 2001). The timing of squid peak abundance advanced by 120- 150 days in the warmest years compared with the coldest. Seabottom temperature were closely linked to the extent of squid movement and temperature increases over the five months prior to and during the month of peak squid abundance did not differ between early and late years. These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which is in turn mediated by climatic changes associated with the North Atlantic Oscillation.

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (for example, see Payne et al. 1990b; Payne et al. 1986; Weinrich et al. 2001); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales.

Sperm whales, whose diets can be dominated by cephalopods, would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well.

The response of North Atlantic right whales to changes in the North Atlantic Oscillation also provides insight into the potential consequences of a changing climate on large whales. Changes in the climate of the North Atlantic have been directly linked to the North Atlantic Oscillation, which results from variability in pressure differences between a low pressure system that lies over Iceland and a high pressure system that lies over the Azore Islands. As these pressure systems shift from east to west, they control the strength of westerly winds and storm tracks across the North Atlantic Ocean. The North Atlantic Oscillation Index, which is positive when both systems are strong (producing increased differences in pressure that produce more and stronger winter storms) and negative when both systems are weak (producing decreased differences in pressure resulting in fewer and weaker winter storms), varies from year to year, but also exhibits a tendency to remain in one phase for intervals lasting several years.

Sea surface temperatures in the North Atlantic Ocean are closely related to this Oscillation and influence the abundance of marine mammal prey such as zooplankton and fish. In the 1970s and 1980s, the North Atlantic Oscillation Index has been positive and sea surface temperatures increased. These increases are believed to have produced conditions that were favorable for the copepod (*Calanus finmarchicus*), which is the principal prey of North Atlantic right whales (Conversi et al. 2001) and may have increased calving rates of these whales (we cannot verify this association because systematic data on North Atlantic right whale was not collected until 1982) (Greene et al. 2003). In the late 1980s and 1990s, the North Atlantic Oscillation Index was mainly positive but exhibited two substantial, multi-year reversals to negative values. This was followed by two major, multi-year declines in copepod prey abundance (Drinkwater et al. 2003; Pershing et al. 2010). Calving rates for North Atlantic right whales followed the declining trend in copepod abundance, although there was a time lag between the two (Greene et al. 2003).

Although the North Atlantic Oscillation Index has been positive for the past 25 years, atmospheric models suggest that increases in ocean temperature associated with climate change forecasts may produce more severe fluctuations in the North Atlantic Oscillation. Such fluctuations would be expected to cause dramatic shifts in the reproductive rate of critically endangered North Atlantic right whales (Drinkwater et al. 2003; Greene et al. 2003) and possibly a northward shift in the location of right whale calving areas (Kenney 2007).

Changes in global climatic patterns are also projected to have profound effect on the coastlines of every continent by increasing sea levels and increasing the intensity, if not the frequency, of hurricanes and tropical storms. Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests that are destroyed by tropical storms and hurricanes. Further, the combination of increasing sea levels, changes in patterns of coastal erosion and accretion, and changes in rainfall patterns are likely to affect coastal estuaries, submerged aquatic vegetation, and reef ecosystems that provide foraging and rearing habitat for several species of sea turtles. Finally, changes in ocean currents associated with climate change projections would affect the migratory patterns of sea turtles. The loss of nesting beaches, by itself, would have catastrophic effect on sea turtles populations globally if they are unable to colonize any new beaches that form of if the beaches that form do not provide the sand depths, grain patterns, elevations above high tides, or temperature regimes necessary to allow turtle eggs to survive. When combined with changes in coastal habitats and oceans currents, the future climates that are forecast place sea turtles at substantially greater risk of extinction than they already face.

As of the date this Opinion was drafted, we do not know whether the computer models on which these projections are based are accurate or, if so, how far into the future these effects might become manifest because these are long-term projections. Nevertheless, based on the best scientific and commercial data available, none of these effects are likely to affect the status or trend of the endangered or threatened species we considered in our 2009 programmatic biological opinion on military readiness activities in the AFAST study area or the activities that would occur during the period of the proposed LOA.

4.4 Species Considered Further in this Opinion

The rest of this section is narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the AFAST activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico from January 22, 2012 to January 21, 2014. In each narrative, we present a summary of information on the distribution and population structure of each species to provides a foundation for the exposure analyses that appear later in this Opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this Opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

After the Status subsection of each narrative, we present information on the diving and social behavior of the different species because that behavior helps determine whether aerial and ship board surveys are likely to detect each species. We also summarize information on the vocalizations and hearing of the different species because that background information lays the foundation for our assessment of the how the different species are likely to respond to sounds produced by detonations.

More detailed background information on the status of these species can be found in a number of published documents including status reviews, recovery plans for the blue whale (NMFS 1998b), fin whales (NMFS 2010c), fin and sei whale (NMFS 1998a), humpback whale (NMFS 1991), right whale (NMFS 2004), a status report on large whales prepared by Perry et al. (1999a) and recovery plans for sea turtles (NMFS and USFWS 1998a; NMFS and USFWS 1998c; NMFS and USFWS 1998d; NMFS and USFWS 2008; NMFS et al. 2010). Richardson et al. (1995a) and Tyack (2000) provide detailed analyses of the functional aspects of cetacean communication and their responses to active sonar. Finally, Croll et al. (1999), NRC (2000; 2003a; 2005b), and Richardson and Wursig (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this Opinion.

4.4.1 Blue Whale

The blue whale, *Balaenoptera musculus* (Linnæus 1758), is a cosmopolitan species of baleen whale. Blue whales are the largest species of whale. Blue whales in the Northern Hemisphere are generally smaller than those in the Southern Ocean. Maximum body length in the North Atlantic was about 88.5 feet (27 m) and the largest blue whale reported from the North Pacific was about 88 feet (26.8 m). Adults in the Antarctic can reach a maximum body length of about 108 feet (33 m) and can weigh more than 330,000 pounds (150,000 kg).

As is true of other baleen whale species, female blue whales are somewhat larger than males. Blue whales are identified by the following characteristics: a long-body and comparatively slender shape; a broad, flat "rostrum" when viewed from above; a proportionately smaller dorsal fin than other baleen whales; and a mottled gray color pattern that appears light blue when seen through the water.

Distribution

Blue whales are found along the coastal shelves of North America and South America (Clarke 1980; Donovan 1984; Rice 1989) in the North Pacific Ocean. In the North Pacific Ocean, blue whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Blue whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea.

In the western North Atlantic Ocean, blue whales are found from the Arctic to at least the mid-latitude waters of the North Atlantic (CETAP 1982; Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Blue whales have been observed frequently off eastern Canada, particularly in waters off Newfoundland, during the winter. In the summer month, they have been observed in Davis Strait (Mansfield 1985), the Gulf of St. Lawrence (from the north shore of the St. Lawrence River estuary to the Strait of Belle Isle), and off eastern Nova Scotia (Sears 1987a). In the eastern North Atlantic Ocean, blue whales have been observed off the Azores Islands, although Reiner et al. (1996) do not consider them common in that area.

In 1992, the U.S. Navy conducted an extensive acoustic survey of the North Atlantic using the Integrated Underwater Surveillance System’s fixed acoustic array system (Clark 1995). Concentrations of blue whale sounds were detected in the Grand Banks off Newfoundland and west of the British Isles. In the lower latitudes, one blue whale was tracked acoustically for 43 days, during which time the animal traveled 1400 nautical miles around the western North Atlantic from waters northeast of Bermuda to the southwest and west of Bermuda (Gagnon and Clark 1993).

There have only been a few reliable reports of blue whales from the Gulf of Mexico and these have been of animals that had stranded in 1924 and 1940 (Würsig et al. 2000). They are assumed to occur only extralimitally in the Gulf of Mexico.

In the North Pacific Ocean, blue whales have been recorded off the island of Oahu in the main Hawaiian Islands and off Midway Island in the western edge of the Hawaiian Archipelago (Barlow 1994; Northrop et al. 1971; Thompson and Friedl 1982), although blue whales are rarely sighted in Hawaiian waters and have not been reported to strand in the Hawaiian Islands. Nishiwaki (1966) reported that blue whales occur in the Aleutian Islands and in the Gulf of Alaska. Fifteen blue whale sightings off British Columbia and in the Gulf of Alaska have been made since 1997 (Calambokidis et al. 2009). Three of these photographically verified sightings were in the northern Gulf of Alaska within 71 nm of each other and were less than 100 nm offshore (Calambokidis et al. 2009).

In the eastern tropical Pacific Ocean, the Costa Rica Dome appears to be important for blue whales based on the high density of prey (euphausiids) available in the Dome and the number of blue whales that appear to reside there (Reilly and Thayer 1990). Blue whales have been sighted in the Dome area in every season of the year, although their numbers appear to be highest from June through November.

Blue whales have also been reported year-round in the northern Indian Ocean, with sightings in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Mizroch et al. 1984). The migratory movements of these whales are unknown.

Historical catch records suggest that “true” blue whales and “pygmy” blue whale (*B. m. brevicada*) may be geographically distinct (Brownell and Donaghue 1994; Kato et al. 1995). The distribution of the “pygmy” blue whale is north of the Antarctic Convergence, while that of the “true” blue whale is south of the Convergence in the austral summer (Kato et al. 1995). “True” blue whales occur mainly in the higher latitudes, where their distribution in mid-summer overlaps with that of the minke whale (*Balaenoptera acutorostrata*). During austral summers, “true” blue whales are found close to the edge of Antarctic ice (south of 58° S) with concentrations between 60°-80° E and 66°-70° S (Kasamatsu 1996).

Population Structure

For this and all subsequent species, the term “population” refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Futuymda (1986) and Wells and Richmond (1995) and is more restrictive than those uses of ‘population’ that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see review by Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as ‘population decline,’ ‘population collapse,’ ‘population extinction,’ and ‘population recovery’ apply to the restrictive definition of ‘population’ but do not explicitly apply to alternative definitions. As a result, we do not treat the different whale “stocks” recognized by the International Whaling Commission or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those “stock” distinctions in these narratives.

At least three subspecies of blue whales have been identified based on body size and geographic distribution (*B. musculus intermedia*, which occurs in the higher latitudes of the Southern Oceans, *B. m. musculus*, which occurs in the Northern Hemisphere, and *B. m. brevicauda* which occurs in the mid-latitude waters of the southern Indian Ocean and north of the Antarctic convergence), but this consultation will treat them as a single entity. Readers who are interested in these subspecies will find more information in Gilpatrick et al. (1997), Kato et al. (1995) , Omura et al. (1970), and Ichihara (1966).

In addition to these subspecies, the International Whaling Commission’s Scientific Committee has formally recognized one blue whale population in the North Pacific (Donovan 1991), although there is increasing evidence that there may be more than one blue whale population in the Pacific Ocean Gilpatrick et al. (1997), Barlow et al. (1995), Mizroch et al. (1984), Ohsumi and Wada (1972). For example, studies of the blue whales that winter off Baja California and in the Gulf of California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick et al. 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (Barlow 1997; Calambokidis et al. 1990; Sears 1987b).

A population or “stock” of endangered blue whales occurs in waters surrounding the Hawaiian archipelago (from the main Hawaiian Islands west to at least Midway Island), although blue whales are rarely reported from Hawai'ian waters. The only reliable report of this species in the central North Pacific was a sighting made from a scientific research vessel about 400 km northeast of Hawai'i in January 1964 (NMFS 1998b). However, acoustic monitoring has recorded blue whales off Oahu and the Midway Islands much more recently (McDonald and Fox 1999; Northrop et al. 1971; Thompson and Friedl 1982).

The recordings made off Oahu showed bimodal peaks throughout the year, suggesting that the animals were migrating into the area during summer and winter (McDonald and Fox 1999; Thompson and Friedl 1982). Twelve aerial surveys were flown within 25 nm^2 of the main Hawaiian Islands from 1993-1998 and no blue whales were sighted. Nevertheless, blue whale vocalizations that have been recorded in these waters suggest that the occurrence of blue whales in these waters may be higher than blue whale sightings. There are no reports of blue whale strandings in Hawaiian waters.

The International Whaling Commission also groups all of the blue whales in the North Atlantic Ocean into one "stock" and groups blue whales in the Southern Hemisphere into six "stocks" (Donovan 1991) which are presumed to follow the feeding distribution of the whales.

Threats to the Species

Natural Threats. Natural causes of mortality in blue whales are largely unknown, but probably include predation and disease (not necessarily in their order of importance). Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1928), which are believed to have caused fin whales to die as a result of renal failure (Lambertsen 1986); see additional discussion under *Fin whales*). Killer whales and sharks are also known to attack, injure, and kill very young or sick fin and humpback whale and probably hunt blue whales as well (Perry et al. 1999a).

Anthropogenic Threats. Two human activities are known to threaten blue whales: whaling and shipping. Historically, whaling represented the greatest threat to every population of blue whales and was ultimately responsible for listing blue whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (Cherfas 1992; Tonnessen and Johnsen 1982). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. Before fin whales became the focus of whaling operations, populations of blue whales had already become commercially extinct (IWC 2005).

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (NMFS 1998b). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 194, 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

Although the International Whaling Commission banned commercial whaling in the North Pacific in 1966, Soviet whaling fleets continued to hunt blue whales in the North Pacific for several years after the ban. Surveys conducted in these former-whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell Jr. 1996). By 1967, Soviet scientists wrote that blue whales in the North Pacific Ocean (including the eastern Bering Sea and Prince William Sound) had been so overharvested by Soviet whaling fleets that some scientists concluded that any additional harvests were certain to cause the species to become extinct in the North Pacific (Latishev 2007). As its legacy, whaling has reduced blue whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push blue whales closer to extinction. Otherwise, whaling currently does not threaten blue whale populations.

In 1980, 1986, 1987, and 1993, ship strikes were implicated in the deaths of blue whales off California (Barlow 1997). More recently, Berman-Kowalewski et al. (2010) reported that between 1988 and 2007, 21 blue whale deaths were reported along the California coast, typically one or two cases annually. In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987).

Status

Blue whales were listed as endangered under the ESA in 1973. Blue whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for blue whales.

It is difficult to assess the current status of blue whales because (1) there is no general agreement on the size of the blue whale populations prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population prior to whaling, although some authors have concluded that their were about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser et al. 1981). These estimates, however, are more than 20 years old.

A lot of uncertainty surrounds estimates of blue whale abundance in the North Pacific Ocean. Barlow (1994) estimated the North Pacific population of blue whales at approximately 1,400 to 1,900. Barlow (1995) estimated the abundance of blue whales off California at 2,200 individuals. Wade and Gerrodette (1993) and Barlow et al. (1997) estimated there were a minimum of 3,300 blue whales in the North Pacific Ocean in the 1990s.

The size of the blue whale population in the north Atlantic is also uncertain. The population has been estimated to number from a few hundred individuals (Allen 1970; Mitchell 1974b) to 1,000 to 2,000 individuals (Sigurjónsson

1995). Gambell (1976) estimated there were between 1,100 and 1,500 blue whales in the North Atlantic before whaling began and Braham (1991) estimated there were between 100 and 555 blue whales in the North Atlantic during the late 1980s and early 1990s. Sears et al. (1987) identified over 300 individual blue whales in the Gulf of St. Lawrence, which provides a minimum estimate for their population in the North Atlantic. Sigurjónsson and Gunnlaugson (1990) concluded that the blue whale population had been increasing since the late 1950s and argued that the blue whale population had increased at an annual rate of about 5 percent between 1979 and 1988, although the level of confidence we can place in these estimates is low.

Estimates of the number of blue whales in the Southern Hemisphere range from 5,000 to 6,000 (Yochem and Leatherwood 1985) with an average rate of increase that has been estimated at between 4 and 5 percent per year. Butterworth et al. (1993), however, estimated the Antarctic population at 710 individuals. More recently, Stern (2001) estimated the blue whale population in the Southern Ocean at between 400 and 1,400 animals (c.v. 0.4). The pygmy blue whale population has been estimated at 6,000 individuals (Yochem and Leatherwood 1985).

The information available on the status and trend of blue whales do not allow us to reach any conclusions about the extinction risks facing blue whales as a species, or particular populations of blue whales. With the limited data available on blue whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate).

Diving and Social Behavior

Blue whales spend more than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 sec intervals before a deep dive of 3-30 min (Mackintosh 1965) (Croll et al. 1999; Leatherwood et al. 1976; Maser et al. 1981; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

Blue whales occur singly or in groups of two or three (Aguayo 1974; Mackintosh 1965; Nemoto 1964; Pike and Macaskie. 1969; Ruud 1956; Slijper 1962). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Fiedler et al. 1998; Schoenherr 1991). Little is known of the mating behavior of blue whales.

Vocalizations and Hearing

The vocalizations that have been identified for blue whales include a variety of sounds described as low frequency moans or long pulses (Cummings and Thompson 1971; Cummings and Thompson 1977; Edds-Walton 1997; Thompson and Friedl 1982). Blue whales produce a variety of low frequency sounds in the 10-100 Hz band (Clark and Fristrup. 1997; Cummings and Thompson 1971; McDonald et al. 2001; Thompson and Friedl 1982). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. The sounds last several tens of seconds. Estimated source levels are as high as 180-190 dB (Cummings and Thompson 1971). Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. 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. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups. The seasonality and structure of long patterned sounds suggest that these sounds are male displays for attracting females, competing with other males, or both. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function. Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish and Mitchell 1971; Cummings and Thompson 1971; Cummings and Thompson 1977; Cummings and Thompson 1994).

Blue whale moans within the low frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). A short, 390 Hz pulse also is produced during the moan. One estimate of the overall source level was as high as 188 dB, with most energy in the 1/3-octave bands centered at 20, 25, and 31.5 Hz, and also included secondary components estimates near 50 and 63 Hz (Cummings and Thompson 1971).

As with other vocalizations produced by baleen whales, the function of blue whale vocalizations is unknown, although there are numerous hypotheses which include; maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey. Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that blue whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Edds-Walton 1997; Payne and Webb. 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

4.4.2 Fin Whale

Fin whales are the second-largest species of whale, with a maximum length of about 75 ft (22 m) in the Northern Hemisphere, and 85 ft (26 m) in the Southern Hemisphere. Fin whales show mild sexual dimorphism, with females measuring longer than males by 5-10 percent. Adults can weigh between 80,000-160,000 lbs (40-80 tons).

Fin whales have a sleek, streamlined body with a V-shaped head. They have a tall, falcate dorsal fin, located about two-thirds of the way back on the body, that rises at a shallow angle from the animal's back. The species has a distinctive coloration pattern: the back and sides of the body are black or dark brownish-gray, and the ventral surface is white. The unique, asymmetrical head color is dark on the left side of the lower jaw, and white on the right side. Many individuals have several light-gray, V-shaped "chevrons" behind their head, and the underside of the tail flukes is white with a gray border.

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean. In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985a).

In the North Atlantic Ocean, fin whales occur in summer foraging areas from the coast of North America to the Arctic, around Greenland, Iceland, northern Norway, Jan Meyers, Spitzbergen, and the Barents Sea. In the western Atlantic, they winter from the edge of sea ice south to the Gulf of Mexico and the West Indies. In the eastern Atlantic, they winter from southern Norway, the Bay of Biscay, and Spain with some whales migrating into the Mediterranean Sea (Gambell 1985a).

In the Southern Hemisphere, fin whales are distributed broadly south of 50° S in the summer and migrate into the Atlantic, Indian, and Pacific Oceans in the winter, along the coast of South America (as far north as Peru and Brazil), Africa, and the islands in Oceania north of Australia and New Zealand (Gambell 1985a).

Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast seaward to the continental shelf (about the 1,000-fathom contour). In this region, they tend to occur north of Cape Hatteras where they accounted for about 46 percent of the large whales observed in surveys conducted between 1978 and 1982. During the summer months, fin whales in this region tend to congregate in feeding areas between 41°20'N and 51°00'N, from shore seaward to the 1,000-fathom contour. Fin whales in the eastern North Atlantic have been found in highest densities in the Irminger Sea between Iceland and Greenland (Víkingsson et al. 2009). In the Atlantic Ocean, a general migration in the fall from the Labrador and Newfoundland region, south past Bermuda, and into the West Indies has been theorized (Clark 1995). Historically, fin whales were by far the most common large whale found off Portugal (Brito et al. 2009).

In the Atlantic Ocean, Clark (1995) reported a general southward pattern of fin whale migration in the fall from the Labrador and Newfoundland region, south past Bermuda, and into the West Indies. The overall distribution may be based on prey availability, and fin whales are found throughout the action area for this consultation in most months of the year. This species preys opportunistically on both invertebrates and fish (Watkins et al. 1984). They feed by filtering large volumes of water for the associated prey. Fin whales are larger and faster than humpback and right whales and are less concentrated in nearshore environments.

Fin whales have been reported more frequently than blue whales in the Gulf of Mexico, although many of these reports are probably of Bryde's whales, which are more common in the Gulf. Like blue whales, fin whales are assumed to occur only extralimitally in the Gulf of Mexico (Jefferson and Schiro 1997; Würsig et al. 2000).

Population Structure

Fin whales have two recognized subspecies: *Balaoptera physalus physalus* occurs in the North Atlantic Ocean while *B. p***.** *quoyi* (Fischer 1829) occurs in the Southern Ocean. Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Within these major areas, different organizations use different population structure.

In the North Atlantic Ocean, the International Whaling Commission recognizes seven management units or "stocks" of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea is believed to be genetically distinct from other fin whales populations (as used in this Opinion, "populations" are isolated demographically, meaning, they are driven more by internal dynamics — birth and death processes — than by the geographic redistribution of individuals through immigration or emigration. Some usages of the term "stock" are synonymous with this definition of "population" while other usages of "stock" do not).

In the North Pacific Ocean, the International Whaling Commission recognizes two "stocks": (1) East China Sea and (2) rest of the North Pacific (Donovan, 1991). However, Mizroch et al. (1984) concluded that there were five possible "stocks" of fin whales within the North Pacific based on histological analyses and tagging experiments: (1) East and West Pacific that intermingle around the Aleutian Islands; (2) East China Sea; (3) British Columbia; (4) Southern-Central California to Gulf of Alaska; and (5) Gulf of California. Based on genetic analyses, Berube et al. (1998) concluded that fin whales in the Sea of Cortez represent an isolated population that has very little genetic exchange with other populations in the North Pacific Ocean (although the geographic distribution of this population and other populations can overlap seasonally). They also concluded that fin whales in the Gulf of St. Lawrence and Gulf of Maine are distinct from fin whales found off Spain and in the Mediterranean Sea.

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrated that individual fin whales migrate between management units (Mitchell 1974a; Sigurjonsson et al. 1989), which suggests that these management units are not geographically isolated populations.

Mizroch et al. (1984) identified five fin whale "feeding aggregations" in the Pacific Ocean: (1) eastern and western groups that move along the Aleutians (Berzin and Rovnin. 1966; Nasu 1974); (2) an East China Sea group; (3) a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (Rice 1974); and (4) a group centered in the Sea of Cortez (Gulf of California).

Hatch (2004) reported that fin whale vocalizations among five regions of the eastern North Pacific were heterogeneous: the Gulf of Alaska, the northeast North Pacific (Washington and British Columbia), the southeast North Pacific (California and northern Baja California), the Gulf of California, and the eastern tropical Pacific.

Sighting data show no evidence of migration between the Sea of Cortez and adjacent areas in the Pacific, but seasonal changes in abundance in the Sea of Cortez suggests that these fin whales might not be isolated (Tershy et al. 1993). Nevertheless, Bérubé et al. (2002) concluded that the Sea of Cortez fin whale population is genetically distinct from the oceanic population and has lower genetic diversity, which suggests that these fin whales might represent an isolated population.

Threats to the Species

Natural Threats. Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range from 0.04 to 0.06. These results are based on studies of fin whales in the northeast Atlantic; there are no comparable estimates for fin whales in the Pacific Ocean. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992). Killer whale or shark attacks may injure or kill very young or sick whales (Perry et al. 1999a).

Anthropogenic Threats. Fin whales have undergone significant exploitation, but are currently protected under the IWC's global moratorium on whaling. Fin whales are still hunted in subsistence fisheries off West Greenland. In 2004, five males and six females were killed, and two other fin whales were struck and lost. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005). In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each ear for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit. The Japanese whalers plan to kill 50 whales per year starting in the 2007-2008 season and continuing for the next 12 years (IWC 2006; Nishiwaki et al. 2006).

Fin whales experience significant injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Douglas et al. 2008; Lien 1994; Perkins and Beamish 1979; Waring et al. 2007). Between 1969 and 1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). In 1999, one fin whale was reported killed in the Gulf of Alaska pollock trawl fishery and one was killed the same year in the offshore drift gillnet fishery (Angliss and Outlaw 2005; Carretta and Chivers. 2004). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004. Jensen and Silber (2004) review of the NMFS' ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the

U.S. and Alaska/Hawaii. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005; Nelson et al. 2007). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008). Similarly, 2.4 percent of living fin whales from the Mediterranean show ship strike injury and 16 percent of stranded individuals were killed by vessel collision (Panigada et al. 2006). There are also numerous reports of ship strikes off the Atlantic coasts of France and England (Jensen and Silber 2004).

Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to be capable of reducing ship strike mortality by 27 percent in the Bay of Fundy region.

The organochlorines DDE, DDT, and PCBs have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

Climate change also presents a potential threat to fin whales, particularly in the Mediterranean Sea, where fin whales appear to rely exclusively upon northern krill as a prey source. These krill occupy the southern extent of their range and increases in water temperature could result in their decline and that of fin whales in the Mediterranean Sea (Gambaiani et al. 2009).

Status

Fin whales were listed as endangered under the ESA in 1970. In 1976, the IWC protected fin whales from commercial whaling. Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for fin whales.

It is difficult to assess the current status of fin whales because (1) there is no general agreement on the size of the fin whale populations prior to whaling and (2) estimates of the current size of the different fin whale populations vary widely (NMFS 2006). We may never know the size of the fin whale populations prior to whaling. The most current estimate of the population size of fin whales in the Pacific Ocean is 85,200 (no coefficient of variance or confidence interval was provided) based on the history of catches and trends in catches per unit of effort (IWC 1979). Based on surveys conducted south of 30°S latitude between 1978 and 1988, fin whales in the Southern Ocean were estimated to number about 400,000 (IWC 1979), no coefficient of variance or confidence interval was provided).

Chapman (1976) estimated the “original” population size of fin whales off Nova Scotia as 1,200 and 2,400 off Newfoundland, although he offered no explanation or reasoning to support that estimate. Sergeant (1977) suggested that between 30,000 and 50,000 fin whales once populated the North Atlantic Ocean based on assumptions about catch levels during the whaling period. Sigurjónsson (1995) estimated that between 50,000 and 100,000 fin whales once populated the North Atlantic, although he provided no data or evidence to support that estimate. More recently, Palumbi and Roman (2006) estimated that about 360,000 fin whales (95 percent confidence interval = 249,000 - 481,000) populated the North Atlantic Ocean before whaling based on mutation rates and estimates of genetic diversity.

Similarly, estimates of the current size of the different fin whale populations and estimates of their global abundance also vary widely. The draft recovery plan for fin whales accepts a minimum population estimate of 2,362 fin whales for the North Atlantic Ocean (NMFS 2006); however, the recovery plan also states that this estimate, which is based on shipboard and aerial surveys conducted in the Georges Bank and Gulf of St. Lawrence in 1999 is the “best” estimate of the size of this fin whale population (NMFS 2010c). However, based on data produced by surveys conducted between 1978-1982 and other data gathered between 1966 and 1989, Hain et al. (1992) estimated that the population of fin whales in the western North Atlantic Ocean (specifically, between Cape Hatteras, North Carolina, and Nova Scotia) numbered about 1,500 whales in the winter and 5,000 whales in the spring and summer. Because authors do not always reconcile “new” estimates with earlier estimates, it is not clear whether the current “best” estimate represents a refinement of the estimate that was based on older data or whether the fin whale population in the North Atlantic has declined by about 50 percent since the early 1980s. The 2010 U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessment Report indicates the best abundance estimate for the western North Atlantic fin whale stock is 3,985 (cv=0.24) based on 2006 Gulf of Maine surveys and 2007 northern Labrador to Scotian Shelf surveys (Waring et al. 2011).

The East Greenland-Iceland fin whale population was estimated at 10,000 animals (95 percent confidence interval = 7,600 - 14,200), based on surveys conducted in 1987 and 1989 (Buckland et al. 1992). The number of eastern Atlantic fin whales, which includes the British Isles-Spain-Portugal population, has been estimated at 17,000 animals (95 percent confidence interval = 10,400 -28,900; (Buckland et al. 1992). These estimates are both more than 15 years old and the data available do not allow us to determine if they remain valid.

Forcada et al. (1996) estimated there were 3,583 fin whales in the western Mediterranean (standard error = 967; 95 percent confidence interval = 2,130 - 6,027), which is similar to an estimate published by Notarbartolo-di-Sciara et al. (2003). In the Mediterraneans’ Ligurian Sea (which includes the Pelagos Whale Sanctuary and the Gulf of Lions), Forcada et al. (1995) estimated there were 901 fin whales (standard error = 196.1).

Regardless of which of these estimates, if any, come closest to actual population sizes, these estimates suggest that the global population of fin whales consists of tens of thousands of individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Nevertheless, based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

Diving and Social Behavior

The percentage of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives with each of these dives lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985a). Other authors have reported that the fin whale's most common dives last between 2 and 6 minutes, with 2 to 8 blows between dives (Hain et al. 1992; Watkins et al. 1981).

In waters off the Atlantic Coast of the U.S. individual fin whales or pairs represented about 75 percent of the fin whales observed during the Cetacean and Turtle Assessment Program (Hain et al. 1992). Individual whales or groups of less than five individuals represented about 90 percent of the observations (out of 2,065 observations of fin whales, the mean group size was 2.9, the modal value was 1, and the range was 1 – 65 individuals; (Hain et al. 1992).

Vocalizations and Hearing

The sounds fin whales produce underwater are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Edds 1988; Thompson et al. 1992; Watkins et al. 1981; Watkins et al. 1987). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton. 1964). Estimated source levels are as high as 190 dB (Patterson and Hamilton. 1964; Thompson et al. 1992; Watkins et al. 1987). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 1995). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins et al. 1987), while the individual counter-calling data of McDonald et al. (1995) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson et al. 1992).

As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses (which include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by Thompson et al. (1992). for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Edds-Walton 1997; Payne and Webb. 1971). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above; that description is also applicable to fin whales.

4.4.3 Humpback Whale

Humpback whales are well known for their long "pectoral" fins, which can be up to 15 feet (4.6 m) in length. Their scientific name, *Megaptera novaeangliae*, means "big-winged New Englander" as the New England population was the one best known to Europeans. These long fins give them increased maneuverability; they can be used to slow down or even go backwards.

Similar to all baleen whales, adult females are larger than adult males, reaching lengths of up to 60 feet (18 m). Their body coloration is primarily dark grey, but individuals have a variable amount of white on their pectoral fins and belly. This variation is so distinctive that the pigmentation pattern on the undersides of their "flukes" is used to identify individual whales, similar to a humans fingerprint.

Humpback whales are the favorite of whale watchers, as they frequently perform aerial displays, such as breaching (jumping out of the water), or slap the surface with their pectoral fins, tails, or heads.

Distribution

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern Oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they reproduce and give birth to calves) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In their summer foraging areas and winter calving areas, humpback whales tend to occupy shallower, coastal waters; during their seasonal migrations, however, humpback whales disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawai'i, southern Japan, the Mariana Islands, and Mexico during the winter.

In the Atlantic Ocean, humpback whales range from the mid-Atlantic bight, the Gulf of Maine, across the southern coast of Greenland and Iceland, and along the coast of Norway in the Barents Sea. These humpback whales migrate to the western coast of Africa and the Caribbean Sea during the winter (Boye et al. 2010; Katona and Beard 1990; Smith et al. 1999b).

In the Southern Ocean, humpback whales occur in waters off Antarctica. These whales migrate to the waters off Venezuela, Brazil, southern Africa, western and eastern Australia, New Zealand, and islands in the southwest Pacific during the austral winter. A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997; Rasmussen et al. 2007).

Population Structure

Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they feed. During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different "reproductive areas" will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form "open" populations; that is, populations that are connected through the movement of individual animals.

<u>North Pacific Ocean</u>. NMFS' Stock Assessment Reports recognize four "stocks" of humpback whales in the North Pacific Ocean, based on genetic and photo-identification studies: two Eastern North Pacific stocks, one Central North Pacific stock, and one Western Pacific stock (Hill and DeMaster 1998). The first two of these "stocks" are based on where these humpback whales winter: the central North Pacific "stock" winters in the waters around Hawai'i while the eastern North Pacific "stock" (also called the California-Oregon-Washington-Mexico stock) winters along coasts of Central America and Mexico. However, Calambokidis et al. (1997) identified humpback whales from Southeast Alaska (central North Pacific), the California-Oregon-Washington (eastern North Pacific), and Ogasawara Islands (Japan, Western Pacific) groups in the Hawai'ian Islands during the winter; humpback whales from the Kodiak Island, Southeast Alaska, and British Columbia groups in the Ogasawara Islands; and whales from the British Columbia, Southeast Alaska, Prince William Sound, and Shumagin-Aleutian Islands groups in Mexico.

Herman (1979), however, presented extensive evidence and various lines of reasoning to conclude that the humpback whales associated with the main Hawaiian Islands immigrated to those waters only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai'i and those that winter off Mexico (with further mixing on feeding areas in Alaska) and suggested that the humpback whales that winter in Hawai'i may have emigrated from wintering areas in Mexico. Based on these patterns of movement, we conclude that the various "stocks" of humpback whales are not true populations or, at least, they represent populations that experience substantial levels of immigration and emigration.

Between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the

North Pacific (Calambokidis et al. 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches.

North Atlantic Ocean. In the Atlantic Ocean, humpback whales aggregate in four feeding areas in the summer months: (1) Gulf of Maine, eastern Canada, (2) west Greenland, (3) Iceland and (4) Norway (Katona and Beard 1990; Smith et al. 1999a). The principal breeding range for these whales lies from the Antilles and northern Venezuela to Cuba (Balcomb III and Nichols Jr. 1982; Whitehead 1982; Winn et al. 1975). The largest contemporary breeding aggregations occur off the Greater Antilles where humpback whales from all of the North Atlantic feeding areas have been identified from photographs (Katona and Beard 1990; Smith et al. 1999a) (Clapham 1993; Mattila et al. 1994; Palsbøll et al. 1997; Stevick et al. 2003). Historically, an important breeding aggregation was located in the eastern Caribbean based on the important humpback whale fisheries this region supported (Mitchell and Reeves 1983; Reeves et al. 2001; Smith and Reeves 2003). Although sightings persist in those areas, modern humpback whale abundance appears to be low (Levenson and Leapley 1978; Swartz et al. 2003; Winn et al. 1975). Winter aggregations also occur at the Cape Verde Islands in the Eastern North Atlantic (Reiner et al. 1996) (Reeves and Smith. 2002). In another example of the "open" structure of humpback whale populations, an individual humpback whale migrated from the Indian Ocean to the South Atlantic Ocean and demonstrated that individual whales may migrate from one ocean basin to another (Pomilla and Rosenbaum 2005).

Indian Ocean. As discussed previously, a separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

Threats to the Species

Natural Threats. There is limited information on natural phenomena that kill or injure humpback whales. We know that humpback whales are killed by orcas (Florezgonzalez et al. 1994; Whitehead and Glass. 1985) and are probably killed by false killer whales and sharks. Because 7 female and 7 male humpback whales stranded on the beaches of Cape Cod and had died from toxin produced by dinoflagellates between November 1987 and January 1988, we also know that adult and juvenile humpback whales are killed by naturally-produced biotoxins (Geraci et al. 1989).

Other natural sources of mortality, however, remain largely unknown. Similarly, we do not know whether and to what degree natural mortality limits or restricts patterns of growth or variability in humpback whale populations.

Anthropogenic Threats. Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of humpback whales and was ultimately responsible for listing humpback whales as an endangered species. From 1900 to 1965, nearly 30,000 whales were taken in modern whaling operations of the Pacific Ocean. Prior to that, an unknown number of humpback whales were taken (Perry et al. 1999a). In 1965, the International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean. As its legacy, whaling has reduced humpback whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push these whales closer to extinction.

Humpback whales are also killed or injured during interactions with commercial fishing gear. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada: a total of 595 humpback whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994; Perkins and Beamish 1979). Of these whales, 94 are known to have died as a result of that capture, although, like fin whales, most of the animals that died were smaller (less than 12 meters in length) (Lien 1994). These data suggest that, despite their size and strength, humpback whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

There are also reports of entangled humpback whales from the Hawaiian Islands. In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill et al. 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. Also in 1996, a vessel from Pacific Missile Range Facility in Hawai'i rescued an entangled humpback, removing two crab pot floats from the whale. From 2001 through 2006, there were 23 reports of entangled humpback whales in Hawaiian waters; 16 of these reports were from 2005 and 2006.

Many of the entangled humpback whales observed in Hawaiian waters brought the gear with them from higher latitude feeding grounds; for example, the whale the U.S. Navy rescued in 1996 had been entangled in gear that was traced to a recreational fisherman in southeast Alaska. Thus far, 6 of the entangled humpback whales observed in the Hawaiian Islands have been confirmed to have been entangled in gear from Alaska. Nevertheless, humpback whales are also entangled in fishing gear in the Hawaiian Islands. Since 2001, there have been 5 observed interactions between humpback whales and gear associated with the Hawai'i-based longline fisheries (NMFS 2008d). In each instance, however, all of the whales were disentangled and released or they were able to break free from the gear without reports of impairment of the animal's ability to swim or feed.

Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these reports, 95 entanglements were confirmed resulting in the injury of 11 humpback whales and the death of 9 whales. No information is available on the number of humpback whales that have been killed or seriously injured by interactions with fishing fleets outside of U.S. waters.

The number of humpback whales killed by ship strikes is exceeded only by fin whales (Jensen and Silber 2003). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow et al. 1997). The humpback whale calf that was found stranded on Oahu with evidence of vessel collision (propeller cuts) in 1996 suggests that ship collisions might kill adults, juvenile, and calves (NMFS unpublished data). Of 123 humpback whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 7 humpback whales. Despite several literature searches, we did not identify information on the number of humpback whales killed or seriously injured by ship strikes outside of U.S. waters.

In addition to ship strikes in North America and Hawai'i, there are several reports of humpback whales being injured as a result of ship strikes off the Antarctic Peninsula, in the Caribbean Sea, the Mediterranean Sea, off Australia, Bay of Bengal (Indian Ocean), Brazil, New Zealand, Peru, and South Africa.

Status

Humpback whales were listed as endangered under the ESA in 1973. Humpback whales are listed as a species of least concern on the IUCN Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for humpback whales.

It is difficult to assess the current status of humpback whales for the same reasons that it is difficult to assess the status of fin whales: (1) there is no general agreement on the size of the humpback whale population prior to whaling and (2) estimates of the current size of the different humpback whale populations vary widely and produce estimates that are not always comparable to one another, although robust estimates of humpback whale populations in the western North Atlantic have been published. We may never know the size of the humpback whale population prior to whaling.

Winn and Reichley (1985) argued that the global population of humpback whales consisted of at least 150,000 whales in the early 1900s, with the largest population historically occurring in the Southern Ocean. Based on analyses of mutation rates and estimates of genetic diversity, Palumbi and Roman (2006) concluded that there may have been as many as 240,000 (95 percent confidence interval = 156,000 – 401,000) humpback whales in the North Atlantic before whaling began. In the western North Atlantic between Davis Strait, Iceland and the West Indies, Mitchell and Reeves (1983) estimated there were at least 4,685 humpback whales in 1865 based on available whaling records (although the authors note that this does not represent a "pre-exploitation estimate" because whalers from Greenland, the Gulf of St. Lawrence, New England, and the Caribbean Sea had been hunting humpback whales before 1865).

Estimates of the number of humpback whales occurring in the different populations that inhabit the Northern Pacific population have risen over time. In the 1980s, the size of the North Pacific humpback whale population was estimated to range from 1,407 to 2,100 (Baker 1985; Baker and Herman. 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). By the mid-1990s, the population was estimated to consist of about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis et al. 1997; Cerchio 1998; Mobley et al. 2001).

As discussed previously, between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis et al. 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches. Of this total, 4,516 individuals were identified at wintering regions in at least one of the three seasons in which the study surveyed wintering area and 4,328 individuals were identified at least once at feeding areas in one of the two years in which the study surveyed feeding areas. Based on the results of that effort, Calambokidis et al. (2008) estimated that the current population of humpback whales in the North Pacific Ocean consisted of about 18,300 whales, not counting calves. Almost half of the humpback whales that were estimated to occur in wintering areas, or about 8,000 humpback whales, occupy the Hawaiian Islands during the winter months.

In the North Atlantic, Stevick et al. (2003) estimated the size of the humpback whale population between 1979 and 1993 by applying statistical analyses that are commonly used in capture-recapture studies to individual humpback whales that were identified based on natural markings. Between 1979 and 1993, they estimated that the North Atlantic populations (what they call the "West Indies breeding population") consisted of between 5,930 and 12,580 individual whales. The best estimate they produced (11,570; 95 percent confidence interval = 10,290 -13,390) was based on samples from 1992 and 1993. If we assume that this population has grown according to the instantaneous rate of increase Stevick et al. (2003) estimated for this population ($r = 0.0311$), this would lead us to estimate that this population might consist of about 18,400 individual whales in 2007-2008.

Regardless of which of these estimates, if any, most closely correspond to the actual size and trend of the humpback whale population, all of these estimates suggest that the global population of humpback whales consists of tens of thousands of individuals, that the North Atlantic population consists of at least 2,000 individuals and the North Pacific population consists of about 18,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, humpback whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that humpback whales will have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) rather than endogenous threats caused by the small size of their population.

Diving and Social Behavior

In Hawaiian waters, humpback whales remain almost exclusively within the 1820 m isobath and usually within waters depths less than 182 meters. Maximum diving depths are approximately 150 m (492 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton et al. 1997). They may remain submerged for up to 21 min (Dolphin 1987). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). Because most humpback prey is likely found above 300 m depths most humpback dives are probably relatively shallow.

In a review of the social behavior of humpback whales, Clapham and Mayo (1987) reported that they form small, unstable social groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long-periods of times. There is good evidence of some territoriality on feeding (Clapham 1994; Clapham 1996), and calving areas. In calving areas, males sing long complex songs directed towards females, other males or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Inter-male competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds which may be as high as 2.4:1.

Vocalizations and Hearing

Humpback whales produce at least three kinds of vocalization: (1) complex songs with components ranging from at least 20Hz to 4 kHz with estimated source levels from 144 to 174 dB, which are mostly produced by males on breeding areas (Richardson et al. 1995a; Winn et al. 1970); (2) social sounds in breeding areas that extend from 50 Hz to more than 10 kHz with most energy below 3 kHz (Richardson et al. 1995a; Tyack 1983); and (3) vocalizations in foraging areas that are less frequent, but tend to be 20Hz B 2 kHz with estimated sources levels in excess of 175 dB re 1 μPa-m (Richardson et al. 1995a; Thompson et al. 1986). Sounds that investigators associate with aggressive behavior in male humpback whales are very different from songs; they extend from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Silber 1986; Tyack and Whitehead. 1983). These sounds appear to have an effective range of up to 9 kilometers (Tyack and Whitehead. 1983). A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above; that description is also applicable to humpback whales.

In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20 Hz–4 kHz with estimated source levels from 144 – 174 dB; these are mostly sung by males on the breeding grounds (Frazer and Mercado III 2000; Richardson et al. 1995a; Winn et al. 1970);

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3 kHz (Richardson et al. 1995a; Tyack 1983); and

3 Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels in excess of 175 dB re 1 ☐Pam (Richardson et al. 1995a; Thompson et al. 1986).

Helweg et al. (2000) produced a mathematical model of a humpback whales hearing sensitivity based on the anatomy of the whale's ear. Based on that model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7kHz to 10kHz, with a maximum sensitivity between 2 and 6kHz.

4.4.4 North Atlantic Right Whale

Right whales are large baleen whales. Adults are generally between 45 and 55 feet (13.7-16.7 m) in length and can weigh up to 70 tons (140,000 lbs; 63,500 kg). Females are larger than males. Calves are 13-15 feet (4-4.5 m) in length at birth.

Distinguishing features for right whales include a stocky body, generally black coloration (although some individuals have white patches on their undersides), lack of a dorsal fin, a large head (about 1/4 of the body length), strongly bowed margin of the lower lip, and callosities (raised patches of roughened skin) on the head region. Two rows of long (up to eight feet in length) dark baleen plates hang from the upper jaw, with about 225 plates on each side. The tail is broad, deeply notched, and all black with a smooth trailing edge.

Females give birth to their first calf at an average age of 9-10 years. Gestation lasts approximately 1 year. Calves are usually weaned toward the end of their first year. In the coastal waters off Georgia and northern Florida, calving occurs from December through March.

Distribution

Right whales exist as three separate species: North Atlantic right whales (*Eubalaena glacialis*) that are distributed seasonally from the Gulf of Mexico north to waters off Newfoundlamd and Labrador (on the western Atlantic) and from northern Africa and Spain north to waters north of Scotland and Ireland (the Shetland and Orkney Islands; on the eastern Atlantic coast); North Pacific right whales (*E. japonica*) that historically ranged seasonally from the coast of Baja California north to the northern Bering Sea (on the eastern Pacific) and the south China Sea north to the Sea of Okhotsk and the Kamchatka Peninsula (on the western Pacific); and Southern right whales (*E. australis*) which historically ranged across the Southern Ocean, including waters off southern Australia, New Zealand, Chile, Argentina, and southern Africa (north to Madagascar).

In the western Atlantic Ocean, right whales generally occur in northwest Atlantic waters west of the Gulf Stream and are most commonly associated with cooler waters (21°C). North Atlantic right whales are most abundant in Cape Cod Bay between February and April (Hamilton and Mayo. 1990; Schevill et al. 1986; Watkins and Schevill. 1982), in the Great South Channel in May and June (Kenney and Winn. 1986; Payne et al. 1990a), and off Georgia and Florida from mid-November through March (Keller et al. 2006). Right whales also frequent the Bay of Fundy, Browns and Baccaro Banks (in Canadian waters), Stellwagen Bank and Jeffrey's Ledge in the spring and summer months, and use mid-Atlantic waters as a migratory pathway between the winter calving grounds and their spring and summer nursery-feeding areas in the Gulf of Maine. North Atlantic right whales are not found in the Caribbean Sea and have been recorded only rarely in the Gulf of Mexico.

Population Structure

NMFS recognizes two extant groups of right whales in the North Atlantic Ocean (*E. glacialis*): an eastern population and a western population. A third population may have existed in the central Atlantic (migrating from east of Greenland to the Azores or Bermuda), but appears to be extinct, if it existed as a distinct population at all (Perry et al. 1999a).

The degree to which the two extant populations of North Atlantic right whales are connected through immigration or emigration is unknown, but the two populations have historically been treated as if they are isolated populations. Nevertheless, on 5 January 2009, a North Atlantic right whale that had been observed in the Bay of Fundy on 24 September 2008 was observed in the Azore Islands (38 22.698 N and 28 30.341W) which demonstrates that at least one right whale migrated across the Atlantic (L. Steiner, post on MarMam, 7 January 2009).

Threats to the Species

<u>Natural Threats</u>. Several researchers have suggested that the recovery of right whales in the northern hemisphere has been impeded by competition with other whales for food (Rice 1974; Scarff 1986). Mitchell (1975a) analyzed trophic interactions among baleen whales in the western North Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods. Reeves *et al.*

(1978) noted that several species of whales feed on copepods in the eastern North Pacific, so that the foraging pattern and success of right whales would be affected by other whales as well. Mitchell (1975a) argued that the right whale population in the North Atlantic had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made more food available to sei whales and helped their population to grow. He then suggested that competition with the sei whale population impedes or prevents the recovery of the right whale population.

Anthropogenic Threats. Several human activities are known to threaten North Atlantic right whales: whaling, commercial fishing, shipping, and water pollution. Historically, whaling represented the greatest threat to every population of right whales and was ultimately responsible for listing right whales as an endangered species. As its legacy, whaling reduced North Atlantic right whales to about 300 individuals in the western North Atlantic Ocean; the North Atlantic right whales population in the eastern North Atlantic Ocean is probably much smaller, although we cannot estimate the size of that population from the data available.

Of the current threats to North Atlantic right whales, entanglement in commercial fishing gear and ship strikes currently pose the greatest threat to the persistence of North Atlantic right whales. Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 43 reports of right whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of the 39 reports that NMFS could confirm, right whales were injured in 5 of the entanglements and killed in 4 entanglements.

In the same region, there were 18 reports of right whales being struck by vessels between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of the 17 reports that NMFS could confirm, right whales were injured in 2 of the ship strikes and killed in 9.

Status

Right whales (both *E. glacialis* and *E. australi*s) were listed as endangered under the ESA in 1970. In March 2008, NMFS divided right whales into three separate listings: North Atlantic right whales (*E. glacialis*), North Pacific right whales (*E. japonica*), and Southern right whales (*E. australis*), all of which were listed as endangered. Since 1949, the North Atlantic right whale has been protected from commercial whaling by the International Whaling Commission. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna (IUCN 2010) and the MMPA.

Caswell et al. (1999), using data on reproduction and survival through 1996, determined that the western North Atlantic right whale population was declining at a rate of 2.4 percent per year. One model they used suggested that the mortality rate of the right whale population has increased five-fold in less than one generation. According to Caswell *et al.* (1999), if the mortality rate as of 1996 does not decrease and the population performance does not improve, extinction could occur within 100 years and would be certain within 400 years, with a mean time to extinction of 191 years. In the three calving seasons following the Cawsell *et al.* (1999) analysis, only 10 calves are known to have been born into the population. However, at least 16 calves (one of which subsequently died of unknown causes) were born during the 2000 to 2001 calving season, providing hope that the right whale’s rate of decline may be slowing.

Kraus et al. (2005) estimated that about 350 individual right whales, including about 70 mature females, occur in the western North Atlantic. Waring et al. (2009) reviewed the data from the recapture database and estimated that the right whale population in the western North Atlantic Ocean numbers about 325 whales.

Based on the catalog of identified North Atlantic right whales through the end of the year 2009, the best estimate of the population is 473(NARWC 2010). This estimate was included in the 2010 Right Whale Report Card provided to attendees at the North Atlantic Right Whale Consortium Meeting, 3-4 November 2010, New Bedford Whaling Museum, New Bedford, Massachusetts, by chairperson Dr. Moira Brown. The estimate is prepared according to standardized criteria, and is reviewed by the Consortium Board. In recent years, the estimate has been steadily increasing: the 2006 estimate was 393, in 2007 it was 415, and in 2008 it was 438(NARWC 2010).

Nevetheless, a population of less than 500 individuals is sufficiently small for the population to experience demographic phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself. These phenomena would increase the extinction probability of North Atlantic right whales and amplify the potential consequences of human-related activities on this species. Based on their population size and population ecology (that is, slow-growing mammals that give birth to single calves with several years between births), we assume that right whales will have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) *as well as* endogenous threats resulting from the small size of their population.

In general, an individual’s contribution to the growth (or decline) of the population it represents depends, in part, on the number of individuals in the population: the smaller the population, the more the performance of a single individual is likely to affect the population’s growth or decline (Coulson et al. 2006). Given the small size of the North Atlantic right whale population, the performance (= “fitness” measured as the longevity of individuals and their reproductive success over their lifespan) of individual whales would be expected to have appreciable consequences for the growth or decline of the North Atlantic right whale population. Evidence of the small population dynamics of North Atlantic right whales appears in demographic models that suggest that the death or survival of one or two individual animals is sufficient to determine whether North Atlantic right whales are likely to accelerate or abate the rate at which their population continues to decline (Fujiwara and CASWell 2001). As populations and species become perilously close to extinction, the death, survival, or reproductive success of one or two individuals can be sufficient to make the difference between persistence and extinction.

Diving and Social Behavior

Right whales dive as deep as 306 m (Mate et al. 1992). In the Great South Channel, average diving time is close to 2 minutes; average dive depth is 7.3 m with a maximum of 85.3 m (Winn et al. 1995). In the U.S. Outer Continental Shelf the average diving time is about 7 min although maximum dive durations are considerably longer (CETAP 1982). For example, Baumgartner and Mate (2003) reported right whale feeding dives were characterized by a rapid descent from the surface to a particular depth between 80 and 175 m (262 to 574 ft) with animals remaining at those depths for 5 to 14 min, then ascending quickly to the surface (Baumgartner and Mate. 2003). Longer surface intervals have been observed for reproductively active females and their calves (Baumgartner and Mate. 2003).

North Atlantic right whales are primarily seen in groups of less than 12, most often singles or pairs (Jefferson et al. 1993). They may form larger groups while on feeding or breeding areas (Jefferson et al. 1993).

Vocalizations

North Atlantic right whales produce a variety of sounds, including moans, screams, gunshots, blows, upcalls, downcalls, and warbles that are often linked to specific behaviors (Laurinolli et al. 2003; Matthews et al. 2001; Parks et al. 2005; Parks and Tyack. 2005; Vanderlaan et al. 2003). Sounds can be divided into three main categories: (1) blow sounds; (2) broadband impulsive sounds; and (3) tonal call types (Parks and Clark, 2007). Blow sounds are those coinciding with an exhalation; it is not known whether these are intentional communication signals or just produced incidentally (Parks and Clark. 2007).

Broadband sounds include non-vocal slaps (when the whale strikes the surface of the water with parts of its body) and the gunshot sound; data suggests that the latter serves a communicative purpose (Parks and Clark. 2007). Tonal calls can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls (Parks and Clark. 2007). Most of these sounds ranges in frequency from 0.02 to 15 kHz (dominant frequency range from 0.02 to less than 2 kHz; durations typically range from 0.01 to multiple seconds) with some sounds having multiple harmonics (Parks and Tyack. 2005).

Source levels for some of these sounds have been measured as ranging from 137 to 192 dB root-mean-square (rms) re 1 μPa-m (decibels at the reference level of one micro Pascal at one meter) (Parks et al. 2005; Parks and Tyack. 2005). Parks and Clark (2007) suggested that the frequency of right whale vocalizations increases significantly during the period from dusk until dawn. Recent morphometric analyses of North Atlantic right whale inner ears estimates a hearing range of approximately 0.01 to 22 kHz based on established marine mammal models (Parks et al. 2007b; Parks et al. 2004; Parks and Tyack. 2005). In addition, Parks et al. (2007b) estimated the functional hearing range for right whales to be 15 Hz to 18 kHz.

4.4.5 Sei Whale

Sei whales (pronounced "say" or "sigh") are members of the baleen whale family and are considered one of the "great whales" or rorquals. Two subspecies of sei whales are recognized, *B. b. borealis* in the Northern Hemisphere and *B. B. schlegellii* in the Southern Hemisphere.

These large animals can reach lengths of about 40-60 ft (12-18 m) and weigh 100,000 lbs (45,000 kg). Females may be slightly longer than males. Sei whales have a long, sleek body that is dark bluish-gray to black in color and pale underneath. The body is often covered in oval-shaped scars (probably caused from cookie-cutter shark and lamprey bites) and sometimes has subtle "mottling". This species has an erect "falcate", "dorsal" fin located far down (about two-thirds) the animals back. They often look similar in appearance to Bryde's whales, but can be distinguished by the presence of a single ridge located on the animal's "rostrum". Bryde's whales, unlike other rorquals, have three distinct prominent longitudinal ridges on their rostrum. Sei whales have 219-410 baleen plates that are dark in color with gray/white fine inner fringes in their enormous mouths. They also have 30-65 relatively short ventral pleats that extend from below the mouth to the naval area. The number of throat grooves and baleen plates may differ depending on geographic population.

When at the water's surface, sei whales can be sighted by a columnar or bushy blow that is about 10-13 feet (3-4 m) in height. The dorsal fin usually appears at the same time as the blowhole, when the animal surfaces to breathe. This species usually does not arch its back or raise its flukes when diving.

Sei whales are usually observed singly or in small groups of 2-5 animals, but are occasionally found in larger (30-50) loose aggregations. Sei whales are capable of diving 5-20 minutes to opportunistically feed on plankton (e.g., copepods and krill), small schooling fish, and cephalopods (e.g., squid) by both gulping and skimming. They prefer to feed at dawn and may exhibit unpredictable behavior while foraging and feeding on prey. Sometimes seabirds are associated with the feeding frenzies of these and other large whales.

Sei whales become sexually mature at 6-12 years of age when they reach about 45 ft (13 m) in length, and generally mate and give birth during the winter in lower latitudes. Females breed every 2-3 years, with a gestation period of 11-13 months. Females give birth to a single calf that is about 15 ft (4.6 m) long and weighs about 1,500 lbs (680 kg). Calves are usually nursed for 6-9 months before being weaned on the preferred feeding grounds. Sei whales have an estimated lifespan of 50-70 years.

Distribution

Sei whales occur in every ocean except the Arctic Ocean. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999a). Sei whales are often associated with deeper waters and areas along the continental shelf edge (Hain et al. 1985); however, this general offshore pattern of sei whale distribution is disrupted during occasional incursions into more shallow and inshore waters (Waring et al. 2011; Waring et al. 2004).

In the western Atlantic Ocean, sei whales occur from Labrador and Nova Scotia, in the summer months and migrate south to Florida, and the northern Caribbean (Gambell 1985b; Mead 1977). In the eastern Atlantic Ocean, sei whales occur in the Norwegian Sea (as far north as Finnmark in northeastern Norway), occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Jonsgård and Darling 1974, (Gambell 1985a). Sei whales have been reported with about the same frequency as fin whales in the Gulf of Mexico, although there are still only five reliable records of sei whales from the Gulf. Like blue and fin whales, sei whales are assumed to occur only extralimitally in the Gulf of Mexico.

In the north Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20°̣̃23°N (Masaki 1977 (1977); Gambell (1985a). Harwood (1987) reported that 75 – 85 percent of the North Pacific population of sei whales resides east of 180° longitude.

Sei whales occur throughout the Southern Ocean during the summer months, although they do not migrate as far south to feed as blue or fin whales. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of Southern Africa and Australia.

Population Structure

The population structure of sei whales is largely unknown because there are so few data on this species. The International Whaling Commission's Scientific Committee groups all of the sei whales in the entire North Pacific Ocean into one population (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research suggest more than one "stock" of sei whales may exist in the Pacific: one between 175°W and 155°W longitude, and another east of 155°W longitude (Masaki 1977); however, the amount of movement between these "stocks" suggests that they probably do not represent demographically-isolated populations as we use this concept in this Opinion.

Mitchell and Chapman (1977) divided sei whales in the western North Atlantic in two populations, one that occupies the Nova Scotian Shelf and a second that occupies the Labrador Sea. Sei whales are most common on Georges Bank and into the Gulf of Maine and the Bay of Fundy during spring and summer, primarily in deeper waters. There are occasional influxes of sei whales further into Gulf of Maine waters, presumably in conjunction with years of high copepod abundance inshore. Sei whales are occasionally seen feeding in association with right whales in the southern Gulf of Maine and in the Bay of Fundy.

Threats to the Species

Natural Threats. Sei whales appear to compete with blue, fin, and right whales for prey and that competition may limit the total abundance of each of the species (Rice 1974; Scarff 1986). As discussed previously in the narratives for fin and right whales, the foraging areas of right and sei whales in the western North Atlantic Ocean overlap and both whales feed preferentially on copepods (Mitchell 1975b).

Anthropogenic Threats. Two human activities are known to threaten sei whales: whaling and shipping. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. From 1910 to 1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Perry et al. 1999a). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300 - 600 sei whales were killed per year from 1911 to 1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters.

In the North Atlantic Ocean, sei whales were hunted from land stations in Norway and Iceland in the early- to mid-1880s, when blue whales started to become scarcer. In the late 1890s, whalers began hunting sei whales in Davis Strait and off the coasts of Newfoundland. In the early 1900s, whalers from land stations on the Outer Hebrides and Shetland Islands started to hunt sei whales. Between 1966 and 1972, whalers from land stations on the east coast of Nova Scotia engaged in extensive hunts of sei whales on the Nova Scotia shelf, killing about 825 sei whales (Mitchell and Chapman 1977).

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, two showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 3 reports of sei whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in the death of the sei whale.

Status

Sei whales were listed as endangered under the ESA in 1973. In the North Pacific, the International Whaling Commission began management of commercial taking of sei whales in 1970, and sei whales were given full protection in 1976. Sei whales are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act. They are listed as endangered under the IUCN Red List of Threatened Animals (IUCN 2010; Reilly et al. 2008). Critical habitat has not been designated for sei whales.

Prior to commercial whaling, sei whales in the north Pacific are estimated to have numbered 42,000 individuals (Tillman 1977), although Ohsumi and Masaki (Ohsumi and Masaki 1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000 or 38,000 whales by 1967, and reduced again to 20,600 to 23,700 whales by 1973. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968 and 1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population of sei whales in the North Pacific had been reduced to between 7,260 and 12,620 animals (Tillman 1977). In the same year, the north Atlantic population of sei whales was estimated to number about 2,078 individuals, including 965 whales in the Labrador Sea group and 870 whales in the Nova Scotia group (Mitchell and Chapman 1977).

About 50 sei whales are estimated to occur in the North Pacific “stock” with another 77 sei whales in the Hawaiian “stock” (Lowry et al. 2007). The abundance of sei whales in the Atlantic Ocean remains unknown (Lowry et al. 2007). In California waters, only one confirmed and five possible sei whale sightings were recorded during 1991, 1992, and 1993 aerial and ship surveys (Carretta and Forney. 1993) (Mangels and Gerrodette. 1994). No sightings were confirmed off Washington and Oregon during recent aerial surveys. Several researchers have suggested that the recovery of right whales in the northern hemisphere has been slowed by other whales that compete with right whales for food. Mitchell (Mitchell 1975b) analyzed trophic interactions among baleen whales in the western north Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods.

Like blue whales, the information available on the status and trend of sei whales do not allow us to reach any conclusions about the extinction risks facing sei whales as a species, or particular populations of sei whales. With the limited data available on sei whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if sei whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate). However, sei whales have historically exhibited sudden increases in abundance in particular areas followed by sudden decreases in number.

With the evidence available, we do not know if this year-to-year variation still occurs in sei whales. However, if sei whales exist as a fraction of their historic population sizes, large amounts of variation in their abundance would increase the extinction probabilities of individual populations (Fagan et al. 1999; Fagan et al. 2001).

Diving and Social Behavior

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 min (Gambell 1985a). The depths of sei whale dives have not been studied; however the composition of their diet suggests that they do not perform dives in excess of 300 meters. Sei whales are usually found in small groups of up to 6 individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985a).

Vocalizations and Hearing

There is a limited amount of information on the vocal behavior of sei whales. McDonald et al.(2005) recorded sei whale vocalizations off the Antarctic Peninsula that included broadband sounds in the 100-600 Hz range with 1.5 second duration and tonal and upsweep call in the 200-600 Hz range 1-3 second duration. McDonald et al. (2005) also reported broadband “growls” and “whooshes” at a frequency of 433 ±192 Hz and source level of 156 ±3.6 dB re 1 μPa at 1 meter. Sei whale vocalizations consist of paired sequences (0.5 to 0.8 seconds [sec], separated by 0.4 to 1.0 sec) of 7 to 20 short (4 milliseconds) frequency-modulated sweeps between 1.5 and 3.5 kHz (Richardson et al. 1995a).

During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency downswept calls. The first variation consisted of sweeps from 100 Hz to 44 Hz, over 1.0 seconds. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 Hz to 21 Hz over 1.3 seconds. These vocalizations are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters. Sei whale calls recorded off the Hawaiian Islands consisted of downsweeps from 100 Hz to 44 Hz over 1.0 sec and low-frequency calls with downsweeps from 39 Hz to 21 Hz over 1.3 seconds (Rankin and Barlow 2007). Sei whales off the east coast of the United States produced single calls that ranged from 82 to 34 Hz over 1.4 s period (Baumgartner et al. 2008).

A general description of the anatomy of the ear for mysticetes is provided in the preceding description of the blue whale.

4.4.6 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Adult females may grow to lengths of 36 feet (11 m) and weigh 15 tons (13607 kg). Adult males, however, reach about 52 feet (16 m) and may weigh as much as 45 tons (40823 kg).

The sperm whale is distinguished by its extremely large head, which takes up to 25 to 35 percent of its total body length. It is the only living cetacean that has a single blowhole asymmetrically situated on the left side of the head near the tip. Sperm whales have the largest brain of any animal (on average 17 pounds (7.8 kg) in mature males); however, compared to their large body size, the brain is not exceptional in size.

There are between 20-26 large conical teeth in each side of the lower jaw. The teeth in the upper jaw rarely erupt and are often considered to be vestigial. It appears that teeth may not be necessary for feeding, since they do not break through the gums until puberty, if at all, and healthy sperm whales have been caught that have no teeth.

Sperm whales are mostly dark gray, but oftentimes the interior of the mouth is bright white, and some whales have white patches on the belly. Their flippers are paddle-shaped and small compared to the size of the body, and their flukes are very triangular in shape. They have small dorsal fins that are low, thick, and usually rounded.

Distribution

Sperm whales occur in every ocean except the Arctic Ocean. Sperm whales are found throughout the North Pacific and are distributed broadly from tropical and temperate waters to the Bering Sea as far north as Cape Navarin. Mature, female, and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45˚ N throughout the year. These groups of adult females and immature sperm whales are rarely found at latitudes higher than 50˚ N and 50˚ S (Reeves and Whitehead 1997). Sexually mature males join these groups throughout the winter. During the summer, mature male sperm whales are thought to move north into the Aleutian Islands, Gulf of Alaska, and the Bering Sea.

In the western Atlantic Ocean, sperm whales are distributed in a distinct seasonal cycle, concentrated east-northeast of Cape Hatteras in winter and shifting northward in spring when whales are found throughout the Mid-Atlantic Bight. Distribution extends further northward to areas north of Georges Bank and the Northeast Channel region in summer and then south of New England in fall, back to the Mid-Atlantic Bight.

In the eastern Atlantic Ocean, mature male sperm whales have been recorded as far north as Spitsbergen (Oien 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature male sperm whales predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Christensen et al. 1992; Gunnlaugsson and Sigurjonsson 1990; Oien 1990).

In the Mediterranean Sea sperm whales are found from the Alboran Sea to the Levant Basin, mostly over steep slope and deep offshore waters. Sperm whales are rarely sighted in the Sicilian Channel, and are vagrant in the northern Adriatic and Aegean Seas (Notarbartolo Di Sciara and Gordon 1997). In the Italian seas sperm whales are more frequently associated with the continental slope off western Liguria, western Sardinia, northern and eastern Sicily, and both coasts of Calabria.

Sperm whales commonly concentrate around oceanic islands in areas of upwelling, and along the outer continental shelf and mid-ocean waters. Because they inhabit deeper pelagic waters, their distribution does not include the broad continental shelf of the Eastern Bering Sea and these whales generally remain offshore in the eastern Aleutian Islands, Gulf of Alaska, and the Bering Sea.

Sperm whales have a strong preference for the 3,280 feet (1,000 meters) depth contour and seaward. Berzin (1971) reported that they are restricted to waters deeper than 300 meters (984 feet), while Watkins (1977) and Reeves and Whitehead (1997) reported that they are usually not found in waters less than 1,000 meters (3,281 feet) deep. While deep water is their typical habitat, sperm whales have been observed near Long Island, New York, in water between 41-55 meters Scott and Sadove (135-180 ft; 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in bottom depth where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956).

Population Structure

There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawaii; (Perry et al. 1999a; Waring et al. 2004). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead and Mesnick 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead 2008).

Several investigators have suggested that the sperm whales that occupy the northern Gulf of Mexico are distinct from sperm whales elsewhere in the North Atlantic Ocean (Fritts et al. 1983; Hansen et al. 1995; Schmidly 1981), although the International Whaling Commission does not recognize these sperm whales as a separate population or "stock."

Atlantic Ocean

Based on harvests of tagged sperm whales or sperm whales with other distinctive marking, sperm whales in the North Atlantic Ocean appear to represent a single population, with the possible exception of the sperm whales that appear to reside in the Gulf of Mexico. Mitchell (1975a) reported one sperm whale that was tagged on the Scotian Shelf and killed about 7 years later off Spain. Donovan (Donovan 1991) reported five to six handheld harpoons from the Azore sperm whale fishery that were recovered from whales killed off northwest Spain, with another Azorean harpoon recovered from a male sperm whale killed off Iceland (Martin 1982). These patterns suggest that at least some sperm whales migrate across the North Atlantic Ocean.

Female and immature animals stay in Atlantic temperate or tropical waters year round. In the western North Atlantic, groups of female and immature sperm whales concentrate in the Caribbean Sea (Gosho et al. 1984) and south of New England in continental-slope and deep-ocean waters along the eastern United States (Blaylock et al.

1995). In eastern Atlantic waters, groups of female and immature sperm whales aggregate in waters off the Azores, Madeira, Canary, and Cape Verde Islands (Tomilin 1967).

Several investigators have suggested that the sperm whales that occupy the northern Gulf of Mexico are distinct from sperm whales elsewhere in the North Atlantic Ocean (Fritts et al. 1983; Hansen et al. 1995; Schmidly 1981), although the International Whaling Commission group does not treat these sperm whales as a separate population or "stock."

In the Mediterranean Sea sperm whales are found from the Alboran Sea to the Levant Basin, mostly over steep slope and deep offshore waters. Sperm whales are rarely sighted in the Sicilian Channel, and are vagrant in the northern Adriatic and Aegean Seas (Notarbartolo Di Sciara et al. 1999). In the Italian seas sperm whales are more frequently associated with the continental slope off western Liguria, western Sardinia, northern and eastern Sicily, and both coasts of Calabria.

Bayed and Beaubrun (1987) suggested that the frequent observation of neonates in the Mediterranean Sea and the scarcity of sperm whale sightings from the Gibraltar area may be evidence of a resident population of sperm whales in the Mediterranean.

Indian Ocean

In the Northern Indian Ocean the International Whaling Commission recognized differences between sperm whales in the northern and southern Indian Ocean (Donovan 1991). Little is known about the Northern Indian Ocean population of sperm whales (Perry et al. 1999b).

Pacific Ocean

Several authors have proposed population structures that recognize at least three sperm whales populations in the North Pacific for management purposes (Bannister and Mitchell 1980; Kasuya 1991). At the same time, the IWC's Scientific Committee designated two sperm whale stocks in the North Pacific: a western and eastern stock or population (Donovan 1991). The line separating these populations has been debated since their acceptance by the IWC's Scientific Committee. For stock assessment purposes, NMFS recognizes three discrete population centers of sperm whales in the Pacific: (1) Alaska, (2) California-Oregon-Washington, and (3) Hawai'i.

Sperm whales are widely distributed throughout the Hawaiian Islands throughout the year and are the most abundance large whale in waters off Hawai'i during the summer and fall (Lee 1993; Mobley et al. 2000; Shallenberger et al. 1981). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawaiian Islands throughout the year (Thompson and Friedl 1982). The primary area of occurrence for the sperm whale is seaward of the shelf break in the Hawaiian Islands.

Sperm whales have been sighted in the Kauai Channel, the Alenuihaha Channel between Maui and the island of Hawai'i, and off the island of Hawai'i (Lee 1993; Mobley et al. 2000). Additionally, the sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Twenty-one sperm whales were sighted during aerial surveys conducted in Hawaiian waters conducted from 1993 through 1998. Sperm whales sighted during the survey tended to be on the outer edge of a 50 - 70 km distance from the Hawaiian Islands, indicating that presence may increase with distance from shore. However, from the results of these surveys, NMFS has calculated a minimum abundance of sperm whales within 46 km of Hawai'i to be 43 individuals (Forney et al. 2000).

Southern Ocean

Sperm whales south of the equator are generally treated as a single "population," although the International Whaling Commission divides these whales into nine different divisions that are based more on evaluations of whaling captures than the biology of sperm whales (Donovan 1991). Several authors, however, have argued that the sperm whales that occur off the Galapagos Islands, mainland Ecuador, and northern Peru are geographically distinct from other sperm whales in the Southern Hemisphere (Dufault and Whitehead 1995; Wade and Gerrodette 1993).

Threats to the Species

<u>Natural Threats</u>. Sperm whales are hunted by killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), and short-finned pilot whales (*Globicephala melas)* (Arnbom et al. 1987; Palacios and Mate. 1996; Weller et al. 1996). Sperm whales have been observed with bleeding wounds their heads and tail flukes after attacks by these species (Arnbom et al. 1987; Palacios and Mate. 1996; Weller et al. 1996). In October 1997, 25 killer whales were documented to have attacked a group of mature sperm whales off Point Conception, California (personal communication from K Roberts cited in Perry *et al.* 1999) and successfully killing one of these mature sperm whales. Sperm whales have also been reported to have papilloma virus (Lambertsen et al. 1987).

Studies on sperm whales in the North Pacific and North Atlantic Oceans have demonstrated that sperm whales are infected by calciviruses and papillomavirus (Lambertsen et al. 1987; Smith and Latham 1978). In some instances, these diseases have been demonstrated to affect 10 percent of the sperm whales sampled (Lambertsen et al. 1987).

<u>Anthropogenic Threats</u>. Three human activities are known to threaten sperm whales: whaling, entanglement in fishing gear, and shipping. Historically, whaling represented the greatest threat to every population of sperm whales and was ultimately responsible for listing sperm whales as an endangered species. Sperm whales were hunted all over the world during the 1800s, largely for its spermaceti oil and ambergris. Harvesting of sperm whales subsided by 1880 when petroleum replaced the need for sperm whale oil (Whitehead 2003).

The actual number of sperm whales killed by whalers remains unknown and some of the estimates of harvest numbers are contradictory. Between 1800 and 1900, the International Whaling Commission estimated that nearly 250,000 sperm whales were killed globally by whalers. From 1910 to 1982, another 700,000 sperm whales were killed globally by whalers (IWC Statistics 1959-1983). These estimates are substantially higher than a more recent estimate produced by Caretta et al. (2005), however, who estimated that at least 436,000 sperm whales were killed by whalers between 1800 and 1987. Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947 and 1987 by commercial whalers. They reported that catches in the North Pacific increased until 1968, when 16,357 sperm whales were harvested, then declined after 1968 because of harvest limits imposed by the IWC. Perry et al. (1999a) estimated that, on average, more than 20,000 sperm whales were harvested in the Southern Hemisphere each year between 1956 and 1976.

These reports probably underestimate the actual number of sperm whales that were killed by whalers, particularly because they could not have incorporated realistic estimates of the number of sperm whales killed by Soviet whaling fleets, which often went unreported. Between 1947 and 1973, Soviet whaling fleets engaged in illegal whaling in the Indian, North Pacific, and southern Oceans. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the International Whaling Commission (Yablokov et al. 1998). Illegal catches in the Northern Hemisphere (primarily in the North Pacific) were smaller but still caused sperm whales to disappear from large areas of the North Pacific Ocean (Yablokov 2000).

In addition to large and illegal harvests of sperm whales, Soviet whalers had disproportionate effect on sperm whale populations because they commonly killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

When the International Whaling Commission (IWC) introduced the International Observer Scheme in 1972, the IWC relaxed regulations that limited the minimum length of sperm whales that could be caught from 11.6 meters to 9.2 meters out of a concern that too many male sperm whales were being caught so reducing this size limit would encourage fleets to catch more females. Unfortunately, the IWC's decision had been based on data from the Soviet fleets who commonly reported female sperm whales as males. As a result, the new regulations allowed the Soviet whalers to continue their harvests of female and immature sperm whales legally, with substantial consequences for sperm whale populations.

Although the International Whaling Commission protected sperm whales from commercial harvest in 1981, whaling operations along the Japanese coast continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). More recently, the Japanese Whaling Association began hunting sperm whales for research. In 2000, the Japanese Whaling Association announced that it planned to kill 10 sperm whales in the Pacific Ocean for research, which was the first time sperm whales have been hunted since the international ban on commercial whaling. Despite protests from the U.S. government and members of the IWC, the Japanese government harvested 5 sperm whales and 43 Bryde's whales in the last six months of 2000. According to the Japanese Institute of Cetacean Research (Institute of Cetacean Research undated), another 5 sperm whales were killed for research in 2002 – 2003.

Sperm whales are still hunted for subsistence purposes by whalers from Lamalera, Indonesia, which is on the south coast of the island of Lembata and from Lamakera on the islands of Solor. These whalers hunt in a traditional manner: with bamboo spears and using small wooden outriggers, 10–12 m long and 2 m wide, constructed without nails and with sails woven from palm fronds. The animals are killed by the harpooner leaping onto the back of the animal from the boat to drive in the harpoon. The maximum number of sperm whales killed by these hunters in any given year was 56 sperm whales killed in 1969.

In U.S. waters in the Pacific Ocean, sperm whales are known to have been incidentally captured only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991 - 1995 (Barlow 1997). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Hill et al. 1999; Rice 1989). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on fish caught in longline gear in the Gulf of Alaska. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill et al. 1999). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear.

Sperm whales are also killed by ship strikes. In May 1994 a sperm whale that had been struck by a ship was observed south of Nova Scotia (Reeves and Whitehead 1997) and in May 2000 a merchant ship reported a strike in Block Canyon (NMFS, unpublished data), which is a major pathway for sperm whales entering southern New England continental shelf waters in pursuit of migrating squid (CETAP 1982; Scott and Sadove 1997).

Status

Sperm whales were listed as endangered under the ESA in 1973. Sperm whales have been protected from commercial harvest by the International Whaling Commission since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna as a vulnerable species (IUCN 2010) and the MMPA. Critical habitat has not been designated for sperm whales.

The status and trend of sperm whales at the time of this summary is largely unknown. Hill and DeMaster (1999) and Angliss and Lodge (2004) reported that estimates for population abundance, status, and trends for sperm whales off the coast of Alaska were not available when they prepared the Stock Assessment Report for marine mammals off Alaska. Similarly, no information was available to support estimates of sperm whales status and trends in the western North Atlantic Ocean (Waring et al. 2004), the Indian Ocean (Perry et al. 1999b), or the Mediterranean Sea.

Nevertheless, several authors and organizations have published "best estimates" of the global abundance of sperm whales or their abundance in different geographic areas. Based on historic whaling data, 190,000 sperm whales were estimated to have been in the entire North Atlantic, but the IWC considers data that produced this estimate unreliable (Perry et al. 1999b). Whitehead (2002) estimated that prior to whaling sperm whales numbered around 1,110,000 and that the current global abundance of sperm whales is around 360,000 (coefficient of variation = 0.36) whales. Whitehead's current population estimate is about 20 percent of past global abundance estimates which were based on historic whaling data.

Waring et al. (2007) concluded that the best estimate of the number of sperm whales along the Atlantic coast of the U.S. was 4,029 (coefficient of variation = 0.38) in 1998 and 4,804 (coefficient of variation = 0.38) in 2004, with a minimum estimate of 3,539 sperm whales in the western North Atlantic Ocean.

Mark and recapture data from sperm whales led Whitehead and his co-workers to conclude that sperm whale numbers off the Galapagos Islands decreased by about 20 percent a year between 1985 and 1995 (Whitehead et al. 1997). In 1985 Whitehead et al. (1997) estimated there were about 4,000 female and immature sperm whales, whereas in 1995 they estimated that there were only a few hundred. They suggested that sperm whales migrated to waters off the Central and South American mainland to feed in productive waters of the Humboldt Current, which had been depopulated of sperm whales as a result of intensive whaling.

A mark recapture analysis using photo-identification images in the Gulf of Mexico resulted in a population estimate of 281 with 95 percent confidence intervals of 202-434 (Jochens et al. 2008). This is in general agreement with, though a little lower than, the population sizes indicated by visual surveys.

The information available on the status and trend of sperm whales do not allow us to make a definitive statement about the extinction risks facing sperm whales as a species or particular populations of sperm whales. However, the evidence available suggests that sperm whale populations probably exhibit the dynamics of small populations, causing their population dynamics to become a threat in and of itself. The number of sperm whales killed by Soviet whaling fleets in the 1960s and 1970s would have substantial and adverse consequence for sperm whale populations and their ability to recover from the effects of whaling on their population. The number of adult females killed by Soviet whaling fleets, including pregnant and lactating females whose death would also have resulted in the death of their calves, would have had a devastating effect on sperm whale populations. In addition to decimating their population size, whaling would have skewed sex ratios in their populations, created gaps in the age structure of their populations, and would have had lasting and adverse effect on the ability of these populations to recover (for example, see Whitehead and Mesnick 2003).Populations of sperm whales could not have recovered from the overharvests of adult females and immature whales in the 30 to 40 years that have passed since the end of whaling, but the information available does not allow us to determine whether and to what degree those populations might have stabilized or whether they have begun the process of recovering from the effects of whaling. Absent information to the contrary, we assume that sperm whales will have elevated extinction probabilities because of both exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) as well as endogenous threats caused by the legacy of overharvests of adult females and immature whales on their populations (that is, a population with a disproportion of adult males and older animals coupled with a small percentage of juvenile whales that recruit into the adult population).

A draft Recovery Plan written in 2006 was finalized in December 2010 (NMFS 2010d).

Diving and Social Behavior

Sperm whales are probably the deepest and longest diving mammal: they can dive to depths of at least 2000 meters (6562 ft), and may remain submerged for an hour or more (Watkins et al. 1993). Typical foraging dives last 40 min and descend to about 400 m followed by about 8 min of resting at the surface (Gordon 1987; Papastavrou et al. 1989). However, dives of over 2 hr and as deep as 3,000 m have been recorded (Clarke 1976; Watkins et al. 1985). Descent rates recorded from echo-sounders were approximately 1.7m/sec and nearly vertical (Goold and Jones 1995). There are no data on diurnal differences in dive depths in sperm whales. However, like most diving vertebrates for which there are data (e.g. rorqual whales, fur seals, chinstrap penguins), sperm whales probably make relatively shallow dives at night when organisms from the ocean’s deep scattering layers move toward the ocean’s surface.

The groups of closely related females and their offspring develop dialects specific to the group (Weilgart and Whitehead. 1997) and females other than birth mothers will guard young at the surface (Whitehead 1996) and will nurse young calves (Reeves and Whitehead 1997).

Vocalizations and Hearing

Sperm whales produce loud broad-band clicks from about 0.1 to 20 kHz (Goold and Jones 1995; Weilgart et al. 1993; Weilgart and Whitehead. 1997). These have source levels estimated at 171 dB re 1 μPa (Levenson 1974). Current evidence suggests that the disproportionately large head of the sperm whale is an adaptation to produce these vocalizations (but see Clarke 1979; Cranford 1992; Norris and Harvey. 1972). This suggests that the production of these loud low frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Goold and Jones 1995; Weilgart and Whitehead. 1993; Weilgart and Whitehead. 1997). Long series of monotonous regularly spaced clicks are associated with feeding and are thought to be produced for echolocation. Distinctive, short, patterned series of clicks, called codas, are associated with social behavior and intragroup interactions; they are thought to facilitate intra-specific communication, perhaps to maintain social cohesion with the group (Weilgart and Whitehead. 1993).

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway. 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1993; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis et al. 1995). Seismic air guns produce loud, broadband, impulsive noise (source levels are on the order of 250 dB) with “shots” every 15 seconds, 240 shots per hour, 24 hours per day during active tests. Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changing the abundance of sperm whales should affect the distribution and abundance of other marine species.

4.4.7 Green Sea Turtle

Green turtles are the largest of all the hard-shelled sea turtles, but have a comparatively small head. While hatchlings are just 2 inches (50 mm) long, adults can grow to more than 3 feet (0.91 m) long and weigh 300-350 pounds (136-159 kg).

Adult green turtles are unique among sea turtles in that they are herbivorous, feeding primarily on sea grasses and algae. This diet is thought to give them greenish colored fat, from which they take their name. A green turtle's carapace (top shell) is smooth and can be shades of black, gray, green, brown, and yellow. Their plastron (bottom shell) is yellowish white.

Scientists estimate green turtles reach sexual maturity anywhere between 20 and 50 years, at which time females begin returning to their natal beaches (i.e., the same beaches where they were born) every 2-4 years to lay eggs.

The nesting season varies depending on location. In the southeastern U.S., females generally nest between June and September, while peak nesting occurs in June and July. During the nesting season, females nest at approximately two week intervals, laying an average of five clutches. In Florida, green turtle nests contain an average of 135 eggs, which will incubate for approximately 2 months before hatching.

Distribution

Green turtles are found in the Pacific Ocean, Atlantic Ocean, Indian Ocean, Carribean Sea, and Mediterranean Sea, primarily in tropical or, to a lesser extent, subtropical waters. These regions can be further divided into nesting aggregations within the eastern, central, and western Pacific Ocean; the western, northern, and eastern Indian Ocean; Mediterranean Sea; and eastern, southern, and western Atlantic Ocean, including the Carribean Sea.

Green turtles appear to prefer waters that usually remain around 20°Celsius in the coldest month. During warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher densities of their food items associated with these oceanic phenomena. For example, in the western Atlantic Ocean, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS 1998b). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS and USFWS 1998b).

Population Structure

The population dynamics of green sea turtles and all of the other sea turtles we consider in this Opinion are usually described based on the distribution and habit of nesting females, rather than their male counterparts. The spatial structure of male sea turtles and their fidelity to specific coastal areas is unknown; however, we describe sea turtle populations based on the nesting beaches that female sea turtles return to when they mature. Because the patterns of increase or decrease in the abundance of sea turtle nests over time are determined by internal dynamics rather than external dynamics, we make inferences about the growth or decline of sea turtle populations based on the status and trend of their nests.

Primary nesting aggregations of green turtles (i.e. sites with greater than 500 nesting females per year) include: Ascension Island (south Atlantic Ocean), Australia, Brazil, Comoros Islands, Costa Rica, Ecuador (Galapagos Archipelago), Equatorial Guinea (Bioko Island), Guinea-Gissau (Bijagos Archipelago), Iles Eparses Islands (Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida; NMFS and USFWS 1998c; Seminoff et al. 2002).

Smaller nesting aggregations include: Angola, Bangladesh, Bikar Atoll, Brazil, Chagos Archipelago, China, Costa Rica, Cuba, Cyprus, Democratic Republic of Yemen, Dominican Republic, d'Entrecasteaux Reef, French Guiana, Ghana, Guyana, India, Iran, Japan, Kenya, Madagascar, Maldives Islands, Mayotte Archipelago, Mexico, Micronesia, Pakistan, Palmerston Atoll, Papua New Guinea, Primieras Islands, Sao Tome é Principe, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Taiwan, Tanzania, Thailand, Turkey, Scilly Atoll, United States (Hawai’i), Venezuela, and Vietnam.

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green turtles. In the Pacific Ocean, green sea turtles group into two distinct regional clades: (1) western Pacific and South Pacific islands, and (2) eastern Pacific and central Pacific, including the rookery at French Frigate Shoals, Hawai'i. In the eastern Pacific, greens forage coastally from San Diego Bay, California in the north to Mejillones, Chile in the South. Based on mtDNA analyses, green turtles found on foraging grounds along Chile's coast originate from the Galapagos nesting beaches, while those greens foraging in the Gulf of California originate primarily from the Michoacan nesting stock. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton et al. 2003).

Threats to the Species

Natural Threats. The various habitat types green sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which green sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings are hunted by predators including herons, gulls, dogfish, and sharks. Larger green sea turtles, including adults, are also killed by sharks and other large, marine predators.

Green turtles in the northwest Hawaiian Islands are afflicted with a tumor disease, fibropapilloma, which is of an unknown etiology and often fatal, as well as spirochidiasis, both of which are the major causes of strandings of this species. The presence of fibropapillomatosis among stranded turtles has increased significantly over the past 17 years, ranging from 47-69 percent during the past decade (Murakawa et al. 2000). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg et al. 1999).

Anthropogenic Threats. Three human activities are known to threaten green sea turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of green sea turtles populations were the number of eggs and adults captured and killed on nesting beaches in combination with the number of juveniles and adults captured and killed in coastal feeding areas. Some population of green sea turtles still lose a large number of eggs, juveniles, and adults to subsistence hunters, local communities that have a tradition of harvesting sea turtles, and poachers in search of turtle eggs and meat.

Directed harvests of eggs and other life stages of green sea turtles were identified as a "major problem" in American Samoa, Guam, Palau, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Republic of the Marshall Islands, and the Unincorporated Islands (Wake, Johnston, Kingman, Palmyra, Jarvis, Howland, Baker, and Midway). In the Atlantic, green sea turtles are captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Brautigam and Eckert 2006); the turtle fishery along the Caribbean coast of Nicaragua, by itself, has captured more than 11,000 green sea turtles each year (Brautigam and Eckert 2006; Lagueux 1998).

Severe overharvests have resulted from a number of factors in modern times: (1) the loss of traditional restrictions limiting the number of turtles taken by island residents; (2) modernized hunting gear; (3) easier boat access to remote islands; (4) extensive commercial exploitation for turtle products in both domestic markets and international trade; (5) loss of the spiritual significance of turtles; (6) inadequate regulations; and (7) lack of enforcement (NMFS and USFWS 1998c).

Green sea turtles are also captured and killed in commercial fisheries. Gillnets account for the highest number of green sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges. Along the Atlantic coast of the U.S., NMFS estimated that almost 19,000 green sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 514 of those sea turtles dying as a result of their capture. Each year, several hundred green sea turtles are captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries in Pamlico Sound. Although most of these turtles are released alive, these fisheries are expected to kill almost 100 green sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Green sea turtles are also threatened by domestic or domesticated animals which prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

Oil spills are a risk for all sea turtles. Several aspects of sea turtles life histories put them at risk, including the lack of avoidance behavior of oiled waters and indiscriminate feeding in convergence zones. Sea turtles are air breathers and all must come to the surface frequently to take a breath of air. In a large oil spill, these animals may be exposed to volatile chemicals during inhalation (NMFS 2010e).

Additionally, sea turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings. Hatchlings emerging from their nests may encounter oil on the beach and in the water as they begin their lives at sea (NMFS 2010e).

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection (NMFS 2010e).

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death (NMFS 2010e).

Status

Green turtles are listed as threatened under the esa, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. Using a precautionary approach, Seminoff (2002) estimates that the global green turtle population has declined by 34 percent to 58 percent over the last three generations (approximately 150 years); although actual declines may be closer to 70 percent to 80 percent. Causes for this decline include harvest of eggs, subadults and adults, incidental capture by fisheries, loss of habitat, and disease.

While some nesting populations of green turtles appear to be stable or increasing in the Atlantic Ocean (e.g. Bujigos Archipelago (Guinea-Bissau), Ascension Island, Tortuguero (Costa Rica), Yucatan Peninsula (Mexico), and Florida), declines of over 50 percent have been documented in the eastern (Bioko Island, Equatorial Guinea) and western Atlantic (Aves Island, Venezuela). Nesting populations in Turkey (Mediterranean Sea) have declined between 42 percent and 88 percent since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50 percent have been documented at Sharma (Republic of Yemen) and Assumption and Aldabra (Seychelles), while no changes have occurred at Karan Island (Saudi Arabia) or at Ras al Hadd (Oman). The number of females nesting annually in the Indian Ocean has increased at the Comoros Islands, Tromelin and maybe Europa Island (Iles Esparses; Seminoff 2004).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawai’i, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert 1993; Seminoff 2004). They are also thought to be declining in the Atlantic Ocean. However, like several of the species we have already discussed, the information available on the status and trend of green sea turtles do not allow us to make a definitive statement about the global extinction risks facing these sea turtles or risks facing particular populations (nesting aggregations) of these turtles. With the limited data available on green sea turtles, we do not know whether green sea turtles exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if green sea turtles are threatened more by exogenous threats such as anthropogenic activities (entanglement, habitat loss, overharvests, etc.) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate). Nevertheless, with the exception of the Hawaiian nesting aggregations, we assume that green sea turtles are endangered because of both anthropogenic and natural threats as well as changes in their population dynamics.

A recovery plan for the U.S Population of Atlantic Green Turtles was written in 1991 (NMFS and USFWS 1991a). A recovery plan for the U.S. Pacific Populations of the Green Turtle was written in 1998 (NMFS and USFWS 1998c).

Diving and Social Behavior

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS 1998c).). The maximum recorded dive depth for an adult green turtle was 110 meters

(Berkson 1967; Lutcavage and Lutz 1997), while subadults routinely dive 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill et al. 1995 in Lutcavage and Lutz 1997).

Vocalizations and Hearing

The information on green turtle hearing is very limited. Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999).

In a study of the auditory brainstem responses of subadult green sea turtles, Bartol and Ketten (2005) reported responses to frequencies between 100 and 500 Hz; with highest sensitivity between 200 and 400 Hz. They reported that two juvenile green turtles had hearing sensitivities that were slightly broader in range: they responded to sounds at frequencies from 100 to 800 Hz, with highest hearing sensitivities from 600 to 700 Hz.

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

4.4.8 Leatherback Sea Turtle

The leatherback is the largest turtle and the largest living reptile in the world. Mature males and females can be as long as six and a half feet (2 m) and weigh almost 2000 lbs. (900 kg). The leatherback is the only sea turtle that lacks a hard, bony shell. A leatherback's carapace is approximately 1.5 inches (4 cm) thick and consists of leathery, oil saturated connective tissue overlaying loosely interlocking dermal bones. The carapace has seven longitudinal ridges and tapers to a blunt point. Adult leatherbacks are primarily black with a pinkish white mottled ventral surface and pale white and pink spotting on the top of the head. The front flippers lack claws and scales and are proportionally longer than in other sea turtles; back flippers are paddle-shaped. The ridged carapace and large flippers are characteristics that make the leatherback uniquely equipped for long distance foraging migrations.

Female leatherbacks lay clutches of approximately 100 eggs on sandy, tropical beaches. Females nest several times during a nesting season, typically at 8-12 day intervals. After 60-65 days, leatherback hatchlings with white striping along the ridges of their backs and on the margins of the flippers emerge from the nest. Leatherback hatchlings are approximately 50-77 cm (2-3 inches) in length, with fore flippers as long as their bodies, and weigh approximately 40-50 grams (1.4-1.8 ounces).

Leatherbacks lack the crushing chewing plates characteristic of sea turtles that feed on hard-bodied prey (Pritchard 1971) Instead, they have pointed tooth-like cusps and sharp edged jaws that are perfectly adapted for a diet of softbodied pelagic (open ocean) prey, such as jellyfish and salps. A leatherback's mouth and throat also have backward-pointing spines that help retain such gelatinous prey.

Distribution

Leatherback turtles are widely distributed throughout the oceans of the world. The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main regional areas may further be divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India and Sri Lanka and KwaZulu Natal, South Africa.

Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Eckert and Eckert 1988; Eckert 1999; Morreale et al. 1994). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert 1998). In the North Atlantic Ocean, leatherback turtles regularly occur in deep waters (>328 ft), and an aerial survey study in the north Atlantic sighted leatherback turtles in water depths ranging from 3 to 13,618 ft, with a median sighting depth of 131.6 ft (CETAP 1982). This same study found leatherbacks in waters ranging from 7 to 27.2°C. In the Pacific Ocean, leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific between 71°N and 47°S latitude and in all other major pelagic ocean habitats (NMFS and USFWS 1998a). Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been hypothesized that leatherback sea turtles probably mate outside of tropical waters, before females swim to their nesting beaches (Eckert and Eckert 1988).

Leatherback turtles are uncommon in the insular Pacific Ocean, but individual leatherback turtles are sometimes encountered in deep water and prominent archipelagoes. To a large extent, the oceanic distribution of leatherback turtles may reflect the distribution and abundance of their macroplanktonic prey, which includes medusae, siphonophores, and salpae in temperate and boreal latitudes (NMFS and USFWS 1998a). There is little information available on their diet in subarctic waters.

Population Structure

Leatherback turtles are widely distributed throughout the oceans of the world. The species is divided into four main populations in the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main populations are further divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India, Sri Lanka, the Andaman and Nicobar Islands, and KwaZulu Natal, South Africa.

Threats to the Species

Natural Threats. The various habitat types leatherback sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which leatherback sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes (Caut et al. 2009). Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Larger leatherback sea turtles, including adults, are also killed by sharks and other large, marine predators (Pitman and Dutton 2004).

Anthropogenic Threats. Leatherback sea turtles are endangered by several human activities, including fisheries interactions, entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris (NMFS and USFWS 1998e).

The foremost threat is the number of leatherback turtles killed or injured in fisheries. Spotila (2000) concluded that a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s is 1,500 animals. He estimates that this represented about a 23 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related.

Leatherback sea turtles are exposed to commercial fisheries in many areas of the Atlantic Ocean. For example, leatherback entanglements in fishing gear are common in Canadian waters where Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland and Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line and crab pot line. Leatherbacks are reported taken by the many other nations that participate in Atlantic pelagic longline fisheries (see NMFS 2001, for a complete description of take records), including Taiwan, Brazil, Trinidad, Morocco, Cyprus, Venezuela, Korea, Mexico, Cuba, U.K., Bermuda, People’s Republic of China, Grenada, Canada, Belize, France, and Ireland.

In the Pacific Ocean, between 1,000 and 1,300 leatherback sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set longline fisheries based out of Hawai'i are estimated to have captured and killed several hundred leatherback sea turtles before they were closed in 2001. When they were re-opened in 2004, with substantial modifications to protect sea turtles, these fisheries were estimated to have captured and killed about 1 or 2 leatherback sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai'i are estimated to have captured about 19 leatherback sea turtles, killing about 5 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future (NMFS 2008d). Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawai'i and American Samoa.

Shrimp trawls in the Gulf of Mexico capture the largest number of leatherback sea turtles: each year, they have been estimated to capture about 3,000 leatherback sea turtles with 80 of those sea turtles dying as a result. Along the Atlantic coast of the U.S., NMFS estimated that about 800 leatherback sea turtles are captured in pelagic longline fisheries, bottom longline and drift gillnet fisheries for sharks as well as lobster, deep-sea red crab, Jonah crab, dolphin fish and wahoo, and Pamlico Sound gillnet fisheries. Although most of these turtles are released alive, these fisheries are combine to kill about 300 leatherback sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Tomás et al. 2000). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alió-M 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95 percent (Eckert et al. 2007). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets. There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

On some beaches, nearly 100 percent of the eggs laid have been harvested. Spotila et al. (1996) and Eckert et al. (2007) note that adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries. Like green and hawksbill sea turtles, leatherback sea turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

Oil spills are a risk for all sea turtles. Several aspects of sea turtles life histories put them at risk, including the lack of avoidance behavior of oiled waters and indiscriminate feeding in convergence zones. Sea turtles are air breathers and all must come to the surface frequently to take a breath of air. In a large oil spill, these animals may be exposed to volatile chemicals during inhalation (NMFS 2010e).

Additionally, sea turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings. Hatchlings emerging from their nests may encounter oil on the beach and in the water as they begin their lives at sea (NMFS 2010e).

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection (NMFS 2010e).

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death (NMFS 2010e).

Status

The leatherback turtles are listed as endangered under the ESA throughout the species' global range. Increases in the number of nesting females have been noted at some sites in the Atlantic Ocean, but these are far outweighed by local extinctions, especially of island populations, and the demise of populations throughout the Pacific, such as in Malaysia and Mexico. Spotila et al. (1996) estimated the global population of female leatherback turtles to be only 34,500 (confidence limits: 26,200 to 42,900) nesting females; however, the eastern Pacific population has continued to decline since that estimate, leading some researchers to conclude that the leatherback is now on the verge of extinction in the Pacific Ocean (e.g., Spotila et al. 1996; Spotila et al. 2000).

Globally, leatherback turtle populations have been decimated worldwide. In 1980, the global leatherback population was estimated at approximately 115,000 adult females (Pritchard 1982). By 1995, this global population (of adult females) is estimated to have declined to 34,500 (Spotila et al. 1996). Populations have declined in Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. Throughout the Pacific, leatherbacks are seriously declining at all major nesting beaches.

In the Atlantic and Caribbean, the largest nesting assemblages of leatherbacks are found in the U.S. Virgin Islands, Puerto Rico, and Florida. Since the early 1980s, nesting data has been collected at these locations. Populations in the eastern Atlantic (*i.e.* off Africa) and Caribbean appear to be stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking and it is certain that some nesting populations (*e.g.*, St. John and St. Thomas, U.S. Virgin Islands) have been extirpated (NMFS and USFWS 1995). Data collected in southeast Florida clearly indicate increasing numbers of nests for the past twenty years (9.1-11.5 percent increase), although it is critical to note that there was also an increase in the survey area in Florida over time (NMFS 2001). However, the largest leatherback rookery in the western North Atlantic remains along the northern coast of South America in French Guiana and Suriname. Recent information suggests that Western Atlantic populations declined from 18,800 nesting females in 1996 (Spotila et al. 1996) to 15,000 nesting females by 2000 (Spotila, personal communication cited in NMFS 2001). The nesting population of leatherback turtles in the Suriname-French Guiana trans-boundary region has been declining since 1992 (Chevalier et al. 1999). Poaching and fishing gear interactions are believed to be the major contributors to the decline of leatherbacks in the area.

Leatherback sea turtles appear to be in a critical state of decline in the North Pacific Ocean. The leatherback population that nests along the east Pacific Ocean was estimated to be over 91,000 adults in 1980 (Spotila et al. 1996), but is now estimated to number less than 3,000 total adult and subadult animals (Spotila et al. 2000). Leatherback turtles have experienced major declines at all major Pacific basin rookeries. At Mexiquillo, Michoacan, Mexico, Sarti et al. (1996) reported an average annual decline in nesting of about 23 percent between 1984 and 1996. The total number of females nesting on the Pacific coast of Mexico during the 1995-1996 season was estimated at fewer than 1,000. Less than 700 females are estimated for Central America (Spotila et al. 2000). In the western Pacific, the decline is equally severe. Current nestings at Terengganu, Malaysia represent 1 percent of the levels recorded in the 1950s (Chan and Liew 1996).

While Spotila et al.(1996) indicated that turtles may have been shifting their nesting from French Guiana to Suriname due to beach erosion, analyses show that the overall area trend in number of nests has been negative since 1987 at a rate of 15.0 -17.3 percent per year (NMFS 2001). If turtles are not nesting elsewhere, it appears that the Western Atlantic portion of the population is being subjected to mortality beyond sustainable levels, resulting in a continued decline in numbers of nesting females.

Based on published estimates of nesting female abundance, leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (NMFS and USFWS 1998a; Spotila et al. 1996; Spotila et al. 2000). Declines in nesting populations have been documented through systematic beach counts or surveys in Malaysia (Rantau Abang, Terengganu), Mexico and Costa Rica. In other leatherback nesting areas, such as Papua New Guinea, Indonesia, and the Solomon Islands, there have been no systematic consistent nesting surveys, so it is difficult to assess the status and trends of leatherback turtles at these beaches. In all areas where leatherback nesting has been documented, however, current nesting populations are reported by scientists, government officials, and local observers to be well below abundance levels of several decades ago. The collapse of these nesting populations was most likely precipitated by a tremendous overharvest of eggs coupled with incidental mortality from fishing (Eckert and Sarti 1997; Sarti et al. 1996).

Based on recent modeling efforts, some authors concluded that leatherback turtle populations cannot withstand more than a 1 percent human-related mortality level which translates to 150 nesting females (Spotila et al. 1996). As noted previously, there are many human-related sources of mortality to leatherbacks; every year, 1,800 leatherback turtles are expected to be captured or killed as a result of federally-managed activities in the U.S. (this total includes both lethal and non-lethal take). An unknown number of leatherbacks are captured or killed in fisheries managed by states. Spotila et al. (1996) recommended not only reducing fishery-related mortalities, but also advocated protecting eggs and hatchlings. Zug and Parham (1996) point out that a combination of the loss of long-lived adults in fishery-related mortalities and a lack of recruitment stemming from elimination of annual influxes of hatchlings because of intense egg harvesting has caused the sharp decline in leatherback populations.

For several years, NMFS’ biological opinions have established that leatherback populations currently face high probabilities of extinction as a result of both environmental and demographic stochasticity. Demographic stochasticity, which is chance variation in the birth or death of an individual of the population, is facilitated by the increases in mortality rates of leatherback populations resulting from the premature deaths of individual sea turtles associated with human activities (either removal of eggs or adult females that are killed on nesting beaches or that die as a result of being captured in fisheries) or incidental capture and mortality of individuals in various fisheries.

In the Pacific Ocean, leatherback sea turtles are critically endangered as a direct consequence of a historical combination of overexploitation and habitat loss. The information available suggests that leatherback sea turtles have high probabilities of becoming extinct in the Pacific Ocean unless they are protected from the combined threats of entanglements in fishing gear, overharvests, and loss of their nesting habitat. The limited data available suggests that leatherback sea turtles exist at population sizes small enough to be calssified as “small” populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) as evidenced by biases in the male to female ratios in the Pacific. The status of leatherback sea turtles in the Atlantic Ocean remains uncertain.

Diving and Social Behavior

The maximum dive depths for post-nesting female leatherbacks in the Caribbean have been recorded at 475 meters and over 1,000 meters, with routine dives recorded at between 50 and 84 meters. The maximum dive length recorded for such female leatherback turtles was 37.4 minutes, while routine dives ranged from 4 -14.5 minutes (in Lutcavage and Lutz 1997). Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert et al. 1989).

A total of six adult female leatherback turtles from Playa Grande, Costa Rica were monitored at sea during their inter-nesting intervals and during the 1995 through 1998 nesting seasons. The turtles dived continuously for the majority of their time at sea, spending 57 - 68 percent of their time submerged. Mean dive depth was 19 ± 1 meters and the mean dive duration was 7.4 ± 0.6 minutes (Southwood et al. 1999). Similarly, Eckert (1999) placed transmitters on nine leatherback females nesting at Mexiquillo Beach and recorded dive behavior during the nesting season. The majority of the dives were less than 150 meters depth, although maximum depths ranged from 132 meters to over 750 meters. Although the dive durations varied between individuals, the majority of them made a large proportion of very short dives (less than two minutes), although Eckert (1999) speculates that these short duration dives most likely represent just surfacing activity after each dive. Excluding these short dives, five of the turtles had dive durations greater than 24 minutes, while three others had dive durations between 12 - 16 minutes.

Migrating leatherback turtles also spend a majority of time at sea submerged, and they display a pattern of continual diving (Standora et al. 1984, cited in Southwood et al. 1999). Based on depth profiles of four leatherbacks tagged and tracked from Monterey Bay, California in 2000 and 2001, using satellite-linked dive recorders, most of the dives were to depths of less than 100 meters and most of the time was spent shallower than 80 meters. Based on preliminary analyses of the data, 75-90 percent of the time the leatherback turtles were at depths less than 80 meters.

Vocalizations and Hearing

There is no information on the vocalizations or hearing of leatherback sea turtles. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtle: their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol et al. 1999).

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

4.4.9 Hawksbill Sea Turtle

The hawksbill turtle is a small to medium-sized sea turtle; adults typically range between 65 and 90 cm (26 to 35 in) in carapace length and weigh around 80 kg (176 lb) (Witzell 1983a). Hawksbills are distinguished from other sea turtles by their hawk-like beaks, posteriorly overlapping carapace scutes, and two pairs of claws on their flippers (NMFS and USFWS 1993). The carapace of this species is often brown or amber with irregularly radiating streaks of yellow, orange, black, and reddish-brown.

Distribution

Hawksbill sea turtles occur in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with individuals from several life history stages occurring regularly along southern Florida and the northern Gulf of Mexico (especially Texas); in the Greater and Lesser Antilles; and along the Central American mainland south to Brazil. Within the United States, hawksbills are most common in Puerto Rico and its associated islands, and in the U.S. Virgin Islands.

In the continental U.S., hawksbill sea turtles have been reported in every state on the coast of the Gulf of Mexico and along the coast of the Atlantic Ocean from Florida to Massachusetts, except for Connecticut; however, sightings of hawksbill sea turtles north of Florida are rare. The only states where hawksbill sea turtles occur with any regularity are Florida (particularly in the Florida Keys and the reefs off Palm Beach County on Florida’s Atlantic coast, where the warm waters of the Gulf Stream pass close to shore) and Texas. In both of these states, most sightings are of post-hatchlings and juveniles that are believed to have originated from nesting beaches in Mexico. Hawksbill sea turtles have stranded along the almost the entire Atlantic coast of the United States, although most stranding records occur south of Cape Canaveral, Florida, particularly in Palm Beach, Broward and Miami-Dade counties (Florida Sea Turtle Stranding and Salvage database). Hawksbill sea turtles are very rare north of Florida, although they have been recorded as far north as Massachusetts. During their pelagic-stage, hawksbills disperse from the Gulf of Mexico and southern Florida in the Gulfstream Current, which would carry them offshore of Georgia and the Carolinas. As evidence of this, a pelagic-stage hawksbill was captured 37 nautical miles east of Sapelo Island, Georgia in May 1994 (Parker 2005). There are also records of hawksbill sea turtles stranding on the coast of Georgia (Odell et al. 2008), being captured in pound nets off Savannah, and being captured in summer flounder trawls (Epperly et al. 1995) , gillnets (Epperly et al. 1995), and power plants off Georgia and the Carolinas.

Within United States territories and U.S. dependencies in the Caribbean Region, hawksbill sea turtles nest principally in Puerto Rico and the U.S. Virgin Islands, particularly on Mona Island and Buck Island. They also nest on other beaches on St. Croix, Culebra Island, Vieques Island, mainland Puerto Rico, St. John, and St. Thomas. Within the continental United States, hawksbill sea turtles nest only on beaches along the southeast coast of Florida and in the Florida Keys.

Hawksbill sea turtles occupy different habitats depending on their life history stage. After entering the sea, hawksbill sea turtles occupy pelagic waters and occupy weed-lines that accumulate at convergence points. When they growth to about 20-25 cm carapace length, hawksbill sea turtles re-enter coastal waters where they inhabit and forage in coral reefs as juveniles, sub-adults and adults. Hawksbill sea turtles also occur around rocky outcrops and high energy shoals, where sponges grow and provide forage, and they are known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

Population Structure

Hawksbill sea turtles, like other sea turtles, are divided into regional groupings that represent major oceans or seas: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. In these regions, the population structure of hawksbill turtles are usually based on the distribution of their nesting aggregations.

Threats to the Species

Natural Threats. The various habitat types hawksbill sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which hawksbill sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Adult hawksbill sea turtles are also killed by sharks and other large, marine predators.

Anthropogenic Threats. Three human activities are known to threaten hawksbill sea turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of hawksbill sea turtle populations was overharvests by humans for subsistence and commercial purposes. In the Atlantic, hawksbill sea turtles are still captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Brautigam and Eckert 2006).

For centuries, hawksbill sea turtles have been captured for their shells, which have commercial value, rather than food (the meat of hawksbill sea turtles is considered to have a bad taste and can be toxic to humans) (NMFS and USFWS 1998d). Until recently, tens of thousands of hawksbills were captured and killed each year to meet demand for jewellery, ornamentation, and whole stuffed turtles (Eckert 1993; Milliken and Tokunaga 1987). In 1988, Japan’s imports from Jamaica, Haiti and Cuba represented some 13,383 hawksbills: it is extremely unlikely that this volume could have originated solely from local waters (Greenpeace 1989 cited in Eckert 1993). Although Japan banned the importation of turtle shell in 1994, domestic harvests of eggs and turtles continue in the United States, its territories, and dependencies, particularly in the Caribbean and Pacific Island territories. Large numbers of nesting and foraging hawksbill sea turtles are captured and killed for trade in Micronesia, the Mexican Pacific coast, southeast Asia and Indonesia (NMFS and USFWS 1998d). In addition to the demand for the hawksbill’s shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Before the U.S. certified Japan under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles.

The second most important threat to hawksbill sea turtles is the loss of nesting habitat caused by the expansion of resident human populations in coastal areas of the world and increased destruction or modification of coastal ecosystems to support tourism. Hawksbill sea turtles are also captured and killed in commercial fisheries. Along the

Atlantic coast of the U.S., NMFS estimated that about 650 hawksbill sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with most of those sea turtles dying as a result of their capture. Each year, about 35 hawksbill sea turtles are captured in Atlantic pelagic longline fisheries. Although most of these turtles are released alive, these fisheries are expected to kill about 50 hawksbill sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown. Like green sea turtles, hawksbill sea turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

Status

Hawksbill sea turtles were listed as endangered under the ESA in 1970. Under the Convention on International Trade in Endangered Species of Wild Fauna and Flora, hawksbill sea turtles are identified as “critically endangered” (IUCN 2010).

Hawksbill sea turtles are solitary nesters, which makes it difficult to estimate the size of their populations. There are no global estimates of the number of hawksbill sea turtles, but a minimum of 15,000 to 25,000 females are thought to nest annually in more than 60 geopolitical entities (Groombridge and Luxmoore 1989). Moderate populations appear to persist around the Solomon Islands, northern Australia, Palau, Persian Gule islands, Oman, and parts of the Seychelles. In a more recent review, Groombridge and Luxmoore (1989) list Papua New Guinea, Queensland, and Western Australia as likely to host 500-1,000 nesting females per year, while Indonesia and the Seychelles may support >1,000 nesting females. The largest known nesting colony in the world is located on Milman Island, Queensland, Australia where Loop (1995) tagged 365 hawksbills nesting within an 11 week period.

Of the 65 geopolitical units on which hawksbill sea turtles nest and where hawksbill nesting densities can be estimated, 38 geopolitical units have hawksbill populations that are suspected or known to be declining. Another 18 geopolitical units have experienced well-substantiated declines (NMFS and USFWS 1995). The largest remaining nesting concentrations occur on remote oceanic islands off Australia (Torres Strait) and the Indian Ocean (Seychelles).

Hawksbill sea turtles, like green sea turtles, are thought to be declining globally as a direct consequence of a historical combination of overexploitation and habitat loss. However, like several of the species we have already discussed, the information available on the status and trend of hawksbill sea turtles do not allow us to make definitive statements about the global extinction risks facing these sea turtles or the risks facing particular populations (nesting aggregations) of these turtles. However, the limited data available suggests that several hawksbill sea turtles populations exist at sizes small enough to be classified as “small” populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) while others are large enough to avoid these problems. Exogenous threats such as overharvests and entanglement in fishing gear only increase their probabilities of becoming extinct in the foreseeable future.

Diving and Social Behavior

The duration of foraging dives in hawksbill sea turtles commonly depends on the size of the turtle: larger turtles diving deeper and longer. At a study site also in the northern Caribbean, foraging dives were made only during the day and dive durations ranged from 19-26 minutes in duration at depths of 8-10 m. At night, resting dives ranged from 35-47 minutes in duration (vanDam and Diez 1997).

Vocalizations and Hearing

There is no information on hawksbill sea turtle vocalizations or hearing. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtle: their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol et al. 1999).

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

4.4.10 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle is the smallest sea turtle; adult straight carapace length is approximately 65 cm (26 in) and adults weigh less than 45 kg (99 lb) (NMFS et al. 2010). The carapace is round to somewhat heart-shaped and distinctly light gray.

Distribution

Adult Kemp's ridley turtles are restricted to the Gulf of Mexico in shallow near shore waters, although adult-sized individuals sometimes are found on the eastern seaboard of the United States. Females rarely leave the Gulf of Mexico and adult males do not migrate. Juveniles feed along the east coast of the United States up to the waters off Cape Cod, Massachusetts (Spotila 2004). A small number of individuals reach European waters and the Mediterranean (Pritchard and Marquez 1973). Juvenile Kemp's ridley sea turtles are the second most abundant sea turtle in the mid-Atlantic region from New England, New York, and the Chesapeake Bay, south to coastal areas off North Carolina. Juvenile Kemp's ridley sea turtles migrate into the region during May and June and forage for crabs in submerged aquatic vegetation (Musick and Limpus 1997). In the fall, they migrate south along the coast, forming one of the densest concentrations of Kemp's ridley sea turtles outside of the Gulf of Mexico (Musick and Limpus 1997).

Population Structure

As discussed previously, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Cole (Cole 1954), Futuyma (Futuymda 1986) and Wells and Richmond (Wells and Richmond 1995) and is more restrictive than those uses of 'population' that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see reviews by Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as ‘population decline,’ ‘population collapse,’ ‘population extinction,’ and ‘population recovery’ apply to the restrictive definition of ‘population’ but do not explicitly apply to alternative definitions. Unlike the other sea turtles discussed in this Opinion, adult Kemp’s ridley sea turtles are generally restricted to the Gulf of Mexico. Almost 95 percent of all Kemp’s ridley sea turtle nesting occurs on the beaches of Rancho Nuevo, Tepehuajes, and Barra del Tordo in the State of Tamaulipas, Mexico. Nesting also occurs in Veracruz, Mexico, and Texas, U.S., but on a much smaller scale. Occasional nesting has been documented in North Carolina, South Carolina, and the Gulf and Atlantic coasts of Florida. As a general matter, Kemp’s ridley sea turtles are treated as a single population.

Threats to the Species

Natural Threats. Kemp’s ridley sea turtles are exposed to a wide variety of threats during every stage of their lives. Eggs and hatchlings on nesting beaches are preyed upon by coyotes, raccoons, coatis, skunks, ghost crabs, ants, and to lesser degrees hawks, vultures, grackles, and caracaras (Dodd Jr. 1988; Witzell 1983b). Those hatchlings that reach the ocean are preyed upon by gulls, terns, sharks, and predatory fish (Dodd Jr. 1988). Sharks and other large marine predators prey on large juvenile Kemp’s ridley sea turtles.

Because of their restricted geographic distribution, the concentration of most nesting activity at one beach, and the frequency of hurricanes in the Gulf of Mexico, hurricanes represent a substantial threat to Kemp’s ridley sea turtles. For example, in 1988 Hurricane Gilbert struck the primary nesting beach, destroyed many of the nests, and altered the structure of the nesting beach.

Anthropogenic Threats. Several human activities contributed to the endangerment of threaten Kemp’s ridley sea turtles: harvests of eggs on nesting beaches, incidental capture in fisheries, loss of foraging habitat, and marine pollution. In 1947, 40,000 female Kemp’s ridley sea turtles were observed nesting on the beaches at Rancho Nuevo on a single day (Carr 1963; Hildebrand 1963). From the 1940s through the early 1960s, poaching on nests on the beaches of Rancho Nuevo, Mexico, were heavily exploited but beach protection in 1966 helped to curtail this activity (NMFS and USFWS 1992).

Kemp’s ridley sea turtles have been captured and killed by fishing gear in several Federal and state fisheries throughout their range. They have been captured in gear used in lobster fisheries and monkfish fisheries off the northeastern United States, pound net fisheries off eastern Long Island, the mid-Atlantic, and Chesapeake Bay; fisheries for squid, mackerel, butterfish, bluefish, summer flounder, Atlantic herring, weakfish, and the sargassum fishery. The most significant fishery-related threat to Kemp’s ridley sea turtles has been the number of sea turtles that have been captured and killed in the shrimp trawl fisheries in the Gulf of Mexico. Kemp’s ridley sea turtles have also been captured and killed as a result of entrainment in power plans along the coast of the United States and coastal dredging.

Recovery Actions. Kemp’s ridley sea turtles have benefited from a concentrated recovery effort that began in the mid-1960s when the government of Mexico established a program to protect eggs on the beach of Rancho Nuevo. In

1977, a Mexican presidential decree included the Rancho Nuevo Nesting Beach Natural Reserve as part of a system of reserves for sea turtles. In 1978, an experiment to “head start” Kemp’s ridley sea turtles was implemented as part of a larger effort to recover the species. From 1978 to 1991, under a cooperative beach patrol effort involving personnel from both countries, the number of released hatchlings was increased to a yearly average of 54,676 individuals. In 1990 a complete ban on taking any species of sea turtle was established by the Government of Mexico (NMFS et al. 2010).

Status

Kemp’s ridley sea turtles were listed as endangered on 2 December 1970 (35 FR 18320). There is no designated critical habitat for the Kemp’s ridley sea turtle. In 1947, 40,000 female Kemp’s ridley sea turtles were observed nesting on the beaches at Rancho Nuevo on a single day (Carr 1963; Hildebrand 1963). By the early 1970s, the estimate of mature female Kemp's ridleys had been reduced to 2,500-5,000 individuals. Between the years of 1978 and 1991 only 200 Kemp's ridleys nested annually.

Today the Kemp's ridley population appears to be in the early stages of recovery. Nesting has increased steadily over the past decade. During the 2000 nesting season, an estimated 2,000 females nested at Rancho Nuevo, a single arribada of 1,000 turtles was reported in 2001, and an estimated 3,600 turtles produced over 8,000 nests in 2003. In 2006, a record number of nests were recorded since monitoring began in 1978; 12,143 nests were documented in Mexico, with 7,866 of those at Rancho Nuevo. By 2004, the number of adult females in the Gulf of Mexico is estimate to have increased to about 5,000 individuals (Spotila 2004) with over 8,000 nests reported in 2003 (Marquez et al. 2005).

On the Texas coast, 251 Kemp's ridley nests were recorded from 2002-2006. For the 2007 nesting season, 127 nests have been recorded in Texas, with 73 of those nests documented at Padre Island National Seashore. Those 127 nests are a record for the Texas coast, passing the 2006 record of 102 nests.

The Turtle Expert Working Group (TEWG 2000) estimated that the population size of Kemp’s ridley sea turtles grew at an average rate of l1.3 percent per year (95 percent C.I. slope = 0.096-0.130) between 1985 and 1998. Over the same time interval, hatchling production increased at a slightly slower rate (9.5 percent per year).

Vocalizations and Hearing

There is no information on the vocalizations or hearing of Kemp’s ridley sea turtles. However, we assume that their hearing sensitivities would be similar to those of green and loggerhead sea turtle: their best hearing sensitivity would be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol et al. 1999).

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

4.4.11 Loggerhead Sea Turtle

Loggerheads were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The carapace (top shell) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the plastron (bottom shell) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. Mean straight carapace length of adults in the southeastern U.S. is approximately 36 in (92 cm); corresponding weight is about 250 lbs (113 kg).

Loggerheads reach sexual maturity at around 35 years of age. In the southeastern U.S., mating occurs in late March to early June and females lay eggs between late April and early September. Females lay three to five nests, and sometimes more, during a single nesting season. The eggs incubate approximately two months before hatching sometime between late June and mid-November.

Hatchlings vary from light to dark brown to dark gray dorsally and lack the reddish-brown coloration of adults and juveniles. Flippers are dark gray to brown above with white to white-gray margins. The coloration of the plastron is generally yellowish to tan. At emergence, hatchlings average 1.8 in (45 mm) in length and weigh approximately 0.04 lbs (20 g).

Distribution

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (NMFS and USFWS 1998e). The majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. Nesting aggregations occur in the eastern Atlantic at Cape Verde, Greece, Libya, Turkey and along the West African Coast. The western Atlantic and Caribbean hosts nesting aggregations along the U.S. east coast from Virginia through the Florida peninsula, the Dry Tortugas and Northern Gulf of Mexico, the Bahamas, the Yucatan Peninsula, Central America and the Caribbean and into South America. Within the Indian Ocean, nesting aggregations occur at Oman, Yemen, Sri Lanka and Madagascar and South Africa. Pacific Ocean nesting sites include western and eastern Australia and Japan.

Adult loggerheads are known to make considerable migrations from nesting beaches to foraging grounds (TEWG 2009); and evidence indicates turtles entering the benthic environment undertake routine migrations along the coast that are limited by seasonal water temperatures. Small juveniles are found in pelagic waters (e.g., of the North Atlantic and the Mediterranean Sea); and the transition from oceanic to neritic juvenile stages can involve trans-oceanic migrations (Bowen et al. 2004). Loggerhead nesting is confined to lower latitudes, concentrated in temperate zones and subtropics; the species generally does not nest in tropical areas (NMFS and USFWS 1991b; NRC 1990; Witherington et al. 2006). Loggerhead turtles travel to northern waters during spring and summer as water temperatures warm, and southward and offshore toward warmer waters in fall and winter; loggerheads are noted to occur year round in offshore waters of sufficient temperature.

Population Structure

Loggerhead sea turtles, like other sea turtles, are divided into regional groupings that represent major oceans or seas: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. In these regions, the population structure of loggerhead turtles is usually based on the distribution of their nesting aggregations. In the Pacific Ocean, loggerhead turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) which may be comprised of separate nesting groups (Hatase et al. 2002) and a smaller southwestern nesting aggregation that occurs in Australia (Great Barrier Reef and Queensland), New Caledonia, New Zealand, Indonesia, and Papua New Guinea. One of the largest loggerhead nesting aggregations in the world is found in Oman, in the Indian Ocean.

Based on genetic analyses of loggerhead sea turtles captured in pelagic longline fisheries in the same general area as that of the proposed action, loogerhead sea turtles along the southeastern coast of the United States might originate from one of the five major nesting aggregations in the western North Atlantic: (1) a northern nesting aggregation that occurs from North Carolina to northeast Florida, about 29°N; (2) a south Florida nesting aggregation, occurring from 29°N on the east coast to Sarasota on the west coast; (3) a Florida panhandle nesting aggregation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán nesting aggregation, occurring on the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas nesting aggregation that occurs in the islands of the Dry Tortugas near Key West, Florida (NMFS 2001).

Loggerhead sea turtles from the northern nesting aggregation, which represents about 9 percent of the loggerhead nests in the western North Atlantic, comprise between 25 and 59 percent of the loggerhead sea turtles captured in foraging areas from Georgia to waters of the northeastern United States (Bass et al. 1998; Rankin-Baransky et al. 1998; Sears et al. 1995). About 10 percent of the loggerhead sea turtles in foraging areas off the Atlantic coast of central Florida will have originated from the northern nesting aggregation (Witzell 1999). Loggerhead sea turtles associated with the South Florida nesting aggregation, in contrast, occur in higher frequencies in the Gulf of Mexico (where they represent about 10 percent of the loggerhead sea turtles captured) and the Mediterranean Sea (where they represent about 45-47 percent of the loggerhead sea turtles captured).

Threats to the Species

<u>Natural Threats.</u> The various habitat types loggerhead sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural and anthropogenic threats. The beaches on which loggerhead sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. For example, in 1992, all of the eggs over a 90-mile length of coastal Florida were destroyed by storm surges on beaches that were closest to the eye of Hurricane Andrew (Milton et al. 1994). Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Adult loggerhead sea turtles are also killed by sharks and other large, marine predators. Loggerhead sea turtles are also killed by cold stunning, exposure to biotoxins, sharks and other large, marine predators.

Anthropogenic Threats. A wide variety of human activities adversely affect hatchlings and adult female turtles when they are on land, including beach erosion, beach armoring and nourishment; artificial lighting; beach cleaning; human presence on nesting beaches; beach driving; coastal construction and fishing piers that alter patterns of erosion and accretion on nesting beaches; exotic dune and beach vegetation; and poaching. As the size of the human population in coastal areas increases, that population brings with it secondary threats such as exotic fire ants, feral hogs, dogs, and the increase of native species that tolerate human presence (*e.g.*, raccoons, armadillos, and opossums) and which feed on turtle eggs.

When they are in coastal or marine waters, loggerhead turtles are affected by a completely different set of human activities that include discharges of toxic chemicals and other pollutants into the marine ecosystem; underwater explosions; hopper dredging, offshore artificial lighting; entrainment or impingement in power plants; entanglement in marine debris; ingestion of marine debris; boat collisions; poaching, and interactions with commercial fisheries. Of these, interactions with fisheries represent a primary threat because of number of individuals that are captured and killed in fishing gear each year.

Loggerhead sea turtles are also captured and killed in commercial fisheries. In the Pacific Ocean, between 2,600 and 6,000 loggerhead sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set Hawai'i based longline fisheries are estimated to have captured and killed several hundred loggerhead sea turtles before they were closed in 2001. When they were re-opened in 2004, with substantial modifications to protect sea turtles, these fisheries were estimated to have captured and killed about fewer than 5 loggerhead sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai'i are estimated to have captured about 45 loggerhead sea turtles, killing about 10 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future (NMFS and USFWS 2008). Loggerhead sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawai'i and American Samoa.

Shrimp trawl fisheries account for the highest number of loggerhead sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges. Along the Atlantic coast of the U.S., NMFS estimated that almost 163,000 loggerhead sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 3,948 of those sea turtles dying as a result of their capture. Each year, several hundred loggerhead sea turtles are also captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries in Pamlico Sound. Although most of these turtles are released alive, these fisheries are combined to capture about 2,000 loggerhead sea turtles each year, killing almost 700; the health effects of being captured on the sea turtles that survive remain unknown.

In the pelagic environment, loggerhead sea turtles are exposed to a series of longline fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various fleets in the Mediterranean Sea (Aguilar et al. 1995; Bolten et al. 2002). In the benthic environment in waters off the coastal U.S., loggerheads are exposed to a suite of fisheries in federal and state waters including trawl, purse seine, hook and line, gillnet, pound net, longline, dredge, and trap fisheries.

Like all of the other sea turtles we have discussed, loggerhead sea turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

Status

Loggerhead sea turtles are currently listed as nine Distinct Population Segments (DPSs); four listed as threatened and five listed as Endangered under the ESA (Table 5).

Table 5. Loggerhead sea turtle distinct population segments (76 FR 58868).

Population Segment	Population Boundaries	Proposed Status
Mediterranean Sea	Mediterranean Sea east of 5°36’ W. Long.	Endangered
North Indian Ocean	North Indian Ocean north of the equator and south of 30° N. Lat.	Endangered
North Pacific Ocean	North Pacific north of the equator and south of 60° N. Lat.	Endangered
Northeast Atlantic Ocean	Northeast Atlantic Ocean north of the equator, south of 60° N. Lat, east of 40° W. Long, and west of 5°36’ W. Long	Endangered
Northwest Atlantic Ocean	Northwest Atlantic Ocean north of the equator, south of 60° N. Lat, and west of 40° W. Long	Threatened
South Atlantic Ocean	South Atlantic Ocean south of the equator, north of 60° S. Lat, west of 20° E. Long, and east of 67° W. Long	Threatened
South Pacific Ocean	South Pacific south of the equator, north of 60° S. Lat, west of 67° W. Long, and east of 139° E. Long.	Endangered
Southeast Indo-Pacific Ocean	Southeast Indian Ocean south of the equator, north of 60° S. Lat, and east of 80° E. Long; South Pacific Ocean south of the equator, north of 60° S. Lat, and west of 139° E. Long	Threatened
Southwest Indian Ocean	Southwest Indian Ocean north of the equator, south of 30° N. Lat, west of 20° E. Long, and east of 80° E. Long	Threatened

All loggerheads inhabiting the North Pacific Ocean are derived primarily, if not entirely, from Japanese beaches (although low level nesting may occur in areas around the South China Sea). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six “submajor’’ beaches (10– 100 nests per season) were identified. Using information collected from these nine beaches (Kamezaki et al. 2003) found a substantial decline (50–90 percent) in the size of the annual loggerhead nesting population over the last half of the 20th century. Also, nest count data for the last two decades suggests that the North Pacific population is “small” and lacks a robust gene pool when compared to the larger northwest Atlantic and north Indian Ocean loggerhead populations. Small populations are more susceptible to demographic variability which increases their probability of extinction. Available evidence indicates that due to loss of adult and juvenile mortalities from fishery bycatch and, to a lesser degree the loss of nesting habitat, the North Pacific loggerhead population is declining.

In the South Pacific, loggerhead nesting is almost entirely restricted to eastern Australia (primarily Queensland) and New Caledonia, with the majority of nesting occurring in eastern Australia. The total nesting population for Queensland was approximately 3,500 females in the 1976–1977 nesting season (Limpus and Reimer 1994; Limpus 1985), however, by the 1999-2000 season Limpus and Limpus (2003) estimated this population at less than 500 females. This represents an estimated 50 to 80 percent decline in the number of breeding females at various Australian rookeries up to 1990 (Limpus and Reimer 1994) and a decline of approximately 86 percent by 1999 (Limpus and Limpus 2003).

Information from pilot surveys conducted in 2005 in New Caledonia, combined with oral history information collected, suggests a decline in loggerhead nesting with 60-70 loggerheads nesting on the four surveyed New Caledonia beaches during the 2004–2005 nesting season (Limpus et al. 2006). Chaloupka and Limpus (2001) determined that the resident non-breeding loggerhead population on coral reefs of the southern Great Barrier Reef in eastern Australia declined at 3 percent per year from 1985 to the late 1990s. The observed decline was hypothesized as a result of recruitment failure, given few anthropogenic impacts and constant high annual survivorship measured at this foraging habitat (Chaloupka and Limpus 2001). This decline also coincided with a measured decline in new recruits in these foraging areas (Limpus and Limpus 2003). Available evidence indicates that due to loss of adult and juvenile mortalities from fishery bycatch the South Pacific population is declining.

Loggerhead sea turtles nesting densities in the North Indian Ocean are the largest in the eastern hemisphere with the vast majority of these nests in Oman (Baldwin et al. 2003). Nesting is rare in the rest of the northern Indian Ocean. Nesting surveys and tagging data were used to extrapolate the number of females nesting at Masirah Island during 1977-78 resulting in 19,000 to 60,000 turtles (assuming 100 percent nesting success) and a partial survey of the island in 1991 estimated 23,000 nesters (Baldwin 1992; Ross 1998). Comparing the nesting data collected after 2008 when nesting surveys were standardized at Masirah to the 1977-78 and 1991 yielded an estimate of 20,000-40,000 nesters (assuming 50 percent nesting success). These estimates suggest a decline in the nesting population over the past three decades which is consistent with observations by local rangers. Mortality across all life stages fishery bycatch and the loss of nesting habitat is likely to cause this population to decline further.

In the southeast Indo-Pacific Ocean, loggerhead nesting is restricted to Western Australia (Dodd Jr. 1988), which is the largest nesting population in Australia (Natural Heritage Trust, 2005 as cited in (NMFS and USFWS 2007). Evidence suggests the nesting population in the Muiron Islands and North West Cape region was depleted before recent beach monitoring programs began although the data are insufficient to determine trends (Nishemura and Nakahigashi 1990; Poiner et al. 1990; Poiner and Harris 1996). Juvenile and adult mortality from fishery bycatch presents the greatest threat to this population’s probability of extinction.

In the Southwest Indian Ocean, the highest concentration of nesting occurs on the coast of Tongaland, South Africa, where surveys and management practices were instituted in 1963 (Baldwin et al. 2003). Nesting beach data from this region from 1965 to 2008 indicates an increasing nesting population between the first decade of surveys, which documented 500–800 nests annually, and the last 8 years, which documented 1,100–1,500 nests annually (Nel 2006). These data represent approximately 50 percent of all nesting within South Africa and are believed to be representative of trends in the region. Loggerhead nesting occurs elsewhere in South Africa and Madagascar, but sampling is not consistent and no trend data are available. This population, although small, is increasing but juvenile mortality from fishery bycatch remains a concern.

Loggerheads in the Northwest Atlantic Ocean comprise one of the two largest nesting assemblages in the world and have been identified as the most significant assemblage in the western hemisphere. Data collected over a period of 10 to 23 years indicates that there has been a significant overall decline in nesting numbers (TEWG 2009; Witherington et al. 2009). The annual number of nests has been declining for all subpopulations of Northwest Atlantic loggerheads for which there were adequate data available. Available evidence indicates that this population is declining due to juvenile and adult mortality from fishery bycatch. Five nesting subpopulations have been identified in the Northwest Atlantic Ocean (NMFS and USFWS 2008). Their status follows:

(1) Northern U.S. (Florida/Georgia border to southern Virginia). The Northern U.S. subpopulation is the second largest unit within the Northwest Atlantic population and has been declining significantly at 1.3 percent annually since 1983 (NMFS and USFWS 2008);

(2) Peninsular Florida (Florida/Georgia border south through Pinellas County, excluding the islands west of Key West, Florida). The most significant declining trend has been documented for the Peninsular Florida subpopulation, where nesting declined 26 percent over the 20-year period from 1989–2008, and declined 41 percent over the period 1998–2008 (NMFS and USFWS 2008; Witherington et al. 2009). This subpopulation represents approximately 87 percent of all nesting effort in the Northwest Atlantic Ocean DPS (Ehrhart et al. 2003);

(3) Dry Tortugas (islands west of Key West, Florida). Data are currently not adequate to assess trends in the annual number of nests for this subpopulation;

(4) Northern Gulf of Mexico (Franklin County, Florida, west through Texas). Data are currently not adequate to assess trends in the annual number of nests for this subpopulation; and

(5) Greater Caribbean (Mexico through French Guiana, the Bahamas, Lesser and Greater Antilles). This is the third largest subpopulation within the Northwest Atlantic population, with the majority of nesting at Quintana Roo, Mexico. The TEWG (2009) reported a greater than 5 percent annual decline in loggerhead nesting from 1995–2006 at Quintana Roo.

In the northeastern Atlantic, the Cape Verde Islands support the only large nesting population of loggerheads in the region (Fretey 2001). Nesting occurs at some level on most of the islands in the archipelago with the largest nesting numbers reported from Boa Vista Island where 833 and 1,917 nests were reported in 2001 and 2002, respectively, and between 1998 and 2002 the local project had tagged 2,856 females (Cruz et al. 2007). More recently, in 2005, about 3,121 females were reported (López-Jurado et al. 2003). Elsewhere in the northeastern Atlantic, loggerhead nesting is non-existent or occurs at very low levels. Population trends could not be determined for the Cape Verde population because of limited data; however, evidence of directed killing of nesting females suggests that this nesting population is under severe pressure and likely significantly reduced from historic levels. Available evidence indicates that this population is declining due to ongoing mortality of mature females and eggs, low hatchling and emergence success and mortality of juveniles and adults from fishery bycatch.

Nesting occurs throughout the central and eastern Mediterranean and sporadic nesting has been reported in the western Mediterranean, however, the vast majority of nesting (greater than 80 percent) occurs in Greece and Turkey (Margaritoulis et al. 2003). The documented annual nesting of loggerheads in the Mediterranean averages about 5,000 nests (Margaritoulis et al. 2003). There is no discernible trend in nesting at the two longest monitoring projects in Greece, Laganas Bay (Margaritoulis 2006) and southern Kyparissia Bay (Margaritoulis and Rees 2001). However, nesting at two beaches, Rethymno Beach, which accounts for approximately 7 percent of all documented loggerhead nesting in the Mediterranean, and Fethiye Beach in Turkey which accounts for 10 percent of nesting in Turkey, showed a declining trend in 1990–2004 and 1993-2004, respectively (Ilgaz et al. 2007). Juvenile and adult mortality from fishery bycatch and the loss of nesting habitat, eggs and hatchlings remain a concern for this population.

In the South Atlantic nesting occurs primarily along the mainland coast of Brazil. Prior to 1980, loggerhead nesting populations in Brazil were considered depleted, however, an increasing trend has been reported from 1988 through 2003 on beaches representing more than 75 percent of all loggerhead nesting in Brazil. A total of 4,837 nests were reported from these survey beaches for the 2003–2004 nesting season (Marcovaldi and Chaloupka 2007). Juvenile mortality from fishery bycatch remains a concern for this population.

Diving and Social Behavior

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). The maximum recorded dive depth for a post-nesting female was 211-233 meters, while mean dive depths for both a post-nesting female and a subadult were 9-22 meters. Routine dive times for a post-nesting female were between 15 and 30 minutes, and for a subadult, between 19 and 30 minutes (Sakamot et al. 1990 cited in Lutcavage and Lutz 1997).Two loggerheads tagged by Hawai'i-based longline observers in the North Pacific and attached with satellite-linked dive recorders were tracked for about 5 months. Analyses of the dive data indicate that most of the dives were very shallow - 70 percent of the dives were no deeper than 5 meters. In addition, the loggerheads spent approximately 40 percent of their time in the top meter and nearly all of their time at depths shallower than 100 meters. On 5 percent of the days, the turtles dove deeper than 100 meters; the deepest daily dive recorded was 178 meters (Polovina et al. 2003).

Polovina et al. (2004) reported that tagged turtles spent 40 percent of their time at the surface and 90 percent of their time at depths shallower than 40 meters. On only five percent of recorded dive days loggerheads dove to depths greater than 100 meters at least once. In the areas that the loggerheads were diving, there was a shallow thermocline at 50 meters. There were also several strong surface temperature fronts the turtles were associated with, one of 20°C at 28°N latitude and another of 17°C at 32°N latitude.

Vocalizations and Hearing

The information on loggerhead turtle hearing is very limited. Bartol et al. (1999) studied the auditory evoked potential of loggerhead sea turtles that had been captured in pound nets in tributaries to the Chesapeake Bay in Maryland and Virginia and concluded that loggerhead sea turtles had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999). This is similar to the results produced by Ridgway et al. (1969) who studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear). They concluded that the maximum sensitivity of green sea turtles occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz.

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological opinion includes the effects of several activities that affect the survival and recovery of endangered whales and sea turtles in the action area.

A number of human activities have contributed to the current status of populations of large whales and sea turtles in the action area. Some of those activities, most notably commercial whaling, occurred extensively in the past, ended, and no longer appear to affect these whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect whale and sea turtle populations. The following discussion summarizes the principal phenomena that are known to affect the likelihood that these endangered whales and sea turtles will survive and recover in the wild.

5.1 Natural Mortality

Natural mortality rates in cetaceans, especially large whale species, are largely unknown. Although factors contributing to natural mortality cannot be quantified at this time, there are a number of suspected causes, including parasites, predation, red tide toxins and ice entrapment. For example, the giant spirurid nematode (*Crassicauda boopis*) has been attributed to congestive kidney failure and death in some large whale species (Lambertsen 1986). A well-documented observation of killer whales attacking a blue whale off Baja, California, demonstrates that blue whales are at least occasionally vulnerable to these predators (Tarpy 1979). Other stochastic events, such as fluctuations in weather and ocean temperature affecting prey availability, may also contribute to large whale natural mortality.

Whales also appear to strand from natural (as compared with anthropogenic) causes. Nitta (1991) reported that between 1936 and 1988, 8 humpback whales, 1 fin whale, and 5 sperm whales stranded in the Hawaiian Archipelago. In a partial update of that earlier report, Maldini et al. (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002. Sperm whales represented 10 percent of that total. Although these two studies did not specify the cause or causes of death in these cases, we include these strandings in this discussion of sources of natural mortality because the causes of death remain unknown. Because most of these stranding events consisted of individual animals or because many of the multiple stranding events identified in these reports occurred prior to the mid-1960s (4 of the 8 multiple stranding events identified by Maldini et al. (2005) occurred between 1957 and 1959, 3 of 8 occurred in 1976, and 1 occurred in 1981).

5.2 Human-Induced Impacts

A variety of human activities can result in the loss of fitness or the mortality of listed marine mammals and sea turtles. These include commercial whaling and subsistence hunting, entrapment and entanglement in commercial fishing gear, ship strikes, habitat degradation, and marine mammal watching.

5.2.1 Commercial Whaling and Subsistence Hunting

Large whale population numbers in the Action Area for this consultation have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission’s 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the esa of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were taken in the Pacific Ocean with an unknown number of additional animals taken prior to 1900 (Perry et al. 1999a). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada 1972); 46,000 fin whales between 1947-1987; and 25,800 sperm whales (Barlow and Clapham 1997). North Pacific right whales once numbered 11,000 animals but commercial whaling has now reduced their population to 29-100 animals (Wada 1973). Although commercial whaling no longer targets the large, endangered whales in the action areas, historical whaling may have altered the age structure and social cohesion of these species in ways that continue to influence them.

5.2.2 Entrapment and Entanglement in Commercial Fishing Gear

Several commercial fisheries operate in the Action Area for this consultation. The fisheries that have the most significant demographic effect on sea turtles are the shrimp trawl fisheries conducted off the southeast United States (from North Carolina to the Atlantic coast of Florida) and Gulf of Mexico (from the Gulf coast of Florida to Texas). Although participants in these fisheries are required to use Turtle Exclusion Devices, which are estimated to reduce the number of sea turtles trawlers capture by as much as 97 percent, each year these fisheries are expected to capture about 185,000 sea turtles and kill about 5,000 of the turtles captured. Loggerhead sea turtles account for most of this total: each year these fisheries are expected to capture about 163,000 loggerhead sea turtles, killing almost 4,000 of them. These are followed by green sea turtles: about 18,700 green sea turtles are expected to be captured each year with more than 500 of them dying as a result of their capture (NMFS 2002).

Portions of the Atlantic pelagic fisheries for swordfish, tuna, shark, and billfish also operate in the Action Area and capture and kill the second highest numbers of sea turtles along the Atlantic coast. These fisheries, which operate off the southeast coast of South Carolina, the coast of Georgia (with the exception of waters off Florida and southernmost Georgia that are closed to the longline component of these fisheries) and the Gulf of Mexico, include purse seine fisheries for tuna, harpoon fisheries for tuna and swordfish, commercial and recreational rod and reel fisheries, gillnet fisheries for shark, driftnet fisheries, pelagic longline fisheries, and bottom longline fisheries.

Between 1986 and 1995, this fishery captured and killed one North Atlantic right whale, two humpback whales, and two sperm whales. Between 1992 and 1998, the longline components of these fisheries are estimated to have captured more than 10,000 sea turtles (4,585 leatherback sea turtles and 5,280 loggerhead sea turtles), killing 168 of these sea turtles in the process (the latter estimate does not include sea turtles that might have died after being released) (Johnson et al. 1999; Yeung 1999). Since then, all components of these fisheries are estimated to capture about 1,350 sea turtles each year, killing 345 sea turtles in the process.

Portions of the Atlantic sea scallop fisheries also operate in the Action Area (off North Carolina) and capture and kill the third highest numbers of sea turtles along the Atlantic coast. These fisheries are expected to capture about 750 loggerhead sea turtles each year, killing about 480 of them. Although these fisheries are only expected to capture 2 green, leatherback, and Kemp’s ridley sea turtles each year, all of these turtles might die as a result of their capture.

In addition, sea turtles are captured and killed in several other Federal fisheries that operate along the Atlantic coast, although most of these fisheries capture and kill fewer sea turtles than the fisheries discussed in the preceding narratives. Of all the factors that influenced NMFS’ decision to list sea turtles as threatened or endangered, the most significant sources of injury or mortality of juvenile, subadult, and adult sea turtles are those associated with commercial fishing.

The fisheries discussed in this section of this Opinion are expected to continue into the foreseeable future at levels of effort that are roughly equivalent to current levels. As a result, we expect the number of sea turtles that are captured and killed in these fisheries to continue for the foreseeable future. These estimates mean that, every five years, more than 800,000 loggerhead sea turtles would be captured in these fisheries, with more than 23,000 of them dying as a result; about 19,000 leatherback sea turtles would be captured, with about 1,500 of them dying as a result; about 95,000 green sea turtles would be captured, with about 2,900 of them dying; and about 3,200 hawksbill sea turtles being captured and killed.

5.2.3 Ship Strikes

Collisions with commercial ships are an increasing threat to many large whale species, particularly because shipping lanes cross important large whale breeding and feeding habitats or migratory routes. As discussed in the *Status of the Species* narratives for several of the whales that are considered in this Opinion, ship strikes pose significant threats to whales along the Atlantic coast, particularly North Atlantic right whales. Commercial and private vessels may affect humpback, fin, sperm and right whales. Small vessel traffic also kills or injures threatened and endangered sea turtles in the action area.

The port of Jacksonville supports some of the country's strongest maritime economies. About 17 million tons of waterborne cargo pass through the Port of Jacksonville, Florida which receives about 1,600 vessels each year moving between the U.S. and South America, Europe, and the Caribbean Region.[5] This amount of traffic increases the probability of collisions between commercial ships, whales, and sea turtles.

5.2.4 Habitat Degradation

Chronic exposure to the neurotoxins associated with paralytic shellfish poisoning from zooplankton prey has been shown to have detrimental effects on marine mammals. Estimated ingestion rates are sufficiently high to suggest that the PSP toxins are affecting marine mammals, possibly resulting in lower respiratory function, changes in feeding behavior and a lower reproduction fitness (Durbin et al. 2002). Other human activities, including discharges from wastewater systems, dredging, ocean dumping and disposal, aquaculture and additional impacts from coastal development are also known to impact marine mammals and their habitat.

Water Pollution. Coastal runoff and river discharges carry large volumes of petrochemical and other contaminants from agricultural activities, cities and industries into the Gulf of Mexico. The coastal waters of the Gulf of Mexico have more sites with high contaminant concentrations than other areas of the coastal United States, due to the large number of waste discharge point sources. Although these contaminant concentrations do not likely affect the more pelagic waters of the action area, the species of turtles analyzed in this biological opinion travel between nearshore and offshore habitats and may be exposed to and accumulate these contaminants during their life cycles.

An extensive review of environmental contaminants in turtles has been conducted by Meyers-Schöne and Walton (1994); however, most of this information relates to freshwater species. High concentrations of chlorobiphenyls and organochlorine pesticides in the eggs of the freshwater snapping turtle, *Chelydra serpentina*, have been correlated with population effects such as decreased hatching success, increased hatchling deformities and disorientation (Bishop et al. 1994).

Very little is known about baseline levels and physiological effects of environmental contaminants on marine turtle populations (Bishop et al. 1991). There are a few isolated studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Aguirre et al. 1994; Davenport et al. 1990). Mckenzie et al. (1999) measured concentrations of chlorobiphenyls and organochlorine pesticides in marine turtles tissues collected from the Mediterranean (Cyprus, Greece) and European Atlantic waters (Scotland) between 1994 and 1996. Omnivorous loggerhead turtles had the highest organochlorine contaminant concentrations in all the tissues sampled, including those from green and leatherback turtles. It is thought that dietary preferences were likely to be the main differentiating factor among species. Decreasing lipid contaminant burdens with turtle size were observed in green turtles, most likely attributable to a change in diet with age. Sakai et al. (1995) found the presence of metal

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[5] These data were derived from the internet websites for each of the ports named

residues occurring in loggerhead turtle organs and eggs. More recently, Storelli et al. (1998) analyzed tissues from twelve loggerhead sea turtles stranded along the Adriatic Sea (Italy) and found that characteristically, mercury accumulates in sea turtle livers while cadmium accumulates in their kidneys, as has been reported for other marine organisms like dolphins, seals and porpoises by Law et al. (1991). Research is needed on the short- and long-term health and fecundity effects of chlorobiphenyl, organochlorine, and heavy metal accumulation in sea turtles.

The impacts from these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (*e.g.*, ddt, pcbs, and polyaromatic hydrocarbons) and immunosuppression ((De Swart et al. 1996; Ross et al. 1995). Organochlorines are chemicals that tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing, some of these contaminants can be passed from the mother to developing offspring. Contaminants like organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (O'Hara et al. 1999; Oshea and Brownell 1994).

Entrainment in Power Plants. Sea turtles entering coastal or inshore areas have been affected by entrainment in the cooling-water systems of electrical generating plants. At the St. Lucie nuclear power plant at Hutchinson Island, Florida, large numbers of green and loggerhead turtles have been captured in the seawater intake canal in the past several years (Norem 2005). Other power plants in south Florida, west Florida, and North Carolina have also reported low levels of sea turtle entrainment. A biological opinion completed in January 2000 estimates that the operations at the Brunswick Steam Electric Plant in Brunswick, North Carolina, may take 50 sea turtles in any combination annually, which are released alive. NMFS also estimated the total lethal take of turtles at this plant may reach 6 loggerhead, 2 Kemp’s ridley or 3 green turtles annually. A biological opinion completed in June 1999 on the operations at the Crystal River Energy Complex in Crystal River, Florida, estimated the level of take of sea turtles in the plant’s intake canal may reach 55 sea turtles with an estimated 50 being released alive every two years.

Anthropogenic Noise. The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson et al. 1995a).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 2005b; Richardson et al. 1995a; Richardson et al. 1995b). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003a). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003a). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003b). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995a). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The Navy estimated that the 60,000 vessels of the world’s merchant fleet annually emit low frequency sound into the world’s oceans for the equivalent of 21.9 million days, assuming that 80 percent of the merchant ships are at sea at any one time (U.S. Navy 2001). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. (Chapman and Price 2010) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. The nrc (NRC 2005a) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships.

US Navy Training and Military Readiness Activities. In 1997, NMFS issued a biological opinion on Navy training activities within and in the vicinity of the critical habitat that had been designated for North Atlantic right whales off of the coasts of Georgia and Florida (NMFS 1997). That Opinion concluded that the Navy‘s training activities were not likely to jeopardize the continued existence of North Atlantic right whales and other endangered or threatened species or result in the destruction or adverse modification of critical habitat that had been designated in the action area for that consultation.

In the late 1990s, the U.S. Navy implemented several new mitigation measures that were designed to protect right whales. Because of these mitigation measures, NMFS concluded that current Navy operations out of Mayport, Florida were not likely to jeopardize the continued existence of endangered or threatened species under NMFS’ jurisdiction (NMFS 1997).

Vessel operations and ordnance detonations adversely affect listed species of sea turtles and whales. U.S. Navy aerial bombing training in the ocean off the southeast U.S. coast involving drops of live ordnance (500 and 1,000-lb bombs) is estimated to have the potential to injure or kill 84 loggerheads, 12 leatherback sea turtles, and 12 green or Kemp’s ridley sea turtles, in combination (NMFS 1997). The Navy ship-shock trials for the USS Winston S. Churchill was conducted in the Action Area for this consultation, although the U.S. Navy employed a suite of measures that appeared to protect marine mammal and sea turtle from being exposed to shock waves produced by the underwater detonations associated with the trial (Clarke and Norman 2005).

From early July through early August 2007, the U.S. Navy conducted a Composite Training Unit-Joint Task Force Exercise within and seaward of the Cherry Point and Jacksonville-Charleston Operating Areas located off South Carolina, North Carolina, Georgia, and Florida. These exercises included antisubmarine warfare training events that employed between 340 and 355 hours of mid-frequency active sonar and deployed 170 DICASS sonobuoys. The Navy reported that one group of dolphins had been observed during this exercise, resulting in a shut-down of active sonar usage. The actual number of marine animals that might have been exposed to mid-frequency active sonar during that exercise, and their responses to any exposure, remains unknown.

In August and September 2008, the U.S. Navy conducted a ship shock trial on the mesa verde in waters east of Jacksonville, Florida, using High Blast Explosive (hbx-1) for the detonations. NMFS' biological opinion on the ship shock trial expected up to 36 sea turtles to be injured as a result of the ship shock trial and up to 1,727 turtles to be harassed as a result of their behavioral responses to the underwater detonations. Although the after action report for the ship shock trial did not confirm these estimates, surveys associated with the trial did not detect any dead or injured marine mammals or sea turtles during the shock trial event or during post-mitigation monitoring. In addition, no marine mammal or sea turtle stranding has been attributed to the shock trial.

In June 2009, NMFS issued a biological opinion on the Permits Division's proposal to promulgate regulations that would authorize the U.S. Navy to "take" marine mammals incidental to (1) the U.S. Navy's proposal to continue to conduct training activities within and adjacent to (a) waters off the Northeast coast of the United States, (b) the Virginia Capes Range Complex; (c) the Cherry Point Range Complex, and (d) the Charleston-Jacksonville Range Complex over a five-year period and the U.S. Navy's proposal to establish a transit protection system at Naval Submarine Base Kings Bay, Georgia, to escort nuclear powered ballistic submarines during transit between the Naval Submarine Base and the dive/surface site.

Each year, over the five-year period extending from 2009 through 2014, NMFS expected the U.S. Navy's training activities to harass blue, fin, humpback, North Atlantic right, sei whale, and sperm whales, and green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtle by exposing them to sound fields produced by underwater detonations or ship noise at received levels that would cause individual animals to change their behavior from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures (NMFS 2008a; NMFS 2008b; NMFS 2009; NMFS 2010a).

Between January and August 2009, the U.S. Navy conducted three Composite Training Unit Exercises and one Southeastern Anti-Submarine Warfare Integrated Training Initiative or SEASWITI (see Table 6). The U.S. Navy conducted three Integrated Anti-Submarine Warfare courses (IAC) in conjunction with three of the Composite Training Unit Exercises it conducted over this time interval: one on 11 and 13 January 2009; a second on 17 and 19 February 2009, and a third on 15 and 17 June 2009. The total numbers of sonar hours that were associated with each of these exercises are classified and are not reported here.

On 28 July 2009, NMFS issued a final biological opinion on the U.S. Navy's proposal to place a network of underwater transducer devices and undersea cables in a 1,713-km^2 (500 nautical mile^2) area of the ocean about 93 km (50 nautical miles) offshore of northeastern Florida, beginning in 2012 or 2013 with operations scheduled to begin in 2014 or 2015. The instrumented area, which would be called the Undersea Warfare Tracking Range (USWTR), would be connected by cable to a facility that would be located on shore where the data collected on the range would be used to evaluate the performance of participants in shallow water training exercises.

That biological opinion concluded that no blue, fin, or sei whales are likely to be exposed to active sonar associated with active sonar training activities on the Jacksonville Operating Area. That opinion also concluded that 106 humpback whales and 47 North Atlantic right whales might be exposed to active sonar operations conducted on uswtr at received levels that might result in behavioral harassment. However, the Opinion concluded that these exposures were not likely to jeopardize the continued existence of these species.

Deep Water Ambient Noise. Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The frequency spectrum and level of ambient noise can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

Shallow Water Ambient Noise. In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick 1983). At any given time and place, the ambient noise level is a mixture of these noise types. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sound levels tend to be higher than when the bottom is absorptive.

5.2.5 Commercial and Private Marine Mammal Watching

In addition to the federal vessel operations, private and commercial shipping vessels, vessels (both commercial and private) engaged in marine mammal watching also have the potential to impact whales in the Action Area for this consultation. A recent study of whale watch activities worldwide has found that the business of viewing whales and dolphins in their natural habitat has grown rapidly over the past decade into a billion dollar ($US) industry involving over 80 countries and territories and over 9 million participants (Hoyt 2001). In 1988, a workshop sponsored by the Center for Marine Conservation and the NMFS was held in Monterey, California to review and evaluate whale watching programs and management needs (NMFS 1988). That workshop produced several recommendations for addressing potential harassment of marine mammals during wildlife viewing activities that include developing regulations to restrict operating thrill craft near cetaceans, swimming and diving with the animals, and feeding cetaceans in the wild.

Since then, NMFS has promulgated regulations at 50 CFR 224.103 that specifically prohibit: (1) the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; (2) feeding or attempting to feed a marine mammal in the wild; and (3) approaching humpback whales in Hawai'i and Alaska waters closer than 100 yards (91.4 m). In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines which in part state that viewers should: (1) remain at least 50 yards from dolphins, porpoise, seals, sea lions and sea turtles and 100 yards from large whales; (2) limit observation time to 30 minutes; (3) never encircle, chase or entrap animals with boats; (4) place boat engine in neutral if approached by a wild marine mammal; (5) leave the water if approached while swimming; and (6) never feed wild marine mammals. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states that: "*NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals or sea lions in the wild. This includes attempting to swim with, pet, touch or elicit a reaction from the animals.*"

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). Another concern is that preferred habitats may be abandoned if disturbance levels are too high.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005a; Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams and Ashe. 2006a). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. The whales' responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions.

5.3 Recovery Actions

Several agencies have engaged in a variety of actions that are designed to reduce the effects of human activities on endangered and threatened species in the Action Area. In 1993, NMFS formed the Southeast Implementation Team for the Right Whale Recovery Plan to address the goals of the Right Whale Recovery Plan within NMFS' Southeast Region. The recovery plan has identified entanglement in fishing gear and ship collisions as the two major direct human impacts affecting both species. Habitat degradation through pollution or other major habitat alteration processes caused by either human sources (discharge or disposal in the marine environment) or resource management activities (fishery or minerals management) is also identified as a major indirect impact requiring attention.

An Early Warning System for right whales has been operational in areas of the southeastern U.S. for several years. This system identifies the known location of right whales within and adjacent to the winter calving area from Savannah, Georgia, to Sebastian Inlet, Florida, from 1 December through 31 May (when right whales are assumed to occur in these waters) and provides this information to mariners. This system has successfully diverted shipping to avoid right whales on several occasions, thus decreasing the threat of vessel collisions.

5.4 The Impact of the Baseline on Listed Resources

Although listed resources are exposed to a wide variety of past and present state, Federal or private actions and other human activities that have already occurred or continue to occur in the action area as well as Federal projects in the action area that have already undergone formal or early section 7 consultation, and state or private actions that are contemporaneous with this consultation, the impact of those activities on the status, trend, or the demographic processes of threatened and endangered species remains largely unknown.

Several of the activities described in this *Environmental Baseline* have had significant and adverse consequences for nesting aggregations of sea turtles whose individuals occur in the Action Area. In particular, the commercial fisheries that have been described have captured substantial numbers of green, hawksbill, leatherback, and loggerhead sea turtles each year.

Although only small percentages of these sea turtles are estimated to have died as a result of their capture, the actual number of sea turtles that are estimated to have died in these fisheries each year for the past 5 to 10 years (or longer) still amounts to about 6,000 sea turtles each year. When we add the percentage of sea turtles that have suffered injuries or handling stress sufficient to have caused them to delay the age at which they reach maturity or the frequency at which they return to nesting beaches, the consequences of these fisheries on nesting aggregations of sea turtles would be greater than we have estimated.

Historically, commercial whaling had occurred in the action area and had caused all of the large whales to decline to the point where the whales faced risks of extinction that were high enough to list them as endangered species. Since the end of commercial whaling, the primary threat to these species has been eliminated. However, all of the whale species have not recovered from those historic declines and scientists cannot determine if those initial declines continue to influence current populations of most large whale species. Species like North Atlantic right whales have not begun to recover from the effects of commercial whaling on their populations and continue to face very high risks of extinction in the foreseeable future because of their small population sizes (on the order of 50 individuals) and low population growth rates. Blue, sei, and sperm whales may face similar problems because of the legacy of whaling on their populations in the Atlantic Ocean. Relationships between potential stressors in the marine environments and the responses of these species that may keep their populations depressed are unknown.

Recent attention has focused on the emergence of a wide number of anthropogenic sound sources in the action area and their role as a pollutant in the marine environment. Relationships between specific sound sources, or anthropogenic sound generally, and the responses of marine mammals to those sources are still subject to extensive scientific research and public inquiry but no clear patterns have emerged. As a result, the potential consequences of these activities on threatened and endangered marine mammals remain uncertain.

Gauthier and Sears (1999), Weinrich et al. (1991; 1992) Clapham and Mattila (1993), Clapham et al. (1993) concluded that close approaches for biopsy samples or tagging caused humpback whales to respond or caused them to exhibit "minimal" responses when approaches were "slow and careful." This caveat is important and is based on studies conducted by Clapham and Mattila (1993) of the reactions of humpback whales to biopsy sampling in breeding areas in the Caribbean Sea. These investigators concluded that the way a vessel approaches a group of whales had a major influence on the whale's response to the approach; particularly cow and calf pairs. Based on their experiments with different approach strategies, they concluded that experienced, trained personnel approaching humpback whales slowly would result in fewer whales exhibiting responses that might indicate stress.

At the same time, several lines of evidence suggest that these human activities might result in greater consequences for individual whales (if not for whale populations). Several investigators reported behavioral responses to close approaches that suggest that individual whales might experience stress responses. Baker et al. (1983) described two responses of whales to vessels, including: (1) "horizontal avoidance" of vessels 2,000 to 4,000 meters away characterized by faster swimming and fewer long dives; and (2) "vertical avoidance" of vessels from 0 to 2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins et al. (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions.

Bauer (1986) and Bauer and Herman (1986) studied the potential consequences of vessel disturbance on humpback whales wintering off Hawai'i. They noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels.

Baker et al. (1983) and Baker and Herman (1987) summarized the response of humpback whales to vessels in their summering areas and reached conclusions similar to those reached by Bauer and Herman (1986): these stimuli are probably stressful to the humpback whales in the action area, but the consequences of this stress on the individual whales remains unknown. Studies of other baleen whales, specifically bowhead and gray whales document similar patterns of short-term, behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel's engine was turned on even at distance of approximately 900 m (3,000 ft). Weinrich er al. (1992) associated "moderate" and "strong" behavioral responses with alarm reactions and stress responses, respectively.

Jahoda et al. (2003) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They concluded that close vessel approaches caused these whales to stop feeding and swim away from the approaching vessel. The whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed for hours after the exposure ended. They recommended keeping vessels more than 200 meters from whales and having approaching vessels move a low speeds to reduce visible reactions in these whales.

Beale and Monaghan (2004b) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity. None of the existing studies examined the potential effects of numerous close approaches on whales or gathered information of levels of stress-related hormones in blood samples that are more definitive indicators of stress (or its absence) in animals.

6 EFFECTS OF THE PROPOSED ACTION

Here we present the results of our assessment of the probable direct and indirect effects of Federal actions as well as the direct and indirect effects of interrelated and interdependent actions on threatened and endangered species and habitat areas in the Action Area. As we described in the *Approach to the Assessment* section of this Opinion, we organize our effects' analyses using a stressor identification - exposure – response – risk assessment framework; we conclude this section with an *Integration and Synthesis of Effects* that integrates information we presented in the *Status of the Species* and *Environmental Baseline* sections of this Opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

The Endangered Species Act does not define "harassment" nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines "harassment" as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" [16 U.S.C. 1362(18)(A)]. For military readiness activities, this definition of "harassment" has been amended to mean "any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild; or any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered" (Public Law 106-136, 2004). The latter portion of these definitions (that is, "...causing disruption of behavioral patterns including... migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's regulatory definition of harass.[6]

For this Opinion, we define "harassment" similarly: "an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents." We are particularly

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[6] An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.4)

concerned about changes in animal behavioral that is likely to result in animals that fail to feed, fail to breed successfully, or fail to complete their life history because those changes may have adverse consequences for populations of those species.

6.1 Potential Stressors

The U.S. Navy has conducted the active sonar and other training activities along the Atlantic Coast of the United States and in the Gulf of Mexico (the Action Area) for several decades and these potential stressors have been associated with most, if not all, of those exercises. The U.S. Navy's proposed action consists of continuing active sonar training activities in the Action Area; the Permits Division's proposed action consists of authorizing the "take" of marine mammals associated with those training activities. By extension, the potential stressors associated with the Navy's proposal are stressors that have been part of the Action Area as well.

The potential stressors we assess in this Opinion consist of (1) mid- and high-frequency active sonar; (2) the explosive source associated with the Improved Extended Echo Ranging (IEER) and Advanced Extended Echo Ranging (AEER) Sonobuoy Systems; (3) vessel traffic associated with the active sonar training exercises; and (4) parachutes associated with some of the sonobuoys. We discuss each of these potential stressors in greater detail in the descriptions that follow. We follow those descriptions with a presentation of our exposure analyses, followed by the results of our response analyses. As outlined in the introductory paragraph of this section, we conclude our effects analyses with an Integration and Synthesis which contains the results of our risk analyses.

Summary of Activities that Occurred in 2011

NMFS' programmatic biological opinion on the U.S. Navy's proposal to conduct active sonar training along the Atlantic Coast of the United States and in the Gulf of Mexico, which covered the period from January 2009 to January 2014, expected the U.S. Navy to conduct a certain number of training events and to produce an estimated number of hours of active sonar each year of that five-year period. In each biological opinion on an annual LOA, we assess data from the preceding years to determine if the assumptions and expectations of our programmatic biological opinion remain valid.

Between January and August 2011, the U.S. Navy conducted three Composite Training Unit Exercises and one Southeastern Anti-Submarine Warfare Integrated Training Initiative or SEASWITI (Table 6). The total numbers of sonar hours that were associated with each of these exercises or the combination of these exercises are classified and are not reported here.

Our programmatic biological opinion on AFAST expected up to four Composite Training Unit Exercises each year with each exercise lasting about 21 days. Data the U.S. Navy provided on training activities they conducted along the Atlantic coast and in the Gulf of Mexico between January and December 2011 indicate that the Navy conducted fewer Composite Training Unit Exercises than expected. Therefore, because the exposure estimate is linked to the number and duration of training exercises, we would assume that fewer animals would have been exposed to active sonar than estimated.

Table 6. Number of active sonar training exercises along the Atlantic coast that the U.S. Navy reported between January and December 2011.

Type of Exercise	Dates	Location	Duration	Number of Ships
Composite training unit exercise with integrated anti-submarine warfare course and joint training exercise	20 Jan – 17 Feb 2011	CHPT/Charleston/JAX	31 days	22
Southeastern Anti-Submarine Warfare Integrated Training Initiative	22-25 Feb 2011	JAX	4	7
Integrated anti-submarine warfare course	25-27 May 2011	VACAPES/CHPT	3	5
Integrated anti-submarine warfare course	16-18 August	VACAPES/CHPT	3	6
Composite training unit exercise	29 Nov – 21 Dec 2011	CHPT/Charleston	23	7-8

The U.S. Navy conducted four Integrated Anti-Submarine Warfare Courses (IACs) during 2011; one in conjunction with a Composite Training Unit Exercises. Our programmatic opinion expected the U.S. Navy to conduct five Integrated Anti-Submarine Warfare Courses each year.

Our programmatic biological opinion on AFAST also expected up to four Southeastern Anti-Submarine Warfare Integrated Training Initiatives (SEASWITIs) each year with each exercise lasting between 5 and 7 days. The U.S. Navy conducted only one of these exercises along the Atlantic coast and in the Gulf of Mexico between January and December 2011, which lasted seven days. Because the U.S. Navy conducted fewer training events than we expected in our programmatic biological opinion, we assume that our programmatic biological opinion and our Opinion on the 2011 LOA overestimated the total number of hours of active sonar that we expected to be associated with these training exercises.

6.1.1 Surface Vessel Traffic

Most of the activities the U.S. Navy proposes to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico involve some level of activity from surface vessels, submarines, or both. Vessel traffic associated with the proposed training exercises actually represents a suite of stressors or stress regimes that pose several potential hazards to endangered and threatened species along the Atlantic Coast of the United States and in the Gulf of Mexico. First, the size and speed of these surface vessels pose some probability of collisions between marine mammals and sea turtles. Second, this amount of traffic represents an acute or chronic source of disturbance to marine animals along the Atlantic Coast of the United States and in the Gulf of Mexico, although it is not clear what environmental cue marine animals might respond to: the sounds of waters being displaced by the ships, the sounds of the ships' engines, or a combination of environmental cues surface vessels produce while they transit.

Probability of Collisions

Given the speeds at which these vessels are likely to move, they pose potential hazards to marine mammals. The Navy's operational orders for ships (and aircraft) that are underway are designed to prevent collisions between surface vessels participating in naval exercises and endangered whales that might occur in the action area. These measures, which include observers on the bridge of ships, requirements for course and speed adjustments (see section 2.6.1 Mitigation) to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales.

Although the probability of a collision seems fairly small, particularly for collision with sea turtles, given the measures that are in place, additional surface vessels engaged in training maneuvers in the Action Area poses some risk of disturbing large whales that might occur in the Action Area. This is particularly true when that traffic is placed in the context of animals that are likely to have had extensive prior experience with existing levels of vessel traffic associated with inter-island transportation, commercial ship traffic, whale-watching vessels, leisure cruises, and research vessels that were discussed in the *Environmental Baseline* of this Opinion.

Disturbance

The presence and movement of vessels represent a source of acute and chronic disturbance for marine mammals and sea turtles. The underwater noise generated by vessels may disturb animals when the animal perceives that an approach has started and during the course of the interaction.

6.1.2 High-frequency active sonar

Several of the torpedoes and the AN/BQS-15 sonar system, which Navy submarines use for under-ice navigation and mine-hunting, produce high-frequency sounds (see Table 7). In addition, two of the active sonar systems the U.S. Navy employs as part of its mine warfare scenarios – AN/AQS-14, which is an active-controlled, helicopter-towed mine-hunting active sonar and AN/AQS-24 which is an upgraded version of AN/AQS-14 – operate at frequencies higher than 200 kHz.

6.1.3 Mid-frequency active sonar

Naval sonars operate on the same basic principle as fish-finders (which are also a kind of sonar): brief pulses of sound, or “pings,” are projected into the ocean and an accompanying hydrophone system in the sonar device listens for echoes from targets such as ships, mines or submarines. Several sonar systems are likely to be employed during the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico, but several systems pose potential risks to listed resources (we should note that other navies that might be involved in some of the active sonar training exercises, such as Joint Task Force Exercises, employ similar active sonar systems as well, but we do not have the information necessary to describe those systems).

Table 7. Description and attributes of sonar sources proposed for use along the Atlantic Coast of the United States and in the Gulf of Mexico.

System	Center Frequency (kHz)	Source Level (re 1 μPa)	Associated Platform	System Description	Annual Quantity	Unit
AN/SQS-53	3.5	235	DDG and CG hull-mounted sonar (surface ship)	ASW search, detection, localization; utilized 70 percent in search mode and 30 percent track mode	3214	Hours
AN/SQS-56	7.5	225	FFG hull-mounted sonar (surface ship)	ASW search, detection, localization; Utilized 70 percent in search mode and 30 percent track mode	1684	Hours
AN/SQS-53 and AN/SQS-56	MF	Classified	DDG, CG, and FFG hull-mounted sonar	Only used when entering and leaving port to detect objects	216	Hours
AN/BQQ-5 or 10	MF	Classified	Submarine hull-mounted sonar	ASW search and attack (approx one ping per two hours when used)	9976	Pings
AN/AQS-13	10	215	Helicopter dipping sonar	ASW sonar lowered from hovering helicopter (approximately 10 pings/dip, 30 sec between pings)	1476	Dips
AN/AQS-22	4.1	217	Helicopter dipping sonar	ASW sonar lowered from hovering helicopter (approximately 10 pings/dip, 30 sec between pings)	1476	Dips
MK-48 Torpedo	HF	Classified	Submarine fired exercise torpedo	ASW sonar lowered from hovering helicopter (approximately 10 pings/dip, 30 sec between pings)	32	Torpedoes
MK-46 or 54 Torpedo	HF	Classified	Surface ship and aircraft fired exercise torpedo	Recoverable and non-explosive exercise torpedo; sonar is active approximately 15 min per torpedo run	24	Torpedoes
Tonal sonobuoy (DICASS)(AN/SSQ-62)	8	201	Helicopter and MPA deployed	Remotely commanded expendable sonar-equipped buoy (approximately 12 pings per use, 30 sec between pings)	5853	Buoys
IEER (AN/SSQ-110A)	Impulsive - Broadband	Classified	MPA deployed	ASW explosive acoustic source buoy (contains two 4.1 lb charges) and expendable passive receiver sonobuoy	1725	Buoys
AN/SLQ-25 (NIXIE)	MF	Classified	DDG, CG, and FFG towed array (countermeasure)	Towed countermeasure to avert localization and torpedo attacks (approximately 20 mins per use)	2500	Hours
AN/SQQ-32	HF	Classified	MCM over the side system (mine-hunting)	Mine warfare to detect, classify, and localize bottom and moored mines	0	Hours
AN/BQS-15	HF	Classified	Submarine navigational sonar	Only used when entering and leaving port	450	Hours
ADC MK-1, MK-2, MK-3, and MK-4 ADCs	MF	Classified	Submarine deployed countermeasure	Expendable acoustic device countermeasure (20 mins per use)	225	ADCs
Noise Acoustic Emitters (NAE)	MF	Classified	Submarine deployed countermeasure	Expendable acoustic countermeasure (20 mins per use)	127	NAEs
AN/SSQ-125 (AEER)	MF	Classified	MPA deployed	ASW system consists of active sonobuoy and expendable passive receiver sonobuoy	1550	Buoys

As discussed in the *Description of the Proposed Action*, a variety of surface ships participate in Navy training exercises, including guided missile cruisers, destroyers, guided missile destroyers, and frigates. Some ships (e.g., aircraft carriers) do not have any onboard active sonar systems, other than fathometers. Others, like guided missile cruisers, are equipped with active as well as passive sonars for submarine detection and tracking. The primary surface ship sonars considered are

1. The AN/SQS-53 which is a large, active-passive, bow-mounted sonar that has been operational since 1975. AN/SQS-53 is the U.S. Navy's most powerful surface ship sonar and is installed on Ticonderoga (22 units) and Arleigh Burke I/II/IIIa class vessels in the U.S. Navy (D'Spain et al. 2006c; Polmar 2001). This sonar transmits at a center frequency of 3.5 kHz at source levels of 235 dB_{rms} re: 1 μPa at 1 meter. The sonar has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-53 operates at depths of about 7 meters.

   The AN/SQS-53 is a computer-controlled, hull-mounted surface-ship sonar that has both active and passive operating capabilities, providing precise information for anti-submarine warfare weapons control and guidance. The system is designed to perform direct-path anti-submarine warfare search, detection, localization, and tracking from a hull-mounted transducer array.The AN/SQS-53 Kingfisher is a modification that provides a surface ship with the ability to detect mine-like objects. However, Navy vessels would use this sonar only when entering and leaving a port. As a result, we would not expect endangered marine mammals to be exposed to this sonar system, although sea turtles that occur in the ports are likely to be exposed to active sonar from this system.

2. The AN/SQS-56 system is a lighter active-passive bow-mounted sonar that has been operational since 1977. AN/SQS-56 is installed on FFG-7 (33 units) class guided missile frigates in the U.S. Navy (D'Spain et al. 2006c; Polmar 2001). This sonar transmits at a center frequency of 7.5 kHz and a source level of 225 dB_{rms} re: 1 μPa at 1 meter source level. This sonar also has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-56 operates at depths of about 6 meters.

Sonar Systems Associated with Submarines

As discussed in the *Description of the Proposed Action,* tactical military submarines (i.e. 29 attack submarines as of 2008) equipped with hull-mounted mid-frequency use active sonar to detect and target enemy submarines and surface ships. The predominant active sonar system mounted on submarine is AN/BQQ-10 sonar that is used to detect and target enemy submarines and surface ships. Two other systems — AN/BQQ-5 and AN/BSY-1/2 — have operational parameters that would affect marine mammals in ways that are similar to the AN/BQQ-10.

1. AN/BQQ-10 (also known as Advanced Rapid Commercial-Off-the-Shelf Insertion– a four-phase program for transforming existing submarine sonar systems (i.e., AN/BQQ -5) from legacy systems to more capable and flexible active and passive systems with enhanced processing using

commercial-off-the-shelf components. The system is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-10 is installed on Seawolf Class SSNS, Virginia Class SSNS, Los Angeles Class SSNS, and Ohio Class ssbn/nuclear guided missile submarines (SSGNS). The BQQ-10 systems installed on Ohio Class SSBNS do not have an active sonar capability.

2. AN/BQQ-5 – a bow- and hull-mounted passive and active search and attack sonar system. The system includes the TB-16 and TB-23 or tb-29 towed arrays and Combat Control System MK 2. This sonar system is characterized as MFA, although the exact frequency range is classified. The AN/BQQ-5 sonar system is installed on Los Angeles Class nuclear attack submarines (SSNS) and Ohio Class ballistic missile nuclear submarines (SSBNS), although the AN/BQQ-5 systems installed on Ohio Class SSBNS do not have an active sonar capability. The AN/BQQ-5 system is being phased out on all submarines in favor of the AN/BQQ-10 sonar.

In addition, Seawolf Class attack submarines, Virginia Class attack submarines, Los Angeles Class attack submarines, and Ohio Class nuclear guided missile submarines also have the AN/BQS-15 sonar system, which uses high-frequency for under-ice navigation and mine-hunting. However, Navy submarines would use this sonar system only when entering and leaving a port. As a result, we would not expect endangered marine mammals to be exposed to this sonar system, although sea turtles that occur in the ports might be exposed to active sonar from this system.

Sonar Systems Associated with Aircraft

As discussed in the *Description of the Proposed Action*, aircraft sonar systems that typically operate during Navy training exercises include sonobuoys and dipping sonar. Current dipping sonar systems used by the Navy are either AN/SQS-22 or AN/AQS -13. AN/AQS -13 is an older and less powerful dipping sonar system (maximum source level 215 dB re µPa-s^2 at 1m) than the AN/AQS -22 (maximum source level 217 dB re µPa-s^2 at 1m). In its modeling, the Navy assumed that all dipping sonar were AN/AQS -22. P-3 aircraft may deploy sonobuoys while helicopters may deploy sonobuoys or dipping sonars (the latter are used by carrier-based helicopters). Sonobuoys are expendable devices used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. In addition, the U.S. Navy employs tonal sonobuoys (DICASS, AN/SSQ-62) and the Improved Extended Echo Ranging (IEER) System discussed in the *Description of the Proposed Action*.

1. The AN/SSQ-62C Directional Command Activated Sonobuoy System (DICASS) sonar system is part of a sonobuoy that operates under direct command of fixed-wing aircraft or helicopters. The system can determine the range and bearing of the target relative to the sonobuoys position and can deploy to various depths within the water column. After it enters the water, the sonobuoy transmits sonar pulses (continuous waveform or linear frequency modulation) upon command from the aircraft. The echoes from the active sonar signal are processed in the buoy and transmitted to the receiving station onboard the launching aircraft.

2. AN/SSQ-110A Explosive Source Sonobuoy – a commandable, air-dropped, high source level explosive sonobuoy. The AN/SSQ-110A explosive source sonobuoy is composed of two sections, an active (explosive) section and a passive section. The upper section is called the "control buoy" and is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the signal underwater sound charges explode, creating a loud acoustic signal. The echoes from the explosive charge are then analyzed on the aircraft to determine a submarine's position. The AN/SSQ-110A explosive source sonobuoy is deployed by maritime patrol aircraft.

   In 2011, the U.S. Navy proposed to increase the number of AN/SSQ-110A (IEER explosive) sonobuoys it would employ from 872 to 1,725 while eliminating the use of the high-frequency active sonar, variable depth mine detection and classification system (AN/SQQ-32). This change is carried forward in the proposed activities for this LOA.

3. AN/SSQ-125 Advanced Extended Echo Ranging (AEER) Sonobuoy - a third generation of multi-static active acoustic search systems to be developed under the Extended Echo Ranging family of the systems and is being developed as the replacement for the AN/SSQ-110A. The AN/SSQ-125 sonobuoy is composed of two sections, the control section and the active source section. The control section is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of the active sonar source. The echoes from pings of the sonar are then analyzed on the aircraft to determine a submarine's position. The AN/SSQ-125 sonobuoy will be deployed by maritime patrol aircraft.

   In 2011, the U.S. Navy proposed to increase the number of AN/SSQ-125 (AEER sonar) sonobuoys it would employ from 872 to 1,550 while eliminating the use of the high-frequency active sonar, variable depth mine detection and classification system (AN/SQQ-32). This change is carried forward in the proposed activities for this LOA.

Torpedoes

Torpedoes (primarily MK-46, MK-54 and MK-48) are the primary anti-submarine warfare weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively ensonifying the target and using the received echoes for guidance.

In addition to these torpedoes, the U.S. Navy employs Acoustic Device Countermeasures in several of their training exercises. These countermeasures (which include MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the an/slq-25A nixie) act as decoys by making sounds that simulate submarines to avert localization or torpedo attacks.

Mine Warfare Sonar Systems

The U.S. Navy uses a variety of different sonar systems during mine warfare training exercises. These sonar systems are typically high-frequency sonars (i.e., greater than 10 kHz) that detect, locate, and characterize moored and bottom mines and can be deployed by helicopters, unmanned underwater vehicles, surf zone crawlers, or surface ships. Most mine warfare systems are deployed by helicopters and typically operate at high (greater than 200 kHz) frequencies. The types of tactical acoustic sources used during mine warfare sonar training activities include the following:

*Surface Ship Sonars***.** Guided missile destroyers, fast frigates, and guided missile cruisers can use their hull-mounted sonars (AN/SQS-53 and AN/SQS-56) in the object detection (Kingfisher) mode. These ships, as well as mine hunters, may utilize over-the-side unmanned underwater vehicle systems containing sonar sensor packages to detect and classify mine shapes. Navy minesweepers use the AN/SQQ-32, a variable depth mine detection and classification high-frequency active sonar system. In addition, mine hunters are equipped with underwater acoustic communication systems.

*Submarine Sonars***.** Submarines can use a sail-mounted sonar, AN/BQS-15, to detect mines and objects. In addition, they employ the AN/BLQ-11 Long Term Mine Reconnaissance System which is an unmanned underwater vehicle that, when in operation, can be launched and recovered through the torpedo tubes by all classes of submarines. It can be equipped with mid-frequency active sonar to detect mines and is intended to extend a submarine’s reach for mine reconnaissance missions.

In addition, the U.S. Navy employs active sonar systems from aircraft as part of its mine warfare scenarios. Two systems in particular – AN/AQS-14, which is an active-controlled, helicopter-towed mine-hunting active sonar and AN/AQS-24 which is an upgraded version of AN/AQS-14 – operate above 200 kHz.

The duration, rise times, and wave form of sonar transmissions that would be used during Navy training exercises are classified; however, the characteristics of the transmissions that were used during the Bahamas exercises might help illustrate attributes of the transmissions from these two sonar sources. During the Bahamas exercises, these two sonars transmitted 1 – 2 second pulses once every 24 seconds (D'Spain et al. 2006b). Pulses had rise times of 0.1 – 0.4 seconds and typically consisted of three waveforms with nominal bandwidths up to 100 Hz (D'Spain et al. 2006b). Both sonars create acoustic fields that are omnidirectional in azimuth, although AN/SQS-53 also can create beams covering 120˚ azimuthal sectors that can be swept from side to side during transits (D'Spain et al. 2006b). Waveforms of both sonar systems are frequency modulated with continuous waves (D'Spain et al. 2006b).

Sound Propagation

Near an ocean’s surface (roughly the uppermost 150 feet), the sound field will be normally dominated by sound generated by wave action, rain, and other surface activity; that would mask most anthropogenic sounds. Below the surface area of this mixed layer, depth (pressure) dominates the sound speed profile and the sound’s speed *increases* with depth. Below the mixed layer, sea temperatures drop rapidly in an area referred to as the thermocline. In this region, temperature dominates the sound speed profile and speed decreases with depth. Finally, beneath the thermocline, the temperature becomes fairly uniform and increasing pressure causes the sound speed profile to increase with depth.

Acoustic waveguides, which include surface ducts as well as the SOFAR (sonar fixing and ranging) channel and deep sound channel of deep waters, focus sound from sources within the waveguide to long ranges. Surface ducts are acoustic waveguides that occur in the uppermost part of the water column when water near the surface is mixed by convection by surface wave activity generated by atmospheric winds. This mixing forms a surface layer with nearly constant temperatures so that sound speeds in the layer increase with depth. If sufficient energy is subsequently reflected downward from the surface, the sound can become “trapped” by a series of repeated upward refractions and downward reflections to create surface ducts or “surface channels”. Surface ducts commonly form in the winter because the surface is cooled relative to deeper water; as a result, surface ducts are predictable for certain locations at specific times of the year.

Sound trapped in a surface duct can travel for relatively long distances with its maximum range of propagation dependent on the specifics of the sound speed profile, the frequency of the sound, and the reflective characteristics of the surface. As a general rule, surface duct propagation will increase as the temperature becomes more uniform and depth of the layer increases. For example, a sound’s transmission is improved when windy conditions create a well-mixed surface layer or in high-latitude midwinter conditions where the mixed layer extends to several hundred feet deep.

6.1.4 Explosive Charges

One of the systems the U.S. Navy proposes to employ as part of its active sonar training includes explosive charges that provide a sound source. The AN/SSQ-110A Explosive Source Sonobuoy is composed of two sections, an active (explosive) section and a passive section. The lower, explosive section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the underwater sound charges explode, creating a loud acoustic signal.

The number of endangered or threatened species that might be exposed to explosions associated with this ordnance treat each in-water explosion as an independent event. The cumulative effect of a series of explosives can be estimated by addition if the detonations are spaced widely in time and space which would provide marine animal’s sufficient time to move out of an area affected by an explosion. As a result, the populations of animals that are exposed to in-water explosions are assumed to consist of different animals each time.

6.1.5 Parachutes Released During Deployment of Sonobuoys

When AN/SQS-62 DICASS sonobuoys impact the water surface after being deployed from aircraft, their parachute assemblies of sonobuoys are jettisoned and sink away from the sonobuoy, while a float containing an antenna is inflated. The parachutes are made of nylon and are about 8 feet in diameter. At maximum inflation, the canopies are between 0.15 to 0.35 square meters (1.6 to 3.8 square feet). The shroud lines range from 0.30 to 0.53 meters (12 to 21 inches) in length and are made of either cotton polyester with a 13.6 kilogram (30 pound) breaking strength or nylon with a 45.4 kilogram (100 pound) breaking strength. All parachutes are weighted with a 0.06 kilogram (2 ounce) steel material weight, which would cause the parachute to sink from the surface within about 15 minutes, although actual sinking rates depend on ocean conditions and the shape of the parachute.

The subsurface assembly descends to a selected depth, and the sonobuoy case falls away and sea anchors deploy to stabilize the hydrophone (underwater microphone). The operating life of the seawater battery is eight hours, after which the sonobuoy scuttles itself and sinks to the ocean bottom. For the sonobouys, concentrations of metals released from batteries were calculated to be 0.0011 mg/L lead, 0.000015mg/L copper, and 0.0000001mg/L silver.

6.2 Exposure Analysis

Our exposure analyses are designed to determine whether listed resources are likely to co-occur with the direct and indirect beneficial and adverse effects of actions and the nature of that co-occurrence. In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action’s effects and the populations or subpopulations those individuals represent.

Because of the limited information available on the distribution and abundance of endangered and threatened species along the Atlantic Coast of the United States and the Gulf of Mexico, our ability to independently estimate the number of endangered or threatened marine animals that might be exposed to the active sonar training activities the U.S. Navy plans to conduct in that area from January 2012 through January 2014 is very limited. Although Navy watchstanders have reported the number of large or small cetaceans they observed during some of the exercises that have been conducted along the Atlantic Coast of the United States and in the Gulf of Mexico in the past, those observations do not identify particular species. Further, they only represent individuals that were at the ocean’s surface, and only represent those individuals that might have been sighted given the sea surface and visibility conditions when the observations were reported. Because marine animals only spend a portion of their time at the ocean’s surface and because the ability to detect marine animals depends on sea states and visibility, the number of marine mammals reported by Navy watchstanders would not correspond to the number of marine animals actually exposed to Navy activities along the Atlantic Coast of the United States and in the Gulf of Mexico. Further, the areas encompassed by sound fields produced by activities like active sonar transmissions are so large that it adds to the difficulty of identifying and estimating the number of different marine species that are actually exposed to the sound field, the received levels associated with the exposure, or changes in the pattern of exposures over the course of an exercise or test.

As a result, the U.S. Navy, NMFS, and most other entities (for example, oil and gas industries for drilling platforms, geophysics organizations that conduct seismic surveys, etc.) that try to estimate the number of marine animals that might be exposed to active sound sources in the marine environment rely on computer models, simulations, or some kind of mathematical algorithm to estimate the number of animals that might be exposed to a sound source. Like all models, these approaches are based on assumptions and are sensitive to those assumptions.

It is important to note that these simulations tend to over-estimate rather than under-estimate the number of marine mammals that might be exposed to one or more of the activities the U.S. Navy plans to conduct along the Atlantic coast of the U.S. and in the Gulf of Mexico. In most cases, these over-estimates will be substantial and could imply that marine mammals are continuously exposed to U.S. Navy training activities along the Atlantic coast of the U.S. and in the Gulf of Mexico. However, most exposures will be periodic or episodic rather than continuous; marine mammals might not be exposed to entire training events that occur in deeper, pelagic waters and may be exposed several times to training events that occur in coastal waters.

6.2.1 Exposure to Vessel Traffic

We did not estimate the number of endangered or threatened species that are likely to be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises (primarily because the data we would have needed to support those analyses were not available). Nevertheless, we assume that any individuals of the endangered or threatened species that occur in the Action Area during major training exercises (COMPTUEX, JTFEX, IAC and SEASWITI) are likely to be exposed to visual and acoustic stimuli associated with vessel traffic and related activities. Unit-level training exercises and research, development, training, and evaluation activities involve fewer vessels, have shorter duration, and are much more localized, so fewer endangered and threatened species would be exposed to vessel traffic during these smaller exercises.

6.2.2 Exposure to Active Sonar

The narratives that follow present the results of the method the U.S. Navy and NMFS’ Permits Division used to estimate the number of marine mammals that might be “taken” (as that term is defined pursuant to the MMPA) during active sonar training the U.S. Navy proposed to conduct in their 2008 Environmental Impact Statement on AFAST. The “take” the Permits Division proposes to authorize using the LOA would reflect these estimates. Acoustic analysis for mid- and high-frequency active sonar activities was not performed for sea turtles due to the fact that sea turtles appear to be most sensitive only to low frequencies.

The Navy proposes mitigation measures to minimize the likelihood of exposure to mid-frequency active sonar and to prevent marine mammals from being exposed to mid frequency active sonar at high received levels. These measures utilize safety zones around marine mammals that trigger reductions in maximum transmission levels depending on the proximity of one or more marine mammals. Within these zones, surface vessels, helicopters, and submarines using active sonar are required to reduce transmission levels based on the distance from any marine mammals.

Because the U.S. Navy does not plan to conduct active sonar training activities within the Stellwagen Bank, Monitor, Gray‘s Reef, Flower Garden Banks, and Florida Keys National Marine Sanctuaries and will avoid these sanctuaries by observing a 5 km (2.7 nautical mile or nm) buffer, individual endangered or threatened animals that occur in these areas would not be exposed to mid-frequency active sonar at received levels greater than about 170 dB (based on estimates of propagation distances and assuming that a vessel near the boundary of this buffer zone would be transmitting active sonar).

Because the U.S. Navy does not propose to conduct active sonar training in North Atlantic right whale calving habitat with the exception of object detection and navigation off shore Mayport, Florida and Kings Bay, Georgia;

helicopter anti-submarine warfare training activities offshore Mayport, Florida; and torpedo exercises in the northeast during the months of August and September, any endangered or threatened species that occur in North Atlantic right whale feeding habitat off Massachusetts would not be exposed to high received levels of active sonar.

The U.S. Navy proposes to implement the safety zone mitigation by relying primarily on Navy watchstanders, helicopter pilots, and other Navy assets to detect marine mammals visually so that the Navy can take the appropriate action. To the degree that the Navy detects marine mammals visually, these safety zones should reduce the number of marine mammals that are exposed to mid-frequency active sonar or the intensity of their exposure. However, the effectiveness of visual monitoring is limited to daylight hours, and its effectiveness declines during poor weather conditions (JNCC 2004). In line transect surveys, the range of effective visual sighting (the distance from the ship's track or the effective strip width) varies with an animal's size, group size, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (which includes the observer's height above the water surface). For most large baleen whales, effective strip width can be about 3 km (1.6 nm) up through Beaufort 6 (Buckland and Borchers. 1993). For harbor porpoises the effective strip width is about 250 m (273 yd), because they are much smaller and less demonstrative on the surface than baleen whales (Palka 1996).

Further, several studies of interactions between seismic surveys and marine mammals and one of the U.S. Navy's low-frequency active sonar system and marine mammals concluded that dedicated marine mammal observers were more effective at detecting marine mammals, were more effective at detecting marine mammals at greater distances than Navy watchstanders (including watchstanders of the Navies of other countries), were better at identifying the marine mammal to species, and reported a broader range of behaviors than other personnel (Aicken et al. 2005; Stone 2000; Stone 2001; Stone 2003). It is not clear, however, how the U.S. Navy's watchstanders and lookouts, who are specifically trained to identify objects in the water surrounding Navy vessels compare with observers who are specifically trained to detect and identify marine mammals. NMFS is working with the Navy to determine the effectiveness of this component of Navy monitoring program and the degree to which it is likely to minimize the probability of exposing marine mammals to mid-frequency active sonar.

A multi-year study conducted on behalf of the United Kingdom's Ministry of Defense (Aicken et al. 2005) concluded that Big Eye binoculars were not helpful. Based on these studies, we would conclude that requiring surface vessels equipped with mid-frequency active sonar to have Big Eye binoculars in good working order is not likely to increase the number of marine mammals detected at distances sufficient to avoid exposing them to received levels that might result in adverse consequences.

The percentage of marine animals Navy personnel would not detect, either because they will pass unseen below the surface or because they will not be seen at or near the ocean surface, is difficult to determine. However, for minke whales, Schweder et al. (1992) estimated that visual survey crews did not detect about half of the animals in a strip width. Palka (1996) and Barlow (1988) estimated that visual survey teams did not detect about 25 percent of the harbor porpoises in a strip width. The information available leads us to conclude that the combinations of safety zones triggered by visual observations would still allow most marine mammals and sea turtles to be exposed to mid-frequency active sonar transmissions because most marine animals will not be detected at the ocean's surface.

6.2.3 Exposure Estimates for Atlantic Fleet Active Sonar Training

In 2008, the U.S. Navy developed the approach it used to estimate the number of marine mammals that might be exposed to the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast of the U.S. and in the Gulf of Mexico over the five-year period beginning in January 2009. What follows is a brief summary of the Navy's current approach; for more details, refer to Appendix H of the U.S. Navy's Environmental Impact Statement on Atlantic Fleet Active Sonar Training (Navy 2008b).

The U.S. Navy's approach focused on a suite of representative provinces based on sound velocity profiles, bathymetries, and bottom types. Within each of these provinces, the U.S. Navy modeled transmission losses in five meter increments and used the results to build sound fields (based on maximum sound pressure levels). The U.S. Navy then calculated an impact volume, which was the volume of water in which an acoustic metric exceeds a specified threshold; in this case, the metric is either energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. Then they multiplied the impact volumes with estimates of animal densities in three dimensions (densities distributed by area and depth), the U.S. Navy calculated the expected number of animals that might be exposed to an acoustic metric (energy flux density, peak pressure, or positive impulse) at levels that exceed specified thresholds. Specifically, the U.S. Navy calculated impact volumes for sonar operations (using energy flux density to estimate the probability of injury), peak pressure, and a Goertner modified positive impulse (for onset of slight lung injury associated with explosions).

To calculate impact volumes, the U.S. Navy applied a "risk continuum" (a curve that related the probability of a behavioral response given exposure to a received level that is generally represented by sound pressure level, but included sound exposure level to deal with threshold shifts) that the U.S. Navy and NMFS developed to this area, and then multiplied that area by a vector that represented the densities of the different species of marine animals that are expected to occur along the Atlantic Coast of the U.S. and in the Gulf of Mexico. The risk continuum, which the U.S. Navy adapted from a mathematical model developed by Feller (1968) (Navy 2008b), was estimated using three data sources: (1) data from controlled experiments conducted at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (Finneran 2003; Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt. 2004; Schlundt et al. 2000a), (2) data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromme 2004), and (3) a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek et al. 2004a).

This approach to estimating the number of endangered and threatened marine mammals that might be "taken" as a result of being exposed to active sonar associated with the activities the U.S. Navy plans to conduct along the Atlantic Coast of the U.S. and in the Gulf of Mexico produced the following results:

Blue Whales

Based on the U.S. Navy's exposure models, each year we would expect 881 instances annually (1,762 instances during the proposed LOA period) in which blue whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. All of these exposure events are likely to occur in the

Northeast Operating Area, which means they are likely to result from exposure to active sonar associated with submarines and maritime patrol aircraft (Table 8).

Fin Whales

Based on the U.S. Navy's exposure models, each year we would expect 970 instances annually (1,940 instances during the proposed LOA period) in which fin whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like blue whales, all of these exposure events are likely to occur in the Northeast Operating Area, which means they are likely to result from exposure to active sonar associated with submarines and maritime patrol aircraft (Table 8).

Humpback Whales

Based on the U.S. Navy's exposure models, each year we would expect 4,622 instances annually (9,244 instances during the proposed LOA period) in which humpback whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Unlike blue and fin whales, some of these exposure events are likely to occur in all Operating Area along the Atlantic coast of the United States and in the Gulf of Mexico, which means they are likely to result from exposure to any of the active sonar training activities the U.S. Navy proposed to conduct in the Action Area (Table 8).

North Atlantic Right Whales

Based on the U.S. Navy's exposure models, each year we would expect 733 instances annually (1,466 instances during the proposed LOA period) in which North Atlantic right whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. All of these exposure events are likely to occur in Operating Areas located along the Atlantic Coast of the United States and are not likely to occur in the Gulf of Mexico. As a result, North Atlantic right whales are not likely to be exposed to active sonar associated with surface ship mine warfare exercises, squadron exercises (RONEX), or Gulf of Mexico exercises, which only occur in the Gulf of Mexico (Table 8).

The U.S. Navy also proposes to reduce the time spent conducting object detection exercises in areas that are important for North Atlantic right whales (Item 4.5.2 of the Navy's mitigation measures). Specifically, the Navy proposes to require ships to contact Fleet Area Control and Surveillance Facility, Jacksonville (FACSFAC JAX) to obtain the latest right whale sighting information. The FACSFAC JAX will advise ships of all reported whale sightings in the vicinity of Areas of Concern prior to conducting surface ship object detection exercises in calving areas for the North Atlantic right whale off the southeast from 15 November to 15 April. To the extent operationally feasible, ships will avoid conducting training in the vicinity of recently sighted right whales. Ships will maneuver to maintain at least 457 m (500 yd) separation from any observed whale, consistent with the safety of the ship. Further, the U.S. Navy has established protocols that would make personnel aboard their ships aware of the distribution of North Atlantic right whales, to increase their probability of detecting right whales (for example, by requiring at least two watchstanders on ships transiting within 56 km of the mid-Atlantic coast), and operating at slow, safe speeds.

Because of these measures, foraging right whales are not likely to be exposed to mid-frequency active sonar at received levels greater than about 170 dB (based on estimates of propagation distances and assuming that a vessel near the boundary of this buffer zone would be transmitting active sonar). Although North Atlantic right whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, the limited evidence available suggests that sounds in this frequency range appear to lie at the periphery of their hearing range and they do not appear likely to respond physiologically or behaviorally to sounds in this frequency range. As a result, the mid-frequency sound sources associated with the Navy's active sonar training activities along the Atlantic Coast should not reduce the value of this habitat for North Atlantic right whales.

Sei Whales

Based on the U.S. Navy's exposure models, each year we would expect 1,163 instances annually (2,326 instances during the proposed LOA period) in which sei whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like North Atlantic right whales, sei whales are not likely to be exposed to active sonar associated with surface ship mine warfare exercises, RONEX, or Gulf of Mexico exercises, which only occur in the Gulf of Mexico (Table 8).

Sperm Whales

Based on the U.S. Navy's exposure models, each year we would expect 10,734 instances annually (21,468 instances during the proposed LOA period) in which sperm whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like humpback whales, some of these exposure events are likely to occur in all Operating Area along the Atlantic coast of the United States and in the Gulf of Mexico, which means they are likely to result from exposure to any of the active sonar training activities the U.S. Navy proposed to conduct in the Action Area (Table 8).

Table 8. Training scenarios and the number of activities associated with those scenarios, by operating area.

Training Scenario	**Operating Area**					
	Northeast	**Virginia Capes**	**Cherry Point**	**Jacksonville – Charleston**	**Gulf of Mexico**	**Totals**
Independent Unit-Level Training						
Surface Ship Anti-submarine Warfare	-	69	91	292	5	457
Surface Ship Object Detection/Navigational Sonar	-	68	-	40	-	108
Helicopter Anti-submarine Warfare	-	25	25	115	-	165
Submarine Anti-submarine Warfare	30	10	14	45	1	100
Submarine Object Detection/Navigational Sonar	165	78	-	57	-	300
Maritime Patrol Aircraft Anti-submarine Warfare (tonal sonobuoy)	238	79	111	356	7	791
Maritime Patrol Aircraft Anti-submarine Warfare (explosive source sonobuoy)	34	34	34	34	34	170
Surface Ship Mine Warfare Exercise	-	-	-	-	266	266
Coordinated Unit-Level Training						
SEASWITI	-	-	-	4	-	4
IAC	-	0.2	1.4	2.4	1	5
Group Sail	-	3	4	13	-	20
SCC Operations	0.4	-	-	1.6	-	2
RONEX and GOMEX Exercises	-	-	-	-	8	8
Strike Group Training						
ESG and CSG Composite Training Unit Exercise	-	0.2	1.4	2.4	1	5
Joint Task Force Exercise	-	0.2	0.6	1.2	0	2
Maintenance						
Surface Ship Sonar Maintenance	-	61	82	263	4	410
Submarine Sonar Maintenance	30	10	14	45	1	100
Event Totals	**497.4**	**437.6**	**378.4**	**1271.6**	**328**	**2913**

6.2.4 Exposure of Sea Turtles to Sonobuoys

Based on the Navy's exposure models, we were unable to quantify with any certainty, the number, if any, sea turtles that would likely be exposed to sound levels produced by sonobuoy deployment explosions sufficient to result a behavior modification, injury or death. Further, because of the relatively small number of sonobuoys that would be employed in each of the exercises, the relatively large geographic area involved, and the relatively low densities of sea turtles that are likely to occur in the Action Area, the likelihood of sea turtles being exposed to sonobuoy explosions is sufficiently small to be discountable.

When AN/SQS-62 DICASS sonobuoys impact the water surface after being deployed from aircraft, their parachute assemblies of sonobuoys deployed by aircraft are jettisoned and sink away from the sonobuoy, while a float containing an antenna is inflated. The parachutes are made of nylon and are about 8 feet in diameter. At maximum inflation, the canopies are between 0.15 to 0.35 square meters (1.6 to 3.8 square feet). The shroud lines range from 0.30 to 0.53 meters (12 to 21 inches) in length and are made of either cotton polyester with a 13.6 kilogram (30 pound) breaking strength or nylon with a 45.4 kilogram (100 pound) breaking strength. All parachutes are weighted with a 0.06 kilogram (2 ounce) steel material weight, which would cause the parachute to sink from the surface within about 15 minutes, although actual sinking rates depend on ocean conditions and the shape of the parachute.

The subsurface assembly descends to a selected depth, and the sonobuoy case falls away and sea anchors deploy to stabilize the hydrophone (underwater microphone). The operating life of the seawater battery is eight hours, after which the sonobuoy scuttles itself and sinks to the ocean bottom. For the sonobuoys, concentrations of metals released from batteries were calculated to be 0.0011 mg/L lead, 0.000015mg/L copper, and 0.0000001mg/L silver.

Sea turtles that occur along the Atlantic Coast of the U.S. and in the Gulf of Mexico might encounter one or more of the parachutes after they have been jettisoned from these sonobuoys and could become entangled as a result. Whales also might encounter one or more of these parachutes and become entangled as it sinks to the bottom or once it is on the seafloor. We cannot, however, determine whether such interactions are probable, given the relatively small number of sonobuoys that would be employed in each of the exercises, the relatively large geographic area involved, and the relatively low densities of sea turtles and whales that are likely to occur in the Action Area.

6.3 Response Analyses

As discussed in the *Approach to the Assessment* section of this biological opinion, response analyses determine how listed resources are likely to respond after being exposed to an Action's effects on the environment or directly on listed species themselves. For the purposes of consultations on activities involving active sonar, our assessments try to detect the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Our response analyses considered and weighed evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

It is important to acknowledge that there is limited empirical evidence on how endangered or threatened marine animals respond upon being exposed to active sonar and sound pressure waves associated with underwater detonations in natural settings. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to active sonar, sound pressure waves associated with underwater detonations, or other acoustic stimuli. Based on those data, we identify the probable responses of endangered and threatened marine animals to mid-frequency active sonar transmissions.

6.3.1 Potential Responses of Listed Species to Vessel Traffic

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson. 1994; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

As we discussed previously, based on the suite of studies of cetacean behavior to vessel approaches (Au and Perryman 1982; Bain et al. 2006; Bauer and Herman 1986; Bejder et al. 1999; Bejder et al. 2006a; Bejder et al. 2006b; Bryant et al. 1984; Corkeron 1995; Erbe and Farmer 2000; Felix 2001; Goodwin and Cotton 2004; Hewitt 1985; Lemon et al. 2008; Lemon et al. 2006; Lusseau 2000; Lusseau 2003; Lusseau 2004; Lusseau 2006; Lusseau and Bejder. 2007; Magalhaes et al. 2002; Ng and Leung 2003; Nowacek et al. 2001; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams and Ashe 2007; Williams and Ashe. 2006a; Williams and Ashe. 2006b; Wursig et al. 1998), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *Number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal’s assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal’s flight initiation distance).

   Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably shared sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior[7]. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with

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[7] As discussed in the Approach to the Assessment section of this Opinion, we distinguish between “avoidance,” “evasion,” and “escape” using the distinctions proposed by Weihs and Webb Weihs, D., and P. W. Webb. 1984. Optimal avoidance and evasion tactics in predator-prey interactions. Journal of Theoretical Biology 106(2):189-206.: “avoidance” is a shift in position by prey before a potential predator begins an attack; “evasion” is a response by potential prey to an perceived attack from a potential predator; and “escape” is the most acute form of evasive behavior.

vertical avoidance behavior (Bryant et al. 1984; David 2002; Kruse 1991; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren. 2007; Williams and Ashe 2007);

2. *the distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982; David 2002; Hewitt 1985; Kruse 1991);
3. *the vessel's speed and vector* (David 2002);
4. *the predictability of the vessel's path*. That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Acevedo 1991; Angradi et al. 1993; Browning and Harland. 1999; Lusseau 2003; Lusseau 2006; Williams and Ashe. 2006a; Williams et al. 2002) than when they engage in frequent course changes (Evans et al. 1994; Lusseau 2006; Williams et al. 2002);
6. *noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed (David 2002; Lusseau 2003; Lusseau 2006);
7. *the type of vessel* (displacement versus running on plane), which marine mammals may be interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004); and
8. *the behavioral state of the marine mammals* (David 2002; Lusseau 2003; Lusseau 2006; Wursig et al. 1998). For example, Würsig et al. (1998) concluded that whales were more likely to engage in avoidance responses when the whales were "milling" or "resting" than during other behavioral states.

Most of the investigations cited earlier reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lusseau 2003; Lusseau 2004; Lusseau 2005; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups moved closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Baker and Herman 1989; Edds and Macfarlane 1987; Evans et al. 1992; Lutkebohle 1997; Nowacek 1999). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991; Stewart et al. 1982). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Although most of these studies focused on small cetaceans (for example, bottlenose dolphins, spinner dolphins, spotted dolphins, harbor porpoises, beluga whales, and killer whales), studies of large whales have reported similar results for fin and sperm whales (David 2002; Notarbartolo Di Sciara et al. 2002). Baker et al. (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km. Richardson et al. (1995) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distance of about 1 km (Edds and Macfarlane 1987).

Some cetaceans detect the approach of vessels at substantial distances. Finley et al. (1990) reported that beluga whales seemed aware of approaching vessels at distances of 85 km and began to avoid the approach at distances of 45-60 km. Au and Perryman (1982) studied the behavioral responses of eight schools of spotted and spinner dolphins (*Stenella attenuata* and *S. longirostris*) to an approaching ship (the NOAA vessel *Surveyor*: 91.4 meters, steam-powered turbine, moving at speeds between 11 and 13 knots) in the eastern Pacific Ocean (10°15 N lat., 109°10 W long.). They monitored the response of the dolphin schools to the vessel from a Bell 204 helicopter flying a track line ahead of the ship at an altitude of 366 – 549 meters (they also monitored the effect of the helicopter on dolphin movements and concluded that it had no observable effect on the behavior of the dolphin schools). All of the schools continuously adjusted their direction of swimming by small increments to continuously increase the distance between the school and the ship over time. The animals in the eight schools began to flee from the ship at distances ranging from 0.9 to 6.9 nm. When the ship turned toward a school, the individuals in the school increased their swimming speeds (for example, from 2.8 to 8.4 knots) and engaged in sharp changes in direction.

Hewitt (1985) reported that five of 15 schools of dolphin responded to the approach of one of two ships used in his study and none of four schools of dolphin responded to the approach of the second ship (the first ship was the NOAA vessel *David Jordan Starr*; the second ship was the *Surveyor*). Spotted dolphin and spinner dolphins responded at distances between 0.5 to 2.5 nm and maintained distances of 0.5 to 2.0 nm from the ship while striped dolphins allows much closer approaches. Lemon et al. (2006) reported that bottlenose dolphin began to avoid approaching vessels at distances of about 100 m.

Würsig et al. (1998) studied the behavior of cetaceans in the northern Gulf of Mexico in response to survey vessels and aircraft. They reported that *Kogia* species and beaked whales (ziphiids) showed the strongest avoidance reactions to approaching ships (avoidance reactions in 11 of 13 approaches) while spinner dolphins, Atlantic spotted dolphins, bottlenose dolphins, false killer whales, and killer whales either did not respond or approached the ship (most commonly to ride the bow). Four of 15 sperm whales avoided the ship while the remainder appeared to ignore its approach.

Because of the number of vessels involved in U.S. Navy training exercises, their speed, their use of course changes as a tactical measure, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat Navy vessels as potential stressors. Further, without considering differences in sound fields associated with any active sonar that is used during these exercises, the available evidence suggests that major training exercises (for example, COMPTUEX, JTFEX exercises), unit- and intermediate-level exercises, and RDT&E activities would represent different stress regimes because of differences in the number of vessels involved, vessel maneuvers, and vessel speeds.

Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (see Blumstein 2003; Nonacs and Dill 1990):

a. Ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist;

b. alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately;

c. change their behavior proportional to increases in their perceived risk of predation which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity; or

d. take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

The latter two options are energetically costly and reduce benefits associated with the animal's current behavioral state. As a result, animals that detect a predator or predatory stimulus at a greater distance are more likely to flee at a greater distance (see Blumstein 2003; Holmes et al. 1993). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts such as causing marine mammals to avoid an area (Lusseau 2005; Salden 1988a) or alter a population's behavioral budget (Lusseau 2004) which could have biologically significant consequences on the energetic budget and reproductive output of individuals and their populations.

Of the endangered and threatened species that occur along the Atlantic coast of the U.S. and in the Gulf of Mexico, the endangered and threatened sea turtles are most likely to ignore U.S. Navy vessels entirely and continue behaving as if the vessels and any risks associated with those vessels did not exist. The data on blue, fin, humpback, right, sperm, and sei whales are too limited to assess their probable responses to approaching vessels and the few reports available (on fin whales) suggest they might engage in any one of these options.

6.3.2 Review of Literature on the Potential Responses of Listed Species to Active Sonar

As discussed in the *Approach to the Assessment* section of this Opinion, we conduct response analyses to determine whether and how listed species and designated critical habitat are likely to respond after being exposed to an Action's effects. For the purposes of consultations on activities that involve active sonar, our assessments try to estimate the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that are likely to directly or indirectly reduce the fitness of listed individuals.

Our response analyses consider and weigh all of the evidence available on the response of marine animals upon being exposed to active sonar and probable fitness consequences for the animals that exhibit particular responses or sequence of responses. It is important to acknowledge, however, that there is limited empirical evidence of how endangered or threatened marine animals respond upon being exposed to active sonar in natural settings. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to active sonar or other acoustic stimuli. Based on those data, we identify the probable responses of endangered and threatened marine animals to mid-frequency active sonar transmissions.

Figure 1 illustrates the conceptual model we use to assess the potential responses of marine animals when they are exposed to active sonar. The narratives that follow are generally organized around the items listed in the column titled “Proximate Responses by Category” in that Figure. These analyses examine the evidence available to determine if exposing endangered and threatened species to mid-frequency active sonar is likely to cause responses that might reduce the fitness of individuals that might be exposed.

In our analysis, we assume that endangered or threatened marine animals along the Atlantic coast of the U.S. and in the Gulf of Mexico would only be exposed to mid- or low-frequency active sonar. We make this assumption because the information that is available generally focuses on the physical, physiological, and behavioral responses of marine mammals to one or two stressors or environmental cues rather than the suite of anthropogenic and natural stressors that most free-ranging animals must contend with in their daily existence. In actuality, however, any individuals that occur in the area of a training event would be exposed to multiple potential stressors and would respond to a wide array of cues from their environment, including natural cues from their social group, predators, and other living organisms.

Injury

For the purposes of this assessment, “injuries” represents physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of those injuries to an animal (we distinguish between injuries that result from an acoustic exposure and injuries that result from an animal’s behavioral reaction to an acoustic exposure, which is discussed later in this section of the Opinion). Based on the literature available, mid-frequency active sonar might injure marine animals through two mechanisms (see “Box P” in Figure 1): acoustic resonance and noise-induced loss of hearing sensitivity (more commonly-called “threshold shift”).

Acoustic Resonance

Acoustic resonance results from hydraulic damage in tissues that are filled with gas or air that resonates when exposed to acoustic signals. Based on studies of lesions in beaked whales that stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, investigators have identified two physiological mechanisms that might explain some of those stranding events: tissue damage resulting from resonance effects (Cudahy and Ellison 2002; Ketten et al. 2004) and tissue damage resulting from “gas and fat embolic syndrome” (Fernández et al. 2005; Jepson et al. 2003; Jepson et al. 2005). Fat and gas embolisms are believed to occur when tissues are supersaturated with dissolved nitrogen gas and diffusion facilitated by bubble-growth is stimulated within those tissues (the bubble growth results in embolisms analogous to the “bends” in human divers).

Cudahy and Ellison (2002) analyzed the potential for resonance from low frequency sonar signals to cause injury and concluded that the expected threshold for *in vivo* (in the living body) tissue damage for underwater sound is on the order of 180 to 190 dB. There is limited direct empirical evidence (beyond Schlundt et al. 2000a) to support a conclusion that 180 dB is “safe” for marine mammals; however, evidence from marine mammal vocalizations suggests that 180 dB is not likely to physically injure marine mammals. For example, Frankel (1994) estimated the source level for singing humpback whales to be between 170 and 175 dB; McDonald et al. (2001) calculated the average source level for blue whale calls as 186 dB, Watkins et al. (1987) found source levels for fin whales up to 186 dB, and Møhl et al. (2000) recorded source levels for sperm whale clicks up to 223 dB_{rms}. Because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that these source levels are not likely to damage the tissues of the endangered and threatened species being considered in this consultation.

Crum and Mao (1994) hypothesized that received levels would have to exceed 190 dB in order for there to be the possibility of significant bubble growth due to super-saturation of gases in the blood. Jepson et al. (2003; Jepson et al. 2005) and Fernández et al. (2004; 2005) concluded that *in vivo* bubble formation, which may be exacerbated by deep, long-duration, repetitive dives may explain why beaked whales appear to be particularly vulnerable to sonar exposures.

Based on the information available, the endangered or threatened marine mammals and sea turtles that we are considering in this Opinion are not likely to experience acoustic resonance. All of the evidence available suggests that this phenomenon poses potential risks to smaller cetaceans like beaked whales rather than the larger cetaceans that have been listed as endangered. Thus far, this phenomenon has not been reported for or associated with sea turtles, perhaps because they do not engage in dive patterns that are similar to those of beaked whales.

Noise-Induced Loss of Hearing Sensitivity

Noise-induced loss of hearing sensitivity or “threshold shift” refers to an ear’s reduced sensitivity to sound following exposure to noise; when an ear’s sensitivity to sound has been reduced, sounds must be louder for an animal to detect and recognize them. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected. These losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting, instead, they affect the frequency ranges that are roughly equivalent to or slightly higher than the frequency range of the noise itself. Nevertheless, most investigators who study TTS in marine mammals report the frequency range of the “noise” at the source, which would change as the spectral qualities of a waveform change as it moves through water, rather than the frequency range at the animals that is receiving the signal. Without information on the frequencies of the sounds we consider in this Opinion at the point at which it is received by endangered and threatened marine mammals, we assume that the frequencies are roughly equivalent to the frequencies of the source.

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift, temporary threshold shift, and compound threshold shift (Ward et al. 1998; Yost 2007). When permanent loss of hearing sensitivity, or PTS, occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness, or an animal's hearing can be permanently impaired in specific frequency ranges, which can cause the animal to be less sensitive to sounds in that frequency range. Traditionally, investigations of temporary loss of hearing sensitivity, or TTS, have focused on sound receptors (hair cell damage) and have concluded that this form of threshold shift is temporary because hair cell damage does not accompany TTS and loss in hearing sensitivity are short-term and are followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks. More recently, however, Kujawa and Liberman (2009) reported on noise-induced degeneration of the cochlear nerve that is a delayed result of acoustic exposures that produce TTS, that occurs in the absence of hair cell damage, and that is irreversible. They concluded that the reversibility of noise-induced threshold shifts, or TTS, disguises progressive neuropathology that would have long-term consequences on an animal's ability to process acoustic information. If this phenomenon occurs in a wide range of species, TTS may have more permanent effects on an animal's hearing sensitivity than earlier studies would lead us to recognize.

Although the published body of science literature contains numerous theoretical studies and discussion papers on hearing impairments that can occur with exposure to a strong sound, only a few studies provide empirical information on noise-induced loss in hearing sensitivity in marine mammals. Most of the few studies available have reported the responses of captive animals exposed to sounds in controlled experiments. Schlundt et al. (2000a); see also (Finneran 2003; 2001) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at the Navy's spawar Systems Center with 1-second tones. Schlundt et al. (2000a), reported on eight individual TTS experiments that were conducted in San Diego Bay. Fatiguing stimuli durations were 1 second. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise.

Finneran et al. (2003; 2001) conducted TTS experiments using 1-second duration tones at 3 kHz. The test method was similar to that of Schlundt et al. except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 $\mu Pa^2/Hz$), and no masking noise was used. Two separate experiments were conducted. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa were randomly presented.

Richardson et al. (1995a) hypothesized that marine mammals within less than 100 meters of a sonar source might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 μPa which might cause TTS. There is no empirical evidence that exposure to active sonar transmissions with this kind of intensity can cause PTS in any marine mammals; instead the probability of PTS has been inferred from studies of TTS (see Richardson et al. 1995a).

Several variables affect the amount of loss in hearing sensitivity: the level, duration, spectral content, and temporal pattern of exposure to an acoustic stimulus as well as differences in the sensitivity of individuals and species. All of these factors combine to determine whether an individual organism is likely to experience a loss in hearing sensitivity as a result of acoustic exposure (Ward et al. 1998; Yost 2007). In free-ranging marine mammals, an animal's behavioral responses to a single acoustic exposure or a series of acoustic exposure events would also determine whether the animal is likely to experience losses in hearing sensitivity as a result of acoustic exposure.

Unlike humans whose occupations or living conditions exposure them to sources of potentially-harmful noise, in most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an animal out of a sound field entirely or reduce the intensity of an exposure would reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity.

More importantly, the data on captive animals and the limited information from free-ranging animals suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the longevity or reproductive success of animals that experience permanent, temporary or compound threshold shifts (Box P2 of Figure 1 illustrates the potential consequences of noise-induced loss in hearing sensitivity). Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues about their environment while their ears recover from the temporary loss of hearing sensitivity. Captive animals that have experienced temporary noise-induced reductions in hearing sensitivity have been reported to recover to within 1 standard deviation of their pre-exposure sensitivity in as little as 20 minutes and all of their pre-exposure sensitivity within 80 minutes (Mooney et al. 2009; Mooney et al. 2008), so marine mammals appear to recover from these losses fairly quickly. Although we could not locate information how animals that experience noise-induced hearing loss alter their behavior or the consequences of any altered behavior on the lifetime reproductive success of those individuals, the limited information available would not lead us to expect temporary losses in hearing sensitivity to incrementally reduce the lifetime reproductive success of animals.

Acoustic Masking

Marine mammals use acoustic signals for a variety of purposes that differ among species, but include communication between individuals, navigation, foraging, reproduction, and learning about their environment (Erbe and Farmer 2000; Tyack 2000). Masking, or auditory interference, generally occurs when sounds in the environment are louder than and of a similar frequency to, auditory signals an animal is trying to receive. Masking, therefore, is a phenomenon that affects animals that are trying to receive acoustic information about their environment, including sounds from other members of their species, predators, prey, and sounds that allow them to orient in their environment (the responses of animals sending acoustic signals are addressed in the next subsection). Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations (Box M of Figure 1 illustrates the potential consequences of acoustic masking).

Richardson et al. (1995a) argued that the maximum radius of influence of an industrial noise (including broadband low frequency sound transmission) on a marine mammal is the distance from the source to the point at which the noise can barely be heard. This range is determined by either the hearing sensitivity of the animal or the background noise level present. Industrial masking is most likely to affect some species' ability to detect communication calls and natural sounds (Richardson et al. 1995a).

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones. 1995). Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

The echolocation calls of toothed whales are subject to masking by high frequency sound. Human data indicate low frequency sound can mask high frequency sounds (i.e., upward masking). Studies on captive odontocetes by (Au 1993; Au et al. 1985; Au et al. 1974) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies these cetaceans use to echolocate, but not at the low-to-moderate frequencies they use for communication (Zaitseva et al. 1980).

Based on the evidence available, four of the endangered baleen whales that are considered in this Opinion — fin, blue, North Atlantic right, and sei whales — are not likely to experience acoustic masking because they are low-frequency hearing specialists who attend to environmental cues at frequencies that are much lower than mid-frequency active sonar. Similarly, the endangered and threatened sea turtles that are considered in this Opinion are low frequency hearing specialists and, as a result, are not likely to experience acoustic masking by mid-frequency active sonar.

Field investigations of humpback whale songs suggest that humpback whales have an upper frequency limit reaching as high as 24 kHz (Au et al. 2006). Based on this information, it is reasonable to assume that the active mid-frequency sonar the U.S. Navy would employ during the proposed active sonar training activities is within the hearing and vocalization range of humpback whales. As a result, we assume that some of the humpback whales that are exposed to mid-frequency active sonar during one or more of the proposed training exercises might experience acoustic masking as a result of their exposure.

Based on their hearing sensitivities, which overlap the frequency range of mid-frequency active sonar, the evidence available leads us to conclude that sonar transmissions might mask environmental cues at the lower range of sperm whale hearing. Although there is no published audiogram for sperm whales, these whales would be expected to have good, high frequency hearing because their inner ear resembles that of most dolphins, and appears tailored for ultrasonic (>20 kHz) reception (Ketten 1994). The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate, which suggest that neonatal sperm whales respond to sounds from 2.5 to 60 kHz, although the lower limit is an artifact of the testing methodology and not an accurate indicator of the likely low frequency hearing limit of this species.

Impaired Communication

Communication is an important component of the daily activity of animals and ultimately contributes to their survival and reproductive success. Animals communicate to find food (Elowson et al. 1991; Marler et al. 1986), acquire mates (Krakauer et al. 2009; Ryan 1985), assess other members of their species (Owings et al. 2002; Parker 1974), evade predators (Greig-Smith 1980), and defend resources (Zuberbuhler et al. 1997). Human activities that impair an animal's ability to communicate effectively might have significant effects on the animals experiencing the impairment.

Communication usually involves individual animals that are producing a vocalization or visual or chemical display for other individuals. Masking, which we have already discussed, affects animals that are trying to receive acoustic cues in their environment, including vocalizations from other members of the animals' species or social group. However, anthropogenic noise presents separate challenges for animals that are vocalizing. This subsection addresses the probable responses of individual animals whose attempts to vocalize or communicate are affected by active sonar.

When they vocalize, animals are aware of environmental conditions that affect the "active space" of their vocalizations, which is the maximum area within which their vocalizations can be detected before it drops to the level of ambient noise noise (Brumm 2004; Lohr et al. 2003). Animals are also aware of environment conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brumm 2004; Patricelli and Blickley 2006).

Most animals that vocalize have evolved with an ability to make vocal adjustments to their vocalizations to increase the signal-to-noise ratio, active space, and salience of their vocalizations in the face of temporary changes in background noise (Brumm 2004; Cody and Brown 1969; Patricelli and Blickley 2006). In some instances, the vocal adjustment may depend on when a competing signal occurs in a vocal sequence; for example, Egnor et al. (2006) reported that tamarin made different vocal adjustments depending on whether they were disturbed at the beginning of their calls, during the middle of their calls, or at the end of their call. Nevertheless, vocalizing animals have been reported to make one or more of the following adjustments to preserve the active space and salience of their vocalizations:

1. Adjust the frequency structure of vocalizations (Box C1.2 of Figure 1). Animals responding in this way adjust the frequency structure of their calls and songs by increasing the minimum frequency of their vocalizations while maximum frequencies remain the same. This reduces the frequency range of their vocalizations and reduces the amount of overlap between their vocalizations and background noise.

Slabbekorn and Ripmeister (2008), Slabbekorn and den Boer-Visser (2006), and Slabbekorn and Peet (2003b) studied patterns of song variation among individual great tits (*Parus major*) in an urban population in Leiden, The Netherlands, and among 20 different urban and forest populations across Europe and the United Kingdom. Adult males of this species that occupied territories with more background noise (primarily traffic noise) sang with higher minimum frequencies than males occupying non-urban or quieter sites. Peak or maximum frequencies of these songs did not shift in the face of high background noise or competing signals.

2. Adjust the amplitude of vocalizations (Box C1.1 of Figure 1). Animals responding in this way increase the amplitude or pitch of their calls and songs by placing more energy into the entire vocalization or, more commonly, shifting the energy into specific portions of the call or song.

This response is called the "Lombard reflex" or "Lombard effect" and represents a short-term adaptation to vocalizations in which a signaler increases the amplitude of its vocalizations in response to an increase in the amplitude of background noise (Lombard 1911). This phenomenon has been studied extensively in humans, who raise the amplitude of the voices while talking or singing in the face of high, background levels of sound (Lombard 1911).

Other species experience the same phenomenon when they vocalize in the presence of high levels of background sound. Brumm et al. (2004) studied the songs of territorial male nightingales (*Luscinia megarhynchos*) in the city of Berlin, Germany, to determine whether and to what degree background noise (from automobile traffic) produced a Lombard effect in these birds. Based on his studies, the birds increased the volume of their songs in response to traffic noise by 14 dB (their songs were more than 5 times louder than birds vocalizing in quiet sites). Cynx et al. (1998) reported similar results based on their study of zebra finches (*Taeniopygia guttata*) exposed to white noise.

Although this type of response also has not been studied extensively in marine animals, Scheifele et al. (2005) reported that beluga whales in the St. Lawrence River increased the decibel levels of their vocalizations from 80.46-86.76 dB in conditions without noise to 91.74-99.10 dB when confronted with vessel noise.

Holt et al. (2007) reported that endangered southern resident killer whales (*Orcinus orca*) in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise.

3. Adjust temporal structure of vocalizations (Box C1.2 of Figure 1). Animals responding this way adjust the temporal structure of their vocalizations by changing the timing of modulations, notes, and syllables within vocalizations or increasing the duration of their calls or songs.

Cody and Brown (1969) studied the songs of adult male Bewick wrens and wrentits that occupied overlapping territories and whose songs had similar physical characteristics (similar song lengths, frequency structure, and amplitude). They reported that wrentits adjusted the timing of their songs so they occurred when the songs of the Bewick wrens subsided.

Ficken et al. (1974) studied vocalizations of ten red-eyed vireos (*Vireo olivaceus*) and least flycatchers (*Empidonax minimus*) at Lake Itasca, Minnesota (a total of 2283 songs). They reported that flycatchers avoided acoustic interference from red-eyed vireos by inserting their shorter songs between the longer songs of the vireos. Although there is some mutual avoidance of acoustic interference, the flycatcher tends more strongly to insert its short songs in between the longer songs of the vireo rather than vice versa. Indeed, most of the overlap occurred when the flycatcher began singing just after the vireo had begun, suggesting that the flycatcher had not heard the vireo begin singing.

A few studies have demonstrated that marine mammals make the same kind of vocal adjustments in the face of high levels of background noise. Rendell and Gordon (1999) reported that long-finned pilot whales (*Globicephala melas*) in the Ligurian Sea made several vocal adjustments in call whistles when putatively exposed to active sonar transmissions at frequencies of 4-5 kHz (reference and received levels were not reported).

Miller et al. (2000) recorded the vocal behavior of singing humpback whales continuously for several hours using a towed, calibrated hydrophone array. They recorded at least two songs in which the whales were exposed to low-frequency active sonar transmissions (42 second signals at 6 minute intervals; sonar was broadcast so that none of the singing whales were exposed at received levels greater than 150 dB re 1µPa). They followed sixteen singing humpback whales during 18 playbacks. In nine follows, whales sang continuously throughout the playback; in four follows, the whale stopped singing when he joined other whales (a normal social interaction); and in five follows, the singer stopped singing, presumably in response to the playback. Of the six whales whose songs they analyzed in detail, songs were 29 percent longer, on average, during the playbacks. Song duration returned to normal after exposure, suggesting that the whale's response to the playback was temporary.

Fristrup et al. (2003) studied the length of 378 humpback whale songs recorded before, during, and after broadcasts from SURTASS LFA sonar in the 150-320 Hz frequency band at sound pressure levels between 140 and 205 dB re 1 µPa. Mean song lengths were 13.8 min (s.d. = 3.1, minimum = 5.4, median = 13.5, max = 33.3 minutes). Songs that overlapped with pings were longer than songs that did not overlap and whale songs were significantly longer when a ping occurred close to the end of a song. The largest increases in song length were observed in songs that were sung between 1 and 2 hours after the last ping.

Foote et al. (2004) compared recordings of endangered southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). They suggested that the amount of boat noise may have reached a threshold above which the killer whales need to increase the duration of their vocalization to avoid masking by the boat noise.

4. Adjust the temporal delivery of vocalizations (Boxes C1.3 – C1.5 of Figure 1). Animals responding in this way change when they vocalize or changing the rate at which they repeat calls or songs.

For example, tawny owls (*Strix aluco*) reduce the rate at which they call during rainy conditions (Lengagne and Slater 2002). Brenowitz (1982) concluded that red-winged blackbirds (*Agelaius phoeniceus*) had the largest active space, or broadcast area, for their calls at dawn because of relatively low turbulence and background noise when compared with other times of the day. Brown and Handford (2003) concluded that swamp and white-throated sparrows (*Melospiza georgiana* and *Zonotrichia albicollis*, respectively) tended to sing at dawn, as opposed to other times of the day, because they encountered the fewest impediments to acoustic transmissions during that time of the day. For example, Miksis-Olds (2006) surmised that Florida manatees (*Trichechus manatus latirostris*) in Sarasota Bay, Florida, appear to wait until the morning, when background noise levels associated with vessel traffic decline, before vocalizing when they are resting.

Many animals will combine several of these strategies to compensate for high levels of background noise. For example, Brumm et al. (2004) reported that common marmosets (*Callithrix jacchus*) increased the median amplitude of the twitter calls as well as the duration of the calls in response to increased background noise. King penguins (*Aptenodytes patagonicus*) increase the number of syllables in a call series and the rate at which they repeat their calls to compensate for high background noise from other penguins in a colony or high winds (Lengagne et al. 1999). California ground squirrels (*Spermophilus beecheyi*) shifted the frequencies of their alarm calls in the face of high ambient noise from highway traffic (Rabin et al. 2003). However, they only shifted the frequency of the second and third harmonic of these alarm calls, without changing the amount of energy in the first harmonic. By emphasizing the higher harmonics, the ground squirrels placed the peak energy of their alarm calls above the frequency range of the masking noise from the highway. Wood and Yezerinac (2006) reported that song sparrows (*Melospiza melodus*) increased the frequency of the lowest notes in their songs and reduced the amplitude of the low frequency range of their songs. Fernandez-Juricic et al. (2005) reported that house finches (*Carpodacus mexicanus*) adopted the same strategy to compensate for background noise.

Although this form of vocal adjustment has not been studied extensively in marine animals, Dahlheim (1987) studied the effects of man-made noise, including ship, outboard engine and oil-drilling sounds, on gray whale calling and surface behaviors in the San Ignacio Lagoon, Baja, California. She reported statistically significant increases in the calling rates of gray whales and changes in calling structure (as well as swimming direction and surface behaviors) after exposure to increased noise levels during playback experiments. Although whale responses varied with the type and presentation of the noise source, she reported that gray whales generally increased their calling rates, the level of calls received, the number of frequency-modulated calls, number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

Parks et al. (2007a) reported that surface active groups of North Atlantic right whales would adopt this strategy as the level of ambient noise increased. As ambient noise levels increased from low to high, the minimum frequency of right whale “scream calls” increased from 381.4 Hz (± 16.50), at low levels of ambient noise, to 390.3 Hz (± 15.14) at medium noise levels, to 422.4 Hz (± 15.55) at high noise levels. Surface active groups of North Atlantic right whales would also increase the duration and the inter-call interval of their vocalizations as the level of ambient noise increased. As noise levels increased from low to high, the duration of right whale “scream calls” would increase from 1.18 seconds (± 0.08) at low levels of ambient noise to 1.22 seconds (± 0.08) at high noise levels (durations decreased to 1.11 seconds ± 0.07 at medium noise levels). The inter-call intervals of these vocalizations would increase from 17.9 seconds (± 5.06) at low levels of ambient noise, to 18.5 seconds (± 4.55) at medium noise levels, to 28.1 seconds (± 4.63) at high noise levels.

Biassoni et al. (2001) studied the effects of exposing singing humpback whales to low-frequency active sonar in Hawai'i. They concluded that the average number of phrases did not differ with exposure; longer songs during exposure had more phrase repetitions and were, as a result, more redundant. Singers also switched from a frequency modulated to a rarer amplitude modulated phrase type overlapping sonar transmissions. Finding rapid and dynamic changes in humpback whale displays in response to LFA sonar suggests that singers have an ability to compensate for interference to anthropogenic sounds.

Potential Fitness Consequences of Vocal Adjustments

Although the fitness consequences of these vocal adjustments remain unknown, like most other trade-offs animals must make, some of these strategies probably come at a cost (Patricelli and Blickley 2006). For example, vocalizing more loudly in noisy environments may have energetic costs that decrease the net benefits of vocal adjustment and alter the bird’s energy budget (Brumm 2004; Wood and Yezerinac 2006). Lambrechts (1996) argued that shifting songs and calls to higher frequencies was also likely to incur energetic costs.

In addition, Patricelli and Blickley (2006) argued that females of many species use the songs and calls of males to determine whether a male is an appropriate potential mate (that is, they must recognize the singer as a member of their species); if males must adjust the frequency or temporal features of their vocalizations to avoid masking by noise, they may no longer be recognized by females of the same species (Brumm 2004; Slabbekoorn and Peet 2003a; Wood and Yezerinac 2006). Although this line of reasoning was developed for bird species, the same line of reasoning should apply to marine mammals, particularly for species like fin and sei whales whose song structures appear to be very similar.

If an animal fails to make vocal adjustments in presence of masking noise, that failure might cause the animal to experience reduced reproductive success or longevity because it fails to communicate effectively with other members of its species or social group, including potential mates.

Based on the evidence available, four of the endangered baleen whales that are considered in this Opinion — blue, fin, North Atlantic right, and sei whales — are not likely to experience impaired communication because they vocalize at frequencies that are much lower than mid-frequency active sonar. Because the endangered and threatened sea turtles that are considered in this Opinion do not appear to vocalize, they are not likely to experience impaired communication by mid-frequency active sonar.

Field investigations of humpback whale songs suggest that humpback whales have an upper frequency limit reaching as high as 24 kHz (Au et al. 2006). Based on this information, it is reasonable to assume that the active mid-frequency sonar the U.S. Navy would employ during training activities in the Action Area is within the vocalization range of humpback whales. As a result, we assume that some of the humpback whales that are exposed to mid-frequency active sonar during one or more of the proposed exercises might experience impaired communication as a result of that exposure. Because the dominant energy in humpback whale songs and calls are in frequency ranges that are substantially lower than that of mid-frequency active sonar, however, we believe humpback whales are likely to protect the saliency of their songs and calls without making the vocal adjustments that have been reported for North Atlantic right whales confronted with increases in continuous, low-frequency sound sources.

Based on their hearing sensitivities, which overlap the frequency range of mid-frequency active sonar, the evidence available leads us to conclude that sonar transmissions might mask environmental cues at the lower range of sperm whale hearing. Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, which overlaps with the mid-frequency sonar. Other studies indicate sperm whales' wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones. 1995; Weilgart and Whitehead. 1993). Ridgeway and Carder (2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.. As a result, we assume that some of the sperm whales that are exposed to mid-frequency active sonar during one or more of the proposed exercises might experience impaired communication as a result of that exposure. Because the dominant energy in sperm whale songs and calls overlaps with the frequency range of mid-frequency active sonar, sperm whales may have to make one or more of the vocal adjustments discussed in this subsection to preserve the saliency of their vocalizations. Because any reductions in the active space of sperm whales caused by active sonar transmissions associated with the proposed exercises would be temporary and episodic, any these vocal adjustments sperm whales would have to make would also be temporary.

Allostasis

Classic stress responses begin when an animal's central nervous system perceives a potential threat to its homeostasis. That perception triggers stress responses regardless of whether a stimulus actually threatens the animal; the mere perception of a threat is sufficient to trigger a stress response (Moberg 2000; Sapolsky 2006; Selye 1950). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune response.

In the case of many stressors, an animal's first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor (Box B1 of Figure 1). An animal's second line of defense to stressors involves the autonomic nervous system and the classical "fight or flight" response which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with "stress." These responses have a relatively short duration and may or may not have significant long-term effect on an animal's welfare.

An animal's third line of defense to stressors involves its neuroendocrine or sympathetic nervous systems; the system that has received the most study has been the hypothalmus-pituitary-adrenal system (also known as the hpa axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Moberg 2000), Box S1.1 of Figure 1) and altered metabolism (Elsasser et al. 2000), reduced immune competence (Blecha

2000) and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals have been equated with stress for many years (Romano et al. 2004).

The primary distinction between *stress* (which is adaptive and does not normally place an animal at risk) and *distress* is the biotic cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose a risk to the animal's welfare (the sequence of boxes beginning with Box S2 in Figure 1). However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions. This would likely impair those functions that experience the diversion. For example, when mounting a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. When mounting a stress response diverts energy from a fetus, an animal's reproductive success and its fitness will suffer. In these cases, the animals will have entered a pre-pathological or pathological state which is called "distress" (*sensu*)(Seyle 1950) or "allostatic loading" (McEwen and Wingfield 2003). This pathological state will last until the animal replenishes its biotic reserves sufficient to restore normal function (the sequence of boxes beginning with Box S2 in Figure 1 illustrate the potential consequences of these stress responses for the fitness of individual animals).

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses have also been documented fairly well through controlled experiment; because this physiology exists in every vertebrate that has been studied, it is not surprising that stress responses and their costs have been documented in both laboratory and free-living animals. Although no information has been collected on the physiological responses of marine mammals upon exposure to anthropogenic sounds, studies of other marine animals and terrestrial animals would lead us to expect some marine mammals to experience physiological stress responses and, perhaps, physiological responses that would be classified as "distress" upon exposure to mid-frequency and low-frequency sounds.

For example, Jansen (1998) reported on the relationship between acoustic exposures and physiological responses that are indicative of stress responses in humans (for example, elevated respiration and increased heart rates). Trimper (1998) reported on the physiological stress responses of osprey to low-level aircraft noise while Krausman et al. (2004) reported on the auditory and physiological stress responses of endangered Sonoran pronghorn to military overflights. Smith et al. (2004a; Smith et al. 2004b) identified noise-induced physiological stress responses in hearing-specialist fish that accompanied short- (TTS) and long-term (PTS) hearing losses. Welch and Welch (1970) reported physiological and behavioral stress responses that accompanied damage to the inner ears of fish and several mammals.

Hearing is one of the primary senses cetaceans use to gather information about their environment and to communicate with other members of their species. Although empirical information on the relationship between sensory impairment (TTS, PTS, and acoustic masking) on cetaceans remains limited, it seems reasonable to assume that reducing an animal's ability to gather information about its environment and to communicate with other members of its species would be stressful for animals that use hearing as their primary sensory mechanism. Therefore, we assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC 2003a). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses (Moberg 2000), we also assume that stress responses are likely to persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS.

Behavioral Responses

Marine animals have not had the time and have not experienced the selective pressure necessary for them to have evolved a behavioral repertoire containing a set of potential responses to active sonar, other potential stressors associated with naval military readiness activities, or human disturbance generally. Instead, marine animals invoke behavioral responses that are already in their behavioral repertoire to decide how they will behaviorally respond to active sonar, other potential stressors associated with naval military readiness activities, or human disturbance generally. An extensive number of studies have established that these animals will invoke the same behavioral responses they would invoke when faced with predation and will make the same ecological considerations when they experience human disturbance that they make when they perceive they have some risk of predation (Beale and Monaghan 2004a; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Gill and Sutherland 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). Specifically, when animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Bejder and Lusseau. 2008) Gill et al. 2001; Lima 1998;(Lima and Bednekoff 1999a). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999b).

The level of risk an animal perceives results from a combination of factors that include the perceived distance between an animal and a potential predator, whether the potential predator is approaching the animal or moving tangential to the animal, the number of times the potential predator changes its vector (or evidence that the potential predator might begin an approach), the speed of any approach, the availability of refugia, and the health or somatic condition of the animal, for example, along with factors related to natural predation risk (e.g., (Frid and Dill 2002; Papouchis et al. 2001). In response to a perceived threat, animals can experience physiological changes that prepare them for flight or fight responses or they can experience physiological changes with chronic exposure to stressors that have more serious consequences such as interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid and Dill 2002; Romero 2004; Sapolsky 2000; Walker et al. 2005)

The behavioral responses of animals to human disturbance have been documented to cause animals to abandon nesting and foraging sites (Bejder et al. 2009a; Gill et al. 2001; Sutherland and Crockford 1993), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan et al. 1996; Feare 1976; Giese 1996; Müllner et al. 2004), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002).

Based on the evidence available from empirical studies of animal responses to human disturbance, marine animals are likely to exhibit one of several behavioral responses upon being exposed to sonar transmissions: (1) they may engage in horizontal or vertical avoidance behavior to avoid exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening (Boxes BR1.1 and BR1.2 of Figure 1); (2) they may engage in evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology (Box BR1.3 of Figure 1); (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, during the time they are vigilant, they are not engaged in other behavior (Box BR1.4 of Figure 1); and (4) they may continue their pre-disturbance behavior and cope with the physiological consequences of continued exposure.

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

Behavioral Avoidance of Initial or Continued Exposure. As used in this Opinion, *behavioral avoidance* refers to animals that abandon an area in which active sonar is being used to avoid being exposed to the sonar (regardless of how long it takes them to return), animals that avoid being exposed to the entire sound field produced by active sonar; and animals that avoid being exposed to particular received levels within a sound field produced by active sonar.

Richardson et al. (1995a) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. There are few empirical studies of avoidance responses of free-living cetaceans to mid-frequency sonar. However, Maybaum (1993) conducted sound playback experiments to assess the effects of mid-frequency active sonar on humpback whales in Hawaiian waters. Specifically, he exposed focal pods to sounds of a 3.3-kHz sonar pulse, a sonar frequency sweep from 3.1 to 3.6 kHz, and a control (blank) tape while monitoring the behavior, movement, and underwater vocalizations. The two types of sonar signals differed in their effects on the humpback whales, although the whales exhibited avoidance behavior when exposed to both sounds. The whales responded to the pulse by increasing their distance from the sound source and responded to the frequency sweep by increasing their swimming speeds and track linearity. Bowles et al. (1994) reported that sperm whales appeared to have altered their distribution to avoid being exposed to the low-frequency transmissions associated with the Heard Island Feasibility Test and the whales returned when the transmissions stopped.

More recently, Kvadsheim et al. (2007) conducted a controlled exposure experiment in which killer whales (*Orcinus orca*) that had been fitted with D-tags were exposed to mid-frequency active sonar (Source A: a 1.0 s upsweep 209 dB @ 1 - 2 kHz every 10 seconds for 10 minutes; Source B: with a 1.0 s upsweep 197 dB @ 6 - 7 kHz every 10 s for 10 min). When exposed to Source A, a tagged whale and the group it was traveling with did not appear to avoid the source. When exposed to Source B, the tagged whales along with other whales that had been carousel feeding ceased feeding during the approach of the sonar and moved rapidly away from the source. When exposed to Source B, Kvadsheim and his co-workers reported that a tagged killer whale seemed to try to avoid further exposure to the sound field by immediately swimming away (horizontally) from the source of the sound; by engaging in a series of erratic and frequently deep dives that seem to take it below the sound field; or by swimming away while engaged in a series of erratic and frequently deep dives. Although the sample sizes in this study are too small to support statistical analysis, the behavioral responses of the orcas were consistent with the results of other studies.

In the Caribbean, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz. Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good sightability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997; 1998; 2000; 2001; 2003). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at times of airgun operation (Stone 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003). Baleen whales also altered course more often during periods of shooting and more were headed away from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003).

Sperm whales responded to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins et al. 1985). Brownell (2004) reported the behavioral responses of western gray whales off the northeast coast of Sakhalin Island to sounds produced by seismic activities in that region. In 1997, the gray whales responded to seismic activities by changing their swimming speed and orientation, respiration rates, and distribution in waters around the seismic surveys. In 2001, seismic activities were conducted in a known feeding area of these whales and the whales left the feeding area and moved to areas farther south in the Sea of Okhotsk. They only returned to the feeding area several days after the seismic activities stopped. The potential fitness consequences of displacing these whales, especially mother-calf pairs and “skinny whales,” outside of their the normal feeding area is not known; however, because gray whales, like other large whales, must gain enough energy during the summer foraging season to last them the entire year. Sounds or other stimuli that cause them to abandon a foraging area for several days seems almost certain to disrupt their energetics and force them to make trade-offs such as delaying their migration south, delaying reproduction, reducing growth, or migrating with reduced energy reserves.

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 second pulsed sounds at frequencies similar to those emitted by the multi-beam sonar that is used by geophysical surveys (Ridgway and Carder 1997; Schlundt et al. 2000b), and to shorter broadband pulsed signals (Finneran et al. 2000; Finneran et al. 2002b). Behavioral changes typically involved what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests(Schlundt et al. 2000a) (Finneran et al. 2002c). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of

178 to 193 dB re 1 μPa $_{\text{rms}}$ and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such responses to shorter pulses were higher (Finneran et al. 2000; Finneran et al. 2002b). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002b). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000a). It is not clear whether or to what degree the responses of captive animals might be representative of the responses of marine animals in the wild. For example, wild cetaceans sometimes avoid sound sources well before they are exposed to received levels such as those used in these experiments. Further, the responses of marine animals in the wild may be more subtle than those described by Ridgway and Carder (1997) and Schlundt et al. (2000a).

Richardson et al. (1995a) and Richardson and Wursig (1997) used controlled playback experiments to study the response of bowhead whales in Arctic Alaska. In their studies, bowhead whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB and seismic sources at estimated received levels of 110 to 132 dB. Richardson *et al.* (1995a) concluded that some marine mammals would tolerate continuous sound at received levels above 120 dB re 1 μPa for a few hours. These authors concluded that most marine mammals would avoid exposures to received levels of continuous underwater noise greater than 140 dB when source frequencies were in the animal's most sensitive hearing range.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson et al. 1995a). Malme et al. (Malme et al. 1983; 1984) studied the behavioral responses of gray whales (*Eschrictius robustus*) that were migrating along the California coast to various sound sources located in their migration corridor. The whales they studied showed statistically significant responses to four different underwater playbacks of continuous sound at received levels of approximately 120 dB. The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform.

Morton et al. (2002) exposed killer whales (*Orcinus orca*) to sounds produced by acoustic harassment devices (devices that were designed to harass harbor seals, source levels were 194 dB at 10 kHz re 1μPa at 1 meter). They concluded that observations of killer whales declined dramatically in the experimental area (Broughton Archipelago) during the time interval the harassment devices had been used (but not before or after the use). Other investigators have concluded that gray whales and humpback whales abandoned some of their coastal habitat in California and Hawai'i, respectively, because of underwater noise associated with extensive vessel traffic (Gard 1974; Reeves 1977; Salden 1988a).

Nowacek et al. (2004b)conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB spl, mildly to conspecific signals, and not at all to ship sounds or actual vessels. The alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface.

Several studies have demonstrated that cetaceans will avoid human activities such as vessel traffic, introduced sounds in the marine environment, or both. Lusseau (2003) reported that bottlenose dolphins in Doubtful Sound, New Zealand, avoided approaching tour boats by increasing their mean diving interval. Male dolphins began to avoid tour boats before the boats were in visible range, while female dolphins only began to avoid the boats when the boats became intrusive (he attributed the differential responses to differences in energetics: the larger body size of male dolphins would allow them to compensate for the energy costs of the avoidance behavior more than female dolphins). Bejder et al. (2006a) studied the effects of vessel traffic on bottlenose dolphins in Shark Bay, Australia, over three consecutive 4.5-year periods. They reported that the dolphins avoided the bay when two tour operators began to operate in the bay.

Marine mammals may avoid or abandon an area temporarily during periods of high traffic or noise, returning when the source of the disturbance declines below some threshold (Allen and Read. 2000; Lusseau 2004). Alternatively, they might abandon an area for as long as the disturbance persists. For example, Bryant et al. (1984 in Polefka 2004) reported that gray whales abandoned a calving lagoon in Baja California, Mexico following the initiation of dredging and increase in small vessel traffic. After the noise-producing activities stopped, the cow-calf pairs returned to the lagoon; the investigators did not report the consequences of that avoidance on the gray whales. Gard (1974) and Reeves (1977) reported that underwater noise associated with vessel traffic had caused gray whales to abandon some of their habitat in California for several years. Salden (1988b) suggested that humpback whales avoid some nearshore waters in Hawai'i for the same reason.

As Bejder et al. (2006a) argued, animals that are faced with human disturbance must evaluate the costs and benefits of relocating to alternative locations; those decisions would be influenced by the availability of alternative locations, the distance to the alternative locations, the quality of the resources at the alternative locations, the conditions of the animals faced with the decision, and their ability to cope with or "escape" the disturbance t(citing Beale and Monaghan 2004b; Frid and Dill. 2002; Gill and Sutherland 2001; Lima and Dill. 1990). Specifically, animals delay their decision to flee from predators and predatory stimuli that they detect, or until they decide that the benefits of fleeing a location are greater than the costs of remaining at the location or, conversely, until the costs of remaining at a location are greater than the benefits of fleeing (Ydenberg and Dills 1986). Ydenberg and Dill (1986) and Blumstein (2003) presented an economic model that recognized that animals will almost always choose to flee a site over some short distance to a predator; at a greater distance, animals will make an economic decision that weighs the costs and benefits of fleeing or remaining; and at an even greater distance, animals will almost always choose not to flee.

Based on a review of observation of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales were reported to ignore sounds that were of relatively low received levels, that had the most energy at frequencies below or above their hearing capacities, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds

From these observations, we would have to conclude that the distance between marine mammals and the source of sound, as well as the received level of the sound itself, will help determine whether individual animals are likely to respond to the sound and engage in avoidance behavior. At the limits of the range of audibility, endangered and threatened marine mammals are likely to ignore cues that they might otherwise detect. At some distance that is closer to the source, these species are likely to engage in low-level avoidance behavior (changing the direction or their movement to take them away from or tangential to the source of the disturbance) accompanied by vigilance behavior. At some distance that is closer still, these species are likely to engage in more active avoidance behavior followed by subsequent low-level avoidance behavior that does not bring them closer to the training activity.

At the closest distances, we assume that endangered and threatened marine mammals will engage in vertical and horizontal avoidance behavior unless they have a compelling reason to remain in a location (for example, to feed). In some circumstances, this will involve abrupt vertical or horizontal movement accompanied by physiological stress responses. Between the nearest and furthest distances, we assume that endangered or threatened marine mammals will base their behavioral decisions on the costs and benefits of remaining or fleeing when faced with acoustic and visual cues associated with U.S. Navy training and other military readiness activities.

The evidence available also suggests that marine mammals might experience more severe consequences if an acoustic cue associated with active sonar leads them to perceive they face an imminent threat, but circumstances do not allow them to avoid or "escape" further exposure. At least six circumstances might prevent an animal from escaping further exposure to mid-frequency active sonar and could produce any of one the following outcomes:

1. when swimming away (an attempted "escape") brings marine mammals into a shallow coastal feature that causes them to strand;
2. they cannot swim away because the exposure occurred in a coastal feature that leaves marine mammals no "escape" route (for example, a coastal embayment or fjord that surrounds them with land on three sides, with the sound field preventing an "escape");
3. they cannot swim away because the marine mammals are exposed to multiple sound fields in a coastal or oceanographic feature that act in concert to prevent their escape;
4. they cannot dive "below" the sound field while swimming away because of shallow depths;
5. to remain "below" the sound field, they must engage in a series of very deep dives with interrupted attempts to swim to the surface (which might lead to pathologies similar to those of decompression sickness);
6. any combination of these phenomena.

Although causal relationships between beaked whale stranding events and active sonar remain unknown, several authors have hypothesized that stranding events involving these species in the Bahamas and Canary Islands may have been triggered when the whales changed their dive behavior to avoid exposure to active sonar (Cox et al. 2006; Rommel et al. 2006). These authors proposed two mechanisms by which the behavioral responses of beaked whales upon being exposed to active sonar might result in a stranding event. First, beaked whales that occur in deep waters that are in close proximity to shallow waters (for example, the “canyon areas” that are cited in the Bahamas stranding event; see (D'Spain et al. 2006a), may respond to active sonar by swimming into shallow waters to avoid further exposures and strand if they were not able to swim back to deeper waters.

Second, beaked whales exposed to active sonar might alter their dive behavior (see Box B1.2.1 of Figure 1). Changes in their dive behavior might cause them to remain at the surface or at depth for extended periods of time which could lead to hypoxia directly by increasing their oxygen demands or indirectly by increasing their energy expenditures (to remain at depth) and increase their oxygen demands as a result. If beaked whales are at depth when they detect a ping from an active sonar transmission and change their dive profile leading to formation of significant gas bubbles, this could damage multiple organs or interfere with normal physiological function (Cox et al. 2006; Rommel et al. 2006; Zimmer and Tyack 2007).

Because many species of marine mammals make repetitive and prolonged dives to great depths, it has long been assumed that marine mammals have evolved physiological mechanisms to protect against the effects of rapid and repeated decompressions. Although several investigators have identified physiological adaptations that may protect marine mammals against nitrogen gas supersaturation (alveolar collapse and elective circulation) (Kooyman and Ponganis 1998; Ridgway and Howard. 1979), Ridgway and Howard (1979) reported that bottlenose dolphins (*Tursiops truncatus*) that were trained to dive repeatedly had muscle tissues that were substantially supersaturated with nitrogen gas. Houser et al. (2001) used these data to model the accumulation of nitrogen gas within the muscle tissue of other marine mammal species and concluded that cetaceans that dive deep and have slow ascent or descent speeds would have tissues that are more supersaturated with nitrogen gas than other marine mammals.

Based on these data, Cox et al. (2006) hypothesized that a critical dive sequence might make beaked whales more prone to stranding in response to acoustic exposures. The sequence began with (1) very deep (to depths as deep as 2 kilometers) and long (as long as 90 minutes) foraging dives with (2) relatively slow, controlled ascents, followed by (3) a series of “bounce” dives between 100 and 400 meters in depth (also see Zimmer and Tyack 2007). They concluded that acoustic exposures that disrupted any part of this dive sequence (for example, causing beaked whales to spend more time at surface without the bounce dives that are necessary to recover from the deep dive) could produce excessive levels of nitrogen super-saturation in their tissues, leading to gas bubble and emboli formation that produces pathologies similar to decompression sickness.

Potential Fitness Consequences of Behavioral Avoidance. As discussed in the introduction to this subsection of our response analyses, several authors have reported that disturbance stimuli cause animals to abandon nesting and foraging sites (Sutherland and Crockford 1993), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan et al.

1996; Feare 1976; Giese 1996; Müllner et al. 2004), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002). Each of these studies addressed the consequences that occur when animals shift from one behavioral state (for example, resting or foraging) to another behavioral state (avoidance or escape behavior) because of human disturbance or disturbance stimuli.

If marine mammals respond to Navy vessels that are transmitting active sonar in the same way that they might respond to a predator, their probability of flight responses should increase when they perceive that Navy vessels are approaching them directly, because a direct approach may convey detection and intent to capture (Burger and Gochfeld 1981; Burger and Gochfeld 1990; Cooper 1997; Cooper 1998). The probability of avoidance responses should also increase as received levels of active sonar increase (and the ship is, therefore, closer) and as ship speeds increase (that is, as approach speeds increase). For example, the probability of flight responses in Dall's sheep *Ovis dalli dalli* (Frid 2003; Frid and Heithaus 2010), ringed seals *Phoca hispida* (Born et al. 1999), Pacific brant (*Branta bernicl nigricans*) and Canada geese (*B. Canadensis*) increased as a helicopter or fixed-wing aircraft approached groups of these animals more directly (Ward et al. 1999). Bald eagles (*Haliaeetus leucocephalus*) perched on trees alongside a river were also more likely to flee from a paddle raft when their perches were closer to the river or were closer to the ground (Steidl and Anthony 1996).

One consequence of behavioral avoidance results from changing the energetics of marine mammals because of the energy required to avoid surface vessels or the sound field associated with active sonar (Frid and Dill 2002). Most animals can avoid that energetic cost by swimming away at slow speeds or those speeds that are at or near the minimum cost of transport (Miksis-Olds 2006), as has been demonstrated in Florida manatees (Hartman 1979; Miksis-Olds 2006).

Those costs increase when animals shift from a resting state, which is designed to conserve an animal's energy, to an active state that consumes energy the animal would have conserved it they had not been disturbed. In the case of humpback whales, lactating females with calves should spend more time in a resting state because of high energetic costs of lactating and their inability to compensate for those costs by feeding (humpback whales generally do not feed in their calving areas). Marine mammals that have been disturbed by anthropogenic noise and vessel approaches are commonly reported to shift from resting behavioral states to active behavioral states, which would imply that they incur an energy cost. Morete et al. (2007) reported that undisturbed humpback whale cows that were accompanied by their calves were frequently observed resting while their calves circled them (milling) and rolling interspersed with dives. When vessels approached, the amount of time cows and calves spent resting and milling, respectively declined significantly. These results are similar to those reported by Scheidat et al. (2004) for the humpback whales they observed off the coast of Ecuador.

Constantine and Brunton (2001) reported that bottlenose dolphins in the Bay of Islands, New Zealand only engaged in resting behavior 5 percent of the time when vessels were within 300 meters compared with 83 percent of the time when vessels were not present. Miksis-Olds (2006), and Miksis-Olds (2005) reported that Florida manatees in Sarasota Bay, Florida, reduced the amount of time they spent milling and increased the amount of time they spent feeding when background noise levels increased. Although the acute costs of these changes in behavior are not likely to exceed an animals' ability to compensate, the chronic costs of these behavioral shifts are uncertain

Based on the evidence available, we believe the endangered whales that are being considered in this Opinion are likely to avoid being exposed to the exercises or, if they are exposed, are likely to avoid continued exposure to the exercises. Fin, humpback, sei, blue, right, and sperm whales would probably be alerted to the start of an exercise by the low-frequency sounds produced by Navy surface vessels entering an area to begin an exercise. With the exception of right whales in calving areas off the southeast coast, the endangered whales seem likely to try to avoid an area in which surface vessels area moving at speed are accompanied by active sonar transmissions and low-frequency sounds produced by aircraft and helicopters, sonobuoys, and submarines.

Waters of the southeast coast of the United States are an important breeding and calving area for North Atlantic right whales, however. If individual right whales try to avoid exposure to mid-frequency active sonar rather than breeding, that avoidance response would disrupt an important event in the life history and ecology of those individuals. Adult right whales with calves do not seem likely to try to avoid further exposure because they are accompanied by calves. Their inability to avoid further exposure, however, seems likely to produce stress responses (see Box S of Figure 1).

Attentional Capture

Attention is the cognitive process of selectively concentrating on one aspect of an animal's environment while ignoring other things (Posner 1994). Because animals (including humans) have limited cognitive resources, there is a limit to how much sensory information they can process at any time. The phenomenon called "attentional capture" occurs when a stimulus (usually a stimulus that an animal is not concentrating on or attending to) "captures" an animal's attention. This shift in attention can occur consciously or unconsciously (for example, when an animal hears sounds that it associates with the approach of a predator) and the shift in attention can be sudden (Dukas 2002). Once a stimulus has captured an animal's attention, the animal can respond by ignoring the stimulus, assuming a "watch and wait" posture, or treat the stimulus as a disturbance and respond accordingly, which includes scanning for the source of the stimulus or "vigilance" (Cowlishaw et al. 2004).

Vigilance is normally an adaptive behavior that helps animals determine the presence or absence of predators, assess their distance from conspecifics, or to attend cues from prey (Bednekoff and Lima 2002). Despite those benefits, however, vigilance has a cost of time: when animals focus their attention on specific environmental cues, it is not attending to other activities such a foraging. These costs have been documented best in foraging animals, where vigilance has been shown to substantially reduce feeding rates (Beauchamp and Livoreil 1997; Fritz et al. 2002; Saino 1994).

Animals will spend more time being vigilant, which translates to less time foraging or resting, when disturbance stimuli approach them more directly, remain at closer distances, have a greater group size (for example, multiple surface vessels), or when they co-occur with times that an animal perceives increased risk (for example, when they are giving birth or accompanied by a calf). Most of the published literature, however, suggests that direct approaches will increase the amount of time animals will dedicate to being vigilant. For example, bighorn sheep and Dall's sheep dedicated more time being vigilant, and less time resting or foraging, when aircraft made direct approaches over them (Frid 2003; Stockwell et al. 1991).

Several authors have established that long-term and intense disturbance stimuli can cause population declines by reducing the body condition of individuals that have been disturbed, followed by reduced reproductive success, reduced survival, or both (Daan et al. 1996; Madsen 1985). For example, Madsen (1985) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46 percent reproductive success compared with geese in disturbed habitat (being consistently scared off the fields on which they were foraging) which did not gain mass and has a 17 percent reproductive success. Similar reductions in reproductive success have been reported for mule deer (*Odocoileus hemionus*) disturbed by all-terrain vehicles (Yarmoloy et al. 1988), caribou disturbed by seismic exploration blasts (Bradshaw et al. 1998), caribou disturbed by low-elevation military jet-fights (Luick et al. 1996), and caribou disturbed by low-elevation jet flights (Harrington and Veitch 1992). Similarly, a study of elk (*Cervus elaphus*) that were disturbed experimentally by pedestrians concluded that the ratio of young to mothers was inversely related to disturbance rate (Phillips and Alldredge 2000).

The primary mechanism by which increased vigilance and disturbance appear to affect the fitness of individual animals is by disrupting an animal's time budget and, as a result, reducing the time they might spend foraging and resting (which increases an animal's activity rate and energy demand). For example, a study of grizzly bears (*Ursus horribilis*) reported that bears disturbed by hikers reduced their energy intake by an average of 12 kcal/min (50.2 x 103kJ/min), and spent energy fleeing or acting aggressively toward hikers (White et al. 1999).

Nevertheless, other investigators concluded that when food handling does not require visual attention, a foraging animal can avoid the energetic costs and costs in time associated with vigilance (Bednekoff and Lima 2002; Cowlishaw et al. 2004; Lima and Bednekoff 1999a). In these cases, however, the foraging animals relied on one sensory modality (vision) to detect food and another sensory modality (hearing) to remain aware of the approximate location and proximity of potential predators. We assume that endangered or threatened marine animals that might be foraging along the Atlantic Coast of the U.S. and in the Gulf of Mexico would be able to remain aware of the number of surface vessels, proximity, speed, and approach vector through acoustic cues while foraging when they are not proximate to the ships (at distances that would normally cause them to avoid rather than evade the ships). At distances that might elicit evasive or escape behavior, however, we assume that endangered or threatened marine mammals would dedicate most or all of their attention on the vessels. Although we cannot discount interrupted foraging caused by vigilance behavior, marine mammals along the Atlantic Coast of the U.S. and in the Gulf of Mexico seem more likely to experience disrupted foraging during attempts to evade approaching surface vessels or received levels of active sonar than because of vigilance behavior.

Continued Pre-Disturbance Behavior, Habituation, or No Response

Under some circumstances, some individual animals that would be exposed to active sonar transmissions and other sounds associated with military readiness activities will continue the behavioral activities they were engaged in before they were exposed (Richardson et al. 1995a; Richardson et al. 1995b) (Box B2 of Figure 1). For example, Watkins (1986) reviewed data on the behavioral reactions of fin, humpback, right and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay is informative. He concluded that underwater sound was the primary cause of behavioral reactions in these species of whales and that the whales responded behaviorally to acoustic stimuli within their respective hearing ranges. Watkins also noted that whales showed the strongest behavioral reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds.

Nevertheless, Watkins concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale’s range of hearing. Further, he noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of his period of study, Watkins (1986) concluded that fin and humpback whales had generally habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

Aicken et al. (2005) monitored the behavioral responses of marine mammals to a new low-frequency active sonar system that was being developed for use by the British Navy. During those trials, fin whales, sperm whales, Sowerby’s beaked whales, long-finned pilot whales (*Globicephala melas*), Atlantic white-sided dolphins, and common bottlenose dolphins were observed and their vocalizations were recorded. These monitoring studies detected no evidence of behavioral responses that the investigators could attribute to exposure to the low-frequency active sonar during these trials (some of the responses the investigators observed may have been to the vessels used for the monitoring).

There are several reasons why such animals might continue their pre-exposure activity:

1. *Risk Allocation*. When animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Bejder and Lusseau. 2008; Gill et al. 2001; Lima 1998; Lima and Bednekoff 1999b; Ydenberg and Dills 1986). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999b). As a result, animals that decide that the ecological cost of changing their behavior exceeds the benefits of continuing their behavior, we would expect them to continue their pre-existing behavior. For example, baleen whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, are more likely to continue foraging in the face of disturbance. Similarly, a cow accompanied by her calf is less likely to flee or abandon an area at the cost of her calf’s survival.

This does not mean, however, that there are no costs involved with continuing pre-disturbance behavior in the face of predation or disturbance. We assume that individual animals that are exposed to sounds associated with military readiness activities will apply the economic model we discussed earlier (Ydenberg and Dills 1986). By extension, we assume that animals that choose to continue their pre-disturbance behavior would have to cope with the costs of doing so, which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill. 2002).

2. *Habituation*. When free-ranging animals do not appear to respond when presented with a stimulus, they are commonly said to have become habituated to the stimulus (Bejder and Lusseau. 2008; Rodriguez-Prieto et al. 2009), and the example cited earlier from Watkins 1986). Habituation has been given several definitions, but we apply the definition developed by Thompson and Spencer (1966) and Groves and Thompson (1970), which are considered classic treatments of the subject, as modified by Rankin et al. (2009): *an incremental reduction in an animal's behavioral response to a stimulus that results from repeated stimulation to that stimulus and that does not involve sensory adaptation, sensory fatigue, or motor fatigue*. The value of this definition, when compared with other definitions (for example, Bejder et al. 2009b citing Thorpe 1963), is that it would lead us to establish that an animal did not experience reduced sensory sensitivity to a stimulus (which would be accompanied by threshold shifts, for example) before we would conclude that the animal had become habituated to the stimulus. Habituation has been traditionally distinguished from sensory adaptation or motor fatigue using dishabituation (presentation of a different stimulus that results in an increase of the decremented response to the original stimulus), by demonstrating stimulus specificity (the response still occurs to other stimuli), or by demonstrating frequency dependent spontaneous recovery (more rapid recovery following stimulation delivered at a high-frequency than following stimulation delivered at a low frequency).

Animals are more likely to habituate (and habituate more rapidly) to a stimulus, the less intense the stimulus (Rankin et al. 2009). Conversely, numerous studies suggest that animals are less likely to habituate (that is, exhibit no significant decline in their responses) as the intensity of the stimulus increases (Rankin et al. 2009). Further, after animals have become habituated to a stimulus, their responses to that stimulus recover (a process that is called "spontaneous recovery") over time, although habituation becomes more rapid and pronounced after a series of habituation-recovery events (a process that is called "potentiation of habituation").

3. *Reduced Sensitivity*. The individuals that might be exposed may have lowered sensitivity to the stimulus. This might occur because the animals are naïve to the potential risks associated with military readiness activities (which would be more common among juveniles than adults) or they have limited sensory sensitivity by physiological constitution or constitutional endowment.

The results reported by Watkins (1986) and Aicken et al. (2005) could be explained either by concluding that the marine mammals had habituated to the sounds or they could be explained by concluding that the animals had made a decision to continue their pre-disturbance behavior despite the potential risks represented by the sounds (that is, the animals tolerated the disturbance). The results reported by Watkins (1986) are better explained using risk allocation than habituation because he associated the strongest, negative reactions (avoidance, interruptions in vocalizations, etc.) with sounds that were either unexpected, too loud, suddenly louder or different, were perceived as being associated with a potential threat (such as an approaching ship on a collision course), or were from distant human activities despite having considerable energy at frequencies well within the whale's range of hearing (whales would be less likely to respond to cues they would associate with a predator if their distance predator from the predator preserved their ability to escape a potential attack).

Because it would be difficult to distinguish between animals that continue their pre-disturbance behavior when exposed to active sonar because of a risk-decision and animals that habituate to disturbance (that is, they may have experienced low-level stress responses initially, but those responses abated over time), we do not assume that endangered or threatened marine mammals that do not appear to respond to active sonar or other sounds associated with military readiness activities have become habituated to those sounds. Without more evidence of actual habituation, such an assumption would lead us to fail to protect these species when protection was warranted.

6.3.3 Stranding Events

In what follows, we address the evidence bearing on assertions from several non-governmental organizations and scientific investigator that low-frequency active sonar causes marine mammals to "strand." Some authors seemed to have contradicted themselves by first publishing articles that initially identified low frequency active sonar as the "cause" of marine mammal stranding events in the Canary Islands and the Mediterranean Sea, and then later publishing articles that identify mid-frequency active sonar as the "cause" of those stranding events after the Bahamas stranding report became available. These causal claims are incoherent: the beaked whale stranding events had a causal association with either low frequency active sonar, mid-frequency active sonar, a combination of the two, or neither of the two. The earlier claims (for example, Frantzis 1998) asserting that low-frequency active sonar was causal are not compatible with the revised claims of a causal relationship between the stranding events and mid-frequency active sonar. As of the date of this Opinion, none of these authors have published retractions, corrections, or clarifications of their published arguments on whether they believe exposure to low-frequency active sonar, mid-frequency active sonar, or both, caused the stranding events or was a contributing cause of those events.

Despite the small number of instances in which marine mammal stranding events have been associated with mid-frequency active sonar usage and despite the fact that none of these stranding events involved endangered or threatened species, the amount of controversy that surrounds this issue requires us to address it. For these analyses, we defined a "stranded marine mammal" as "any dead marine mammal on a beach or floating nearshore; any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; any live pinniped which is unable or unwilling to leave the shore because of injury or poor health" (Gulland et al. 2001; Wilkinson and van Aarde 2001).

Marine mammals are known to strand for a variety of reasons, although the cause or causes of most stranding are unknown (Best 1982; Eaton 1979; Geraci et al. 1976; Odell et al. 1980). Klinowska (1985; 1986)correlated marine mammal stranding events and geomagnetism and geomagnetic disturbance. Numerous other studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. For example, several studies of stranded marine mammals suggest a linkage between unusual mortality events and body burdens of toxic chemicals in the stranded animals (Kajiwara et al. 2002; Kuehl and Haebler. 1995; Mignucci-Giannoni et al. 2000). These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Creel 2005; Fair and Becker. 2000; Moberg 2000; Romero 2004; Sih et al. 2004).

Those studies suggest that, in many animal species, disease, reproductive state, age, experience, stress loading, energy reserves, and genetics combine with other stressors like body burdens of toxic chemicals to create fitness consequences in individual animals that would not occur without these risk factors. The contribution of these potential risk factors to stranding events (or causal relationships between these risk factors and stranding events) is still unknown, but the extensive number of published reports in the literature suggests that an experiment investigation into a causal relationship is warranted.

Over the past three decades, several “mass stranding” events — stranding events that involve two or more individuals of the same species (excluding a single cow-calf pair) — that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduce sound into the marine environment.

Although only one of these events involved threatened or endangered species, we analyzed the information available on stranding events to determine if listed cetaceans are likely to strand following an exposure to mid-frequency active sonar. To conduct these analyses, we searched for and collected any reports of mass stranding events of marine mammals and identified any causal agents that were associated with those stranding events.

Global Stranding Patterns

Several sources have published lists of mass stranding events of cetaceans during attempts to identify relationships between those stranding events and military sonar (D'Amico et al. 2009; Hildebrand and Balcomb 2004; IWC 2005; Taylor et al. 2004). For example, based on a review of stranding records between 1960 and 1995, the International Whaling Commission (2005) identified ten mass stranding events of Cuvier’s beaked whales that had been reported and one mass stranding of four Baird’s beaked whale (*Berardius bairdii*). The IWC concluded that, out of eight stranding events reported from the mid-1980s to the summer of 2003, seven had been associated with the use of mid-frequency sonar, one of those seven had been associated with the use of low-frequency sonar, and the remaining stranding event had been associated with the use of seismic airguns.

Taxonomic Patterns

Most of the stranding events reviewed by the International Whaling Commission involved beaked whales. A mass stranding of Cuvier’s beaked whales (*Ziphius cavirostris*) in the eastern Mediterranean Sea occurred in 1996 (Frantzis 1998) and mass stranding events involving Gervais’ beaked whales (*Mesoplodon europaeus*), de Blainville’s dense-beaked whales (*M. densirostris*), and Cuvier’s beaked whales occurred off the coast of the Canary Islands in the late 1980s (Simmonds and Lopez-Jurado. 1991). Other stranding events of beaked whales have also occurred in the Bahamas and Canary Islands (which included Gervais' beaked whales, *Mesoplodon europaeus*, de Blainville's dense-beaked whales, *M. densirostris*, and Cuvier's beaked whales; (Simmonds and Lopez-Jurado. 1991). The stranding events that occurred in the Canary Islands and Kyparissiakos Gulf in the late 1990s and the Bahamas in 2000 have been the most intensively-studied mass stranding events and have been associated with naval maneuvers that were using sonar. These investigations did not evaluate information associated with the stranding of Cuvier's beaked whales, *Ziphius cavirostris*, around Japan (IWC 2005).

Between 1960 and 2006, 48 (68 percent) involved beaked whales, 3 (4 percent) involved dolphins, and 14 (20 percent) involved whale species. Cuvier's beaked whales were involved in the greatest number of these events (48 or 68 percent), followed by sperm whales (7 or 10 percent), and Blainville and Gervais' beaked whales (4 each or 6 percent). Naval activities that might have involved active sonar are reported to have coincided with 9 (13 percent) or 10 (14 percent) of those stranding events. Between the mid-1980s and 2003 (the period reported by the International Whaling Commission), we identified reports of 44 mass cetacean stranding events of which at least 7 have been correlated with naval exercises that were using mid-frequency sonar.

Stranding events involving baleen whales (blue, bowhead, Bryde's, fin, gray, humpback, minke, right, and sei whales) and stranding events involving sperm whales have very different patterns than those of beaked whales and other smaller cetaceans. First, mass stranding events of baleen whales are very rare. Fourteen humpback whales stranded on the beaches of Cape Cod, Massachusetts between November 1987 and January 1988 (Geraci et al. 1989); however, that stranding event has been accepted as being caused by neurotoxins in the food of the whales. In 1993, three humpback whales stranded on the east coast of Sao Vincente Island in the Cape Verde Archipelago, but they were in an advanced state of decay when they stranded so their cause of death remains unknown (Reiner et al. 1996). Finally, two minke whales (*Balaenoptera acutirostra*) stranded during the mass stranding event in the Bahamas in 2000 (see further discussion of this stranding event below) this event is noteworthy because it the only mass stranding of baleen whales that has coincided with the Navy's use of mid-frequency active sonar and because there are so few mass stranding events involving baleen whales.

Sperm whales, however, commonly strand and commonly strand in groups. Our earliest record of a mass stranding of sperm whales is for six sperm whales that stranded in Belgium in 1403 or 1404 (De Smet 1997). Since then, we have identified 85 mass stranding events involving sperm whales have been reported. Of those 85 mass stranding events, 29 represent stranding events that occurred before 1958; 25 of those 29 (about 34 percent) stranding events occurred before 1945 (which would pre-date the use of this mid-frequency active sonar). Ten of these stranding events involved sperm whales and long-finned pilot whales (*Globicephala melas*). These mass stranding events have been reported in Australia, Europe, North America, Oceania, and South America.

Major Mass Stranding Events

In 1998, the North Atlantic Treaty Organization (NATO) Supreme Allied Commander, Atlantic Center Undersea Research Centre that conducted the sonar tests convened panels to review the data associated with the maneuvers in 1996 and beaked whale stranding events in the Mediterranean Sea. The report of these panels presented more detailed acoustic data than were available for beaked whales stranded in the Canary Islands (McMullen and

McCarthy 1998). The NATO sonar transmitted two simultaneous signals lasting four seconds and repeating once every minute.

The simultaneous signals were broadcast at source levels of just under 230 dB re 1 µPa at 1 m. One of the signals covered a frequency range from 450-700 Hz and the other one covered 2.8-3.3 kHz. The *Ziphius* stranding events in the Kyparissiakos Gulf occurred during the first two sonar runs on each day of 12 and 13 May 1996. The close timing between the onset of sonar transmissions and the first stranding events suggests closer synchrony between the onset of the transmissions and the stranding events than was presented in Frantzis (1998). However, the Bioacoustics Panel convened by NATO concluded that the evidence available did not allow them to accept or reject sonar exposures as a causal agent in these stranding events. Their official finding was “An acoustic link can neither be clearly established nor eliminated as a direct or indirect cause for the May 1996 strandings.”

Kyparissiakos Gulf, Greece (1996). Frantzis (1998) reported an ‘atypical’ mass stranding of 12 Cuvier’s beaked whales on the coast of Greece that was associated with acoustic trials by vessels from the NATO. He was the first to hypothesize that these stranding events were related to exposure to low-frequency military sonar. However, the sonar in question produced both low- and mid-frequency signals (600Hz, 228 dB spl re: 1µPa at 1m rms and 3kHz, 226 dB spl, D’Amico and Verboom, 1998). Frantzis’ hypothesis prompted an in-depth analysis of the acoustic activity during the naval exercises, the nature of the stranding events and the possibility that the acoustic source was related to the stranding events (D’Amico and Verboom 1998). Since full necropsies had not been conducted and no gross or histological abnormalities were noted, the cause of the stranding events could not be determined unequivocally (D’Amico and Verboom 1998). The analyses thus provided some support but no clear evidence for the hypothesized cause-and-effect relationship of sonar operations and stranding events.

Bahamas (2000). Concern about potential causal relationships between low-frequency sonar and marine mammal stranding resurfaced after a beaked whale stranding in the Bahamas in 2000. NMFS and the U.S. Navy (2001) ruled out natural sound sources as a possible cause of the stranding, which pointed to an anthropogenic source. In 2001, the *Joint Interim Report, Bahamas Marine Mammal Stranding Event of 14-16 March 2000* (USN 2001) exonerated the low-frequency sonar but concluded that “tactical mid-range frequency sonar onboard U.S. Navy ships that were in use during the sonar exercise in question were the most plausible source of this acoustic or impulse trauma.” The report also went on to conclude, “the cause of this stranding event was the confluence of Navy tactical mid-range frequency sonar and the contributory factors acting together.” The contributory factors identified included “a complex acoustic environment that included the presence of a strong surface duct, unusual underwater bathymetry, intensive use of multiple sonars over an extended period of time, a constricted channel with limited access, and the presence of beaked whales that appear to be sensitive to the frequencies produced by these sonars.”

Madeira, Spain (2000). The stranding in the Bahamas was soon followed by another atypical mass stranding of Cuvier’s beaked whales in the Madeira Islands. Between 10 and 14 May 2000, three Cuvier’s beaked whales stranded on two islands in the Madeira archipelago. NATO naval exercises involving multiple ships occurred concurrently with these stranding events, although NATO has thus far been unwilling to provide information on the sonar activity during their exercises. Only one of the stranded animals was marginally fresh enough for a full necropsy (24 hours post-stranding). The necropsy revealed evidence of haemorrhage and congestion in the right lung and both kidneys (Freitas 2004), as well as evidence of intracochlear and intracranial haemorrhage similar to that observed in the Bahamas beaked whales (D. Ketten, unpublished data).

Canary Islands (2002). In September 2002, a beaked whale stranding event occurred in the Canary Islands. On 24 September, 14 beaked whales (7 Cuvier's beaked whales, 3 Blainville's beaked whales, 1 Gervais' beaked whale, M. europeaus, and 3 unidentified beaked whales) stranded on the beaches of Fuerteventura and Lanzarote Islands, close to the site of an international naval exercise (called Neo-Tapon 2002) held that same day. The first animals are reported to have stranded about four hours after the onset of the use of mid-frequency sonar activity (3- 10 kHz, (D'Spain et al. 2006a; Jepson et al. 2003). Seven whales (1 female Blainville's beaked whale, 1 female Gervais' beaked whale and 5 male Cuvier's beaked whales) are known to have died that day (Fernández et al. 2005). The remaining seven live whales were returned to deeper waters. Over the next three days, three male and one female Cuvier's beaked whales were found dead and a carcass of an unidentified beaked whale was seen floating offshore.

A total of nine Cuvier's beaked whales, one Blainville's beaked whale and one Gervais' beaked whale were examined post mortem and studied histopathologically (one Cuvier's beaked whale carcass was lost to the tide). No inflammatory or neoplastic processes were noted grossly or histologically and no pathogens (e.g. protozoa, bacteria and viruses, including morbillivirus) were identified. Stomach contents were examined in seven animals and six of them had recently eaten, possibly indicating that the event(s) leading to their deaths had had a relatively sudden onset (Fernández et al. 2005). Macroscopic examination revealed that the whales had severe, diffuse congestion and hemorrhages, especially in the fat in the jaw, around the ears, in the brain (e.g. multifocal subarachnoid hemorrhages) and in the kidneys (Fernandez 2004; Fernández et al. 2004). Gas bubble-associated lesions were observed in the vessels and parenchyma (white matter) of the brain, lungs, subcapsular kidney veins and liver; fat emboli were observed in epidural veins, liver sinusoids, lymph nodes and lungs (Fernandez 2004; Fernández et al. 2004; Fernández et al. 2005; Jepson et al. 2003). After the event, researchers from the Canary Islands examined past stranding records and found reports of eight other stranding events of beaked whales in the Canaries since 1985, at least five of which coincided with naval activities offshore (Martin et al. 2004).

Gulf of California (2002). In September 2002, marine mammal researchers vacationing in the Gulf of California, Mexico discovered two recently deceased Cuvier's beaked whales on an uninhabited island. They were not equipped to conduct necropsies and in an attempt to contact local researchers, found that a research vessel had been conducting seismic surveys approximately 22km offshore at the time that the stranding events occurred (Taylor et al. 2004). The survey vessel was using three acoustic sources: (1) seismic air guns (5-500Hz, 259dB re: 1mPa Peak to Peak (p-p); Federal Register, 2003); (2) sub-bottom profiler (3.5 kHz, 200dB SPL; Federal Register, 2004); and (3) multi-beam sonar (15.5kHz, 237dB SPL; Federal Register, 2003). Whether or not this survey caused the beaked whales to strand has been a matter of debate because of the small number of animals involved and a lack of knowledge regarding the temporal and spatial correlation between the animals and the sound source. This stranding underlines the uncertainty regarding which sound sources or combinations of sound sources may cause beaked whales to strand. Although some of these stranding events have been reviewed in government reports or conference proceedings (e.g., Evans and Miller 2003), many questions remain. Specifically, the mechanisms by which beaked whales are affected by sound remain unknown. A better understanding of these mechanisms will facilitate management and mitigation of sound effects on beaked whales.

As a result, in April 2004, the United States' Marine Mammal Commission convened a workshop of thirty-one scientists from a diverse range of relevant disciplines (e.g. human diving physiology and medicine, marine mammal ecology, marine mammal anatomy and physiology, veterinary medicine and acoustics) to explore issues related to the vulnerability of beaked whales to anthropogenic sound. The purpose of the workshop was to (1) assess the current knowledge of beaked whale biology and ecology and recent beaked whale mass stranding events; (2) identify and characterize factors that may have caused the stranding events; (3) identify ways to more adequately investigate possible cause and effect relationships; and (4) review the efficacy of existing monitoring and mitigation methods. The following text arose out of the discussions at that workshop.

Hanalei Bay, Kaua'i, Hawai'i (2004). On 3 – 4 July 2004, between 150 and 200 melon-headed whales (*Peponocephala electra*) occupied the shallow waters of Hanalei Bay, Kaua'i, Hawai'i for over 28 hours. These whales, which are usually pelagic, milled in the shallow confined bay and were returned to deeper water with human assistance. The whales are reported to have entered the Bay in a single wave formation on July 3, 2004, and were observed moving back into shore from the mouth of the Bay shortly thereafter. On the next morning, the whales were herded out of the Bay with the help of members of the community, the Hanalei Canoe Club, local and Federal employees, and staff and volunteers with the Hawaiian Islands Stranding Response Group and were out of visual sight later that morning.

One whale, a calf, had been observed alive and alone in Hanalei Bay on the afternoon of 4 July 2004 and was found dead in the Bay the morning of 5 July 2004. A full necropsy performed on the calf could not determine the cause of its death, although the investigators concluded that maternal separation, poor nutritional condition, and dehydration were probably contributing factors in the animal's death.

Environmental factors, abiotic and biotic, were analyzed for any anomalous occurrences that would have contributed to the animals entering and remaining in Hanalei Bay. The bathymetry in the bay is similar to many other sites in the Hawaiian Island chain and dissimilar to that which has been associated with mass stranding events in other parts of the U.S. The weather conditions appeared to be normal for the time of year with no fronts or other significant features noted. There was no evidence for unusual distribution or occurrence of predator or prey species or unusual harmful algal blooms. Weather patterns and bathymetry that have been associated with mass stranding events elsewhere were not found to occur in this instance.

This stranding event was spatially and temporally correlated with 2004 Rim of the Pacific exercises. Official sonar training and tracking exercises in the Pacific Missile Range Facility warning area did not commence until about 0800 hrs (local time) on 3 July and were ruled out as a possible trigger for the initial movement into Hanalei Bay. However, the six naval surface vessels transiting to the operational area on 2 July had been intermittently transmitting active mid-frequency sonar [for ~9 hours total] as they approached from the south. After ruling out other phenomena that might have caused this stranding, NMFS concluded that the active sonar transmissions associated with the 2004 Rim of the Pacific exercise were a plausible contributing causal factor in what may have been a confluence of events. Other factors that may have contributed to the stranding event include the presence of nearby deep water, multiple vessels transiting in a directed manner while transmitting active sonar over a sustained period, the presence of surface sound ducting conditions, or intermittent and random human interactions while the animals were in the Bay.

Other Mass Stranding Events. Several unusual stranding events have also occurred in Chinese waters in 2004 during a period when large-scale naval exercises were taking place in nearby waters south of Taiwan (IWC 2005). Between 24 February and 10 March 2004, 9-10 short-finned pilot whales (*Globicephala macrorhynchus*), one ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), one striped dolphin (*Stenella coeruleoalba*), seven short-finned pilot whales, and one short-finned pilot whale were reported to have stranded. The stranding events were unusual (with respect to the species involved) compared to previous stranding records since 1994 for the region. Gross examination of the only available carcass, a ginkgo-toothed beaked whale, revealed many unusual injuries to structures that are associated with, or related to acoustics or diving. The injuries, the freshness of the carcass, its discovery location and the coincidence of the event with a military exercise suggest that this beaked whale died from acoustic or blast trauma that may have been caused by exposure to naval activities south of Taiwan. Taiwanese newspapers reported that live ammunition was used during these exercises. At the same time, natural phenomena that might cause whales to strand – such as earthquakes and underwater volcanoes – have not been ruled out in these cases.

Association between Mass Stranding Events and Exposure to Active Sonar

Several authors have noted similarities between some of these stranding incidents: they occurred in islands or archipelagoes with deep water nearby, several appeared to have been associated with acoustic waveguides like surface ducting, and the sound fields created by ships transmitting mid-frequency sonar (Cox et al. 2006; D'Spain et al. 2006a). Although Cuvier’s beaked whales have been the most common species involved in these stranding events (81 percent of the total number of stranded animals), other beaked whales (including *Mesoplodon europeaus, M. densirostris*, and *Hyperoodon ampullatus*) comprise 14 percent of the total. Other species (*Stenella coeruleoalba*, *Kogia breviceps* and *Balaenoptera acutorostrata*) have stranded, but in much lower numbers and less consistently than beaked whales.

Based on the evidence available, however, we cannot determine whether (a) *Ziphius cavirostris* is more prone to injury from high-intensity sound than other species, (b) their behavioral responses to sound makes them more likely to strand, or (c) they are more likely to be exposed to mid-frequency active sonar that other cetaceans (for reasons that remain unknown). Because the association between active sonar exposures and marine mammals mass stranding events is not consistent — some marine mammals strand without being exposed to sonar and some sonar transmissions are not associated with marine mammal stranding events despite their co-occurrence — other risk factors or a groupings of risk factors probably contribute to these stranding events.

Stranding Patterns Associated With Rim of the Pacific Exercises in Hawai'i. Nitta (1991) reported that between 1936 and 1988, 8 humpback whales, 1 fin whale, and 5 sperm whales stranded in the Hawaiian Archipelago. In a partial update of that earlier report, Maldini et al. (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002. Sperm whales represented 10 percent of that total. Until recently, however, there has been no correlation between the number of known stranding events and the Navy's anti-submarine training exercises in Hawai'i. The number of stranding events have increased over time, but the number of stranding events in the main Hawaiian Islands recorded between 1937 and 2002 is low compared with other geographic areas (although this may be an result of having large areas of coastline where no people or few people can report a stranding). Known stranding events also occurred in all months with no significant temporal trend (Maldini et al. 2005).

The Navy has conducted Rim of the Pacific exercises every second year since 1968 and anti-submarine warfare activities have occurred in each of the 19 exercises that have occurred thus far. This observation supports several different inferences. One line of reasoning is: if the mid-frequency sonar employed during those exercises killed or injured whales whenever the whales encountered the sonar, mass stranding events are likely to have occurred at least once or twice over the 38-year period since 1968. With one exception, there is little evidence of a pattern in the record of stranding events reported for the main Hawaiian Islands.

A second line of reasoning leads to a very different conclusion: the absence of reports of stranding events may result from the small number of people searching for stranded animals relative to the coastline of Hawai'i —although stranding events have been reported in the Hawaiian Islands since 1937, no toothed whales were reported until 1950 — or it may be because only a fraction of the whales that are killed or injured in Hawaiian waters strand (as opposed to sinking, being transported to the open ocean by the strong currents that flow across the northern shore of the islands, or being eaten by predators like sharks). Faerber and Baird (2007) presented evidence that supports this inference. They compared patterns of beaked whale stranding events in the Canary Islands and the main Hawaiian Islands (they compared water depths immediately adjacent to shore, accessibility of shorelines, and population densities relative to land area and amount of shoreline) and concluded that beaked whales were less likely to strand in the main Hawaiian Islands and were not likely to be detected if they did strand.

Finally, the apparent absence of stranding events coincident with the 38 years of antisubmarine warfare training exercises in waters off the main Hawaiian Islands could also suggest that mid-frequency sonar transmissions pose a hazard to cetaceans in some circumstances, but not others (for example, see the discussion under *Behavioral Avoidance*).

6.4 Probable Responses to Mid-Frequency Active Sonar

Based on the evidence available, the mid-frequency sonars associated with the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast of the U.S. and in the Gulf of Mexico from January 2012 through January 2014 are not likely to kill or injure threatened or endangered marine mammals. However, little is known about the effect of short-term disruptions of a marine mammal's normal behavior (Richardson et al. 1995a). Most of the evidence available suggests that most sources of disturbance do not directly kill or injure marine mammals. The evidence available also does not lead us to expect threatened or endangered cetaceans to strand or suffer resonance effects from the mid-frequency sonars associated with the anti-submarine warfare (ASW) exercises that the U.S. Navy plans to conduct along the Atlantic Coast of the U.S. and in the Gulf of Mexico.

Probable Response of Blue Whales

Based on the U.S. Navy's exposure models, each year we would expect 881 instances annually in which blue whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. All of these exposure events are likely to occur in the Northeast Operating Area, which means they are likely to result from exposure to active sonar associated with submarines and maritime patrol aircraft.

Blue whales are not likely to respond to high-frequency sound sources associated with the proposed training activities. Although blue whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, sounds in this frequency range lie at the periphery of their hearing range and they are less likely to devote attentional resources to stimuli in this frequency range. Blue whale vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Clark and Fristrup. 1997; Cummings and Thompson 1971; Edds 1982; McDonald et al. 2005; Rivers 1997; Thompson and Friedl 1982). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1994) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten (1994). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction. Blue whale moans within the frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). The whale produced a short, 390 Hz pulse during the moan. Based on this information blue whales exposed to received levels of active mid-frequency sonar are not likely to respond physiologically or behaviorally to sounds in this frequency range.

Probable Response of Fin Whales

Based on the U.S. Navy's exposure models, each year we would expect 970 instances annually in which fin whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like blue whales, all of these exposure events would occur in the Northeast Operating Area, which means they are likely to result from exposure to active sonar associated with submarines and maritime patrol aircraft involved in unit-level training activities, not major training exercises.

Fin whales are not likely to respond to high-frequency sound sources associated with the proposed training activities and the evidence available suggests they are not likely to respond to mid-frequency sound sources as well. As discussed in the *Status of the Species* section of this Opinion, fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Edds 1988; Thompson et al. 1992; Watkins et al. 1981; Watkins et al. 1987). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton. 1964). Estimated source levels are as high as 190 dB (McDonald et al. 2005; Patterson and Hamilton 1964; Thompson et al. 1992; Watkins et al. 1987). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 2005). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999). This information would lead us to conclude that fin whales exposed to these received levels of active mid-frequency sonar are not likely to respond if they are exposed to mid-frequency (1 kHz–10 kHz) sounds.

Probable Response of Humpback Whales

Based on the U.S. Navy's exposure models, each year we would expect 4,622 instances annually in which humpback whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Unlike blue and fin whales, some of these exposure events are likely to occur in all Operating Areas along the Atlantic coast of the United States and in the Gulf of Mexico, which means they are likely to result from exposure to any of the active sonar training activities the U.S. Navy proposed to conduct in the Action Area.

There is almost no empirical information available on how humpback whales respond to active sonar exposures. The 68 humpback whales that were observed during monitoring surveys associated with the March 2008 Undersea Warfare Exercises in the Hawaiian Islands reported that none of the marine animals observed from survey vessels or aircraft exhibited unusual behavior or changes in behavior during the surveys.

As discussed in the *Status of the Species* narrative for humpback whales, these whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Thompson et al. 1986; Winn et al. 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson et al. 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Silber 1986; Tyack and Whitehead. 1983).

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al. 1985; Sharpe and Dill. 1997). In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20Hz – 4 kHz with estimated source levels from 144 – 174 dB; these are mostly sung by males on the breeding (Richardson et al. 1995a; Winn et al. 1970);

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Richardson et al. 1995a; Tyack 1983); and

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated source levels in excess of 175 dB re 1 uPa-m (Richardson et al. 1995a; Thompson et al. 1986). Sounds often associated with possible aggressive behavior by males (Silber 1986; Tyack and Whitehead. 1983) are quite different from songs, extending from 50 Hz to 10 kHz (or higher),

> with most energy in components below 3 kHz. These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead. 1983).

More recently, Au et al. (2006) conducted field investigations of humpback whale songs which led these investigators to conclude that humpback whales have an upper frequency limit reaching as high as 24 kHz. Based on this information, it is reasonable to assume that the active mid-frequency sonar the U.S. Navy would employ during the active sonar training activities the U.S. Navy proposes to conduct in the Action Area are within the hearing and vocalization ranges of humpback whales. There is limited information on how humpback whales are likely to respond upon being exposed to mid-frequency active sonar (most of the information available addresses their probable responses to low-frequency active sonar or impulsive sound sources). Humpback whales responded to sonar in the 3.1–3.6 kHz by swimming away from the sound source or by increasing their velocity (Maybaum 1989a). The frequency or duration of their dives or the rate of underwater vocalizations, however, did not change.

Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme et al. 1985), and to calls of other humpback whales at received levels as low as 102 dB (Frankel et al. 1995). Malme et al. (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 μPa. Studies of reactions to airgun noises were inconclusive (Malme et al. 1985). Humpback whales on the breeding grounds did not stop singing in response to underwater explosions (Payne and Mcvay. 1971). Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150dB re 1 μPa/Hz at 350Hz (Lien et al. 1993; Todd et al. 1996). However, at least two individuals were probably killed by the high-intensity, impulsed blasts and had extensive mechanical injuries in their ears (Ketten et al. 1993; Todd et al. 1996). The explosions may also have increased the number of humpback whales entangled in fishing nets (Todd et al. 1996). Frankel and Clark (2000) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60 - 90 Hz sounds with a received level of up to 190 dB. Although these studies have demonstrated that humpback whales will exhibit short-term behavioral reactions to boat traffic and playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

Because the frequency range on which humpback whales are likely to focus attentional resources appears to overlap with the frequency range of mid-frequency active sonar, we assume that in 4,172 of the instances in which humpback whales are exposed to mid-frequency active sonar during one or more of the proposed exercises might cause these whales to experience acoustic masking, impairment of acoustic communication, behavioural disturbance, and physiological stress responses as a result of their exposure.

Probable Responses of North Atlantic Right Whales

Based on the U.S. Navy's exposure models, each year we would expect 733 instances annually in which North Atlantic right whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. All of these exposure events are likely to occur in Operating Areas located along the Atlantic Coast of the United States and are not likely to occur in the Gulf of Mexico. As a result, North Atlantic right whales are not likely to be exposed to active sonar associated with surface ship mine warfare exercises, ronex, or Gulf of Mexico exercises, which only occur in the Gulf of Mexico.

North Atlantic right whales are not likely to respond to high-frequency sound sources associated with the proposed training activities. However, the evidence is equivocal on whether North Atlantic right whales are likely to respond upon being exposed to mid-frequency active sonar or the nature of any responses they might exhibit if they respond at all. The information available on right whales vocalizations suggests that right whales produce moans less than 400 Hz in frequency (Spero 1981; Thompson et al. 1979), However, Nowacek et al. (2004a) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB spl, mildly to conspecific signals, and not at all to ship sounds or actual vessels. Although the alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface, Nowacek et al. (2004a) offer no information on whether the whales were probably responding to the low- or mid-frequency components of the signals.

Although North Atlantic right whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, the limited evidence available suggests that sounds in this frequency range appear to lie at the periphery of their hearing range. The tonal vocalizations right whales produce can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls (Parks and Clark 2007). Most of these sounds range in frequency from 0.02 to 15 kHz, with dominant frequency ranges from 0.02 to less than 2 kHz with some sounds having multiple harmonics (Parks and Tyack. 2005). Assuming that right whales will focus their attentional resources on the frequency ranges of their vocalizations, right whales seem less likely to devote attentional resources to stimuli in the frequency ranges of mid-frequency active sonar. As a result, they are not likely to respond physiologically or behaviorally to sounds in this frequency range.

Probable Responses of Sei Whales

Based on the U.S. Navy’s exposure models, each year we would expect 1,163 instances annually in which sei whales might be exposed to active sonar associated with AFAST training activities and be “taken” as a result of that exposure. Like North Atlantic right whales, sei whales are not likely to be exposed to active sonar associated with surface ship mine warfare exercises, ronex, or Gulf of Mexico exercises, which only occur in the Gulf of Mexico.

As discussed in the *Status of the Species* section of this opinion, we have no specific information on the sounds produced by sei whales or their sensitivity to sounds in their environment. Based on their anatomical and physiological similarities to both blue and fin whales, we assume that the hearing thresholds of sei whales will be similar as well and will be centered on low-frequencies in the 10-200 Hz. This information would lead us to conclude that, like blue and fin whales, sei whales exposed to these received levels of active mid-frequency sonar are not likely to respond if they are exposed to mid-frequency (1 kHz–10 kHz) sounds.

Probable Responses of Sperm Whales

Based on the U.S. Navy's exposure models, each year we would expect 10,734 instances annually in which sperm whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like humpback whales, some of these exposure events are likely to occur in all Operating Areas along the Atlantic coast of the United States and in the Gulf of Mexico, which means they are likely to result from exposure to any of the active sonar training activities the U.S. Navy proposed to conduct in the Action Area.

Based on their hearing sensitivities, which overlap the frequency range of mid-frequency active sonar, sonar transmissions might mask environmental cues at the lower range of sperm whale hearing. Although there is no published audiogram for sperm whales, sperm whales would be expected to have good, high frequency hearing because their inner ear resembles that of most dolphins, and appears tailored for ultrasonic (>20 kHz) reception (Ketten 1994). The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate, which suggest that neonatal sperm whales respond to sounds from 2.5 to 60 kHz.

Based on the frequencies of their vocalizations, which overlap the frequency range of mid-frequency active sonar, sonar transmissions might temporarily reduce the active space of sperm whale vocalizations. Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, which overlaps with the mid-frequency sonar. Other studies indicate sperm whales' wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). Ridgway and Carder (2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.

There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999; Watkins 1985; Watkins and Schevill 1975), pingers (Watkins and Schevill 1975), the Heard Island Feasibility Test (Bowles et al. 1994), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins and Schevill 1975; Weilgart and Whitehead 1993). Goold (Goold 1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also stopped vocalizing for brief periods when codas were being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones. 1995).

As discussed previously, sperm whales have been reported to have reacted to military sonar, apparently produced by a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent, and becoming difficult to approach (Watkins 1985). Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway et al. 1997; Schlundt et al. 2000a), and to shorter broadband pulsed signals (Finneran et al. 2002a; Finneran et al. 2000). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002a; Schlundt et al. 2000a). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa $_{rms}$ and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran et al. 2000; Finneran et al. 2002b). Test animals occasionally vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002c). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000a).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 μPa from impulsive sounds produced by 1 g tnt detonators (Madsen and Mohl 2000). Richardson et al. (1995a) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre et al. (1997) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 db re 1 μPa at the source), but not to the other sources played to them.

Published reports identify instances in which sperm whales may have responded to an acoustic source and other instances in which they did not appear to respond behaviorally when exposed to seismic surveys. Mate (1994) reported an opportunistic observation of the number of sperm whales to have decreased in an area after the start of airgun seismic testing. However, Davis et al. (2000) noted that sighting frequency did not differ significantly among the different acoustic levels examined in the northern Gulf of Mexico, contrary to what Mate et al. (1994) reported. In one dtag deployment in the northern Gulf of Mexico on July 28, 2001, researchers documented that the tagged whale moved away from an operating seismic vessel once the seismic pulses were received at the tag at roughly 137 dB re 1 μPa (Johnson and Miller 2002). Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles et al. 1994).

A recent study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall Howard 1999). Recent data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003). However, the compilation and analysis of the data led the author to conclude that seismic surveys did not result in observable effects to sperm whales (Stone 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

These studies suggest that the behavioral responses of sperm whales to anthropogenic sounds are highly variable, but do not appear to result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. Responses of sperm whales to anthropogenic sounds probably depend on the age and sex of animals being exposed, as well as other factors. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not.

Probable Response of Sea Turtles

The information on the hearing capabilities of sea turtles is also limited, but the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz) (Bartol et al. 1999; Lenhardt 1994; Lenhardt et al. 1983; Ridgway et al. 1969). Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999). These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

We assume that these sensitivities to sound apply to the hardshell turtles (i.e., the green, hawksbill, Kemp’s ridley, and loggerhead sea turtles). No audiometric data are available for leatherback sea turtles, but we assume that they have hearing ranges similar to those of other sea turtles (or at least, their hearing is more likely to be similar to other sea turtles than marine mammals). Based on this information sea turtles exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency sounds (sounds between 1 kHz and 10 kHz); therefore, they are not likely to respond physiologically or behaviorally to those received levels.

A recent study on the effects of airguns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds. McCauley et al. (2000) reported that green and loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km with received levels of 166 dB re 1 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa $_{\mathrm{rms}}$ the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. Because the sonar that would be used during the proposed exercises transmits at frequencies above hearing thresholds for sea turtles, sea turtles that are exposed to those transmissions are not likely to respond to that exposure. As a result, mid-frequency active sonar associated with the proposed exercises “may affect, but is not likely to adversely affect” green, hawksbill, leatherback, or loggerhead sea turtles.

6.5 Effects Resulting from Interactions of the Potential Stressors

Several organizations have argued that several of our previous biological opinions on the U.S. Navy’s use of active sonar failed to consider the “cumulative impact” (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them. In each instance, we have explained how biological opinions consider “cumulative impacts” (in the NEPA sense of the term; see Approach to the Assessment for a complete treatment of this issue). There is a nuance to the idea of “cumulative impacts,” however, that we have chosen to address separately and explicitly in this Opinion: potential interactions between stressors associated with the Atlantic Fleet training exercises and other physical, chemical, and biotic stressors that pre-exist in the environment.

Exposing living organisms to individual stressors or a suite of stressors that are associated with a specific action may be insignificant or minor when considered in isolation, but may have significant adverse consequences when they are added to other stressors, operate synergistically in combination with other stressors, or magnify or multiply the effects of other stressors. Further, the effects of life events, natural phenomena, and anthropogenic phenomena on an individual's performance will depend on the individual's phenotypic state when the individual is exposed to these phenomena. Disease, dietary stress, body burden of toxic chemicals, energetic stress, percentage body fat, age, reproductive state, and social position, among many other phenomena can "accumulate" to have substantial influence on an organism's response to subsequent exposure to a stressor. That is, exposing animals to individual stressors associated with a specific action can interact with the animal's prior condition (can have "accumulate" and have additive, synergistic, magnifying, and multiplicative effect) and produce significant, adverse consequences that would not occur if the animal's prior condition had been different.

An illustrative example of how a combination of stressors interact was provided by Relyea (2000; 2009) who demonstrated that exposing several different amphibians to a combination of pesticides and chemical cues of natural predators, which induced stress, increased the mortality rates of the amphibians (see also Sih et al. 2004). For some species, exposing the amphibians to the combination of stressors produced mortality rates that were twice as high as the mortality rates associated with each individual stressor. This section considers the evidence available to determine if interactions associated with mid-frequency active sonar are likely to produce responses we have not considered already or if interactions are likely to increase the severity — and, therefore, the potential consequences — of the responses we have already considered.

The active sonar training activities the U.S. Navy proposes to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico over the next year would add several hundred hours of mid-frequency active sonar to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment in the Action Area and any endangered or threatened species that occur in that area. The behavioral responses of any endangered whales that occur in those sound fields are likely to result from their response to mid-frequency active sonar, per se, as well as other salient cues in their environment, including their perception of their distance from a sonar source and their perception of whether the source of those sounds is approaching them, moving parallel to them, or moving away from them. The behavioral response of endangered whales that are likely to be exposed to active sonar during the training exercises considered in this Opinion would also be shaped by their reproductive condition, their state of health, and their prior experience.

With the possible exception of hatchling sea turtles or new-born calves, the prior experience of any individual endangered whales or listed sea turtles that occur off the Atlantic coast of the United States and in the Gulf of Mexico would include regular exposure to a wide variety of natural and anthropogenic stressors produced by commercial fisheries in Federal and State waters, vessel traffic, whale-watch vessels and researchers, and human occupation of coastal areas. Whales that occur in the Action Area are almost certain to have been exposed to ship traffic entering and leaving ports like Boston, New York, Baltimore, Virginia Beach, and Jacksonville or Port Everglades and Fort Lauderdale. As we discussed in the *Environmental Baseline* section of this Opinion, these whales will also have been exposed to the continuous, low-frequency sounds produced by commercial vessels, may have interacted with commercial fishing gear, and may have prior experience with mid-frequency active sonar from surface vessels, sonobuoys, or submarines in other geographic areas or during previous exercises within the Action Area.

Any individual humpback or sperm whales that have high body burdens of some antibiotics and other prescription drugs (which are introduced to marine environments in sewage discharges and freshwater run-off), organic solvents, metals, and chemical asphyxiants may be more susceptible to noise-induced loss of hearing sensitivity (Fechter et al. 2000). Nevertheless, none of the information available suggests that the responses of whales to the cumulative effects of these stressors or their prior experience with these stressors is likely to produce consequences other than those we have already considered in this Opinion, although it is important to note that this statement probably results from the limits in the information available more than the absence of interactive effects.

Similarly, sea turtles that occur in the Action Area are almost certain to have been exposed to ship traffic entering and leaving ports like Boston, New York, Baltimore, Virginia Beach, and Jacksonville (if they arrive from the north) or Port Everglades and Fort Lauderdale (if they arrive from the south). As we discussed in the *Environmental Baseline* section of this Opinion, these sea turtles will also have been exposed to the continuous, low-frequency sounds produced by commercial vessels, are likely to have been captured at least once in commercial fishing gear (given that almost twice the estimated population of loggerhead sea turtles has been estimated to be captured in shrimp trawls each year for the past five years, every loggerhead sea turtle in the western Atlantic has had some probability of being captured in these fisheries), and may have prior experience with mid-frequency active sonar from surface vessels, sonobuoys, or submarines in other geographic areas or during previous exercises within the Action Area. Nevertheless, none of the information available suggests that the responses of sea turtles to these stressors or their prior experience with these stressors is likely to produce consequences other than those we have already considered in this Opinion, although it is important to note that this statement probably results from the limits in the information available more than the absence of interactive effects.

6.6 Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the esa.

During this consultation, NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area. Most of the action area includes federal military reserves or is outside of territorial waters of the United States of America, which would preclude the possibility of future state, tribal, or local action that would not require some form of federal funding or authorization. NMFS conducted electronic searches of business journals, trade journals, and newspapers using *First Search*, Google, and other electronic search engines. Those searches produced no evidence of future private action in the action area that would not require federal authorization or funding and is reasonably certain to occur. As a result, NMFS is not aware of any actions of this kind that are likely to occur in the action area during the foreseeable future.

6.7 Integration and Synthesis of Effects

In the *Assessment Approach* section of this Opinion, we stated that we measure risks to individuals of endangered or threatened species using changes in the individuals' "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed plants or animals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Anderson et al. 2000; Mills and Beatty 1979; Stearns 1977; Stearns 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

The following discussions summarize the probable risks future active sonar training exercises along the Atlantic coast of the United States and in the Gulf of Mexico pose to threatened and endangered species that are likely to be exposed to those transmissions. These summaries integrate the exposure profiles presented previously with the results of the response analyses that were also presented previously.

6.7.1 Blue Whales

Based on the U.S. Navy's exposure models, each year we would expect 881annual instances (1,762 during the two year LOA period) in which blue whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. All of these exposure events are likely to occur in the Northeast Operating Area, which means they are likely to result from exposure to active sonar associated with submarines and maritime patrol aircraft.

As discussed in the introduction to our *Exposure Analyses*, it is important to note that these estimates probably over-estimate the actual number of blue whales that might be exposed to one or more of the active sonar training activities the U.S. Navy plans to conduct in the Action Area. Most marine mammals would only be exposed periodically or episodically, if at all, to those activities and many exercises would occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations.

Blue whales are not likely to respond to high-frequency sound sources associated with the proposed training activities. Blue whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, however, sounds in this frequency range lie at the periphery of their hearing range and they are less likely to devote attentional resources to stimuli in this frequency range. Blue whale vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Clark and Fristrup. 1997; Cummings and Thompson 1971; Edds 1982; McDonald et al. 2005; Rivers 1997; Thompson and Friedl 1982). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten 1997). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction. Blue whale moans within the frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). The whale produced a short, 390 Hz pulse during the moan. Based on this information blue whales exposed to received levels of active mid-frequency sonar are not likely to respond physiologically or behaviorally to sounds in this frequency range.

Blue whales in the action area seem likely to respond to the ship traffic associated with each of the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico in ways that approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. Blue whales seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the information necessary to determine which of the many sounds associated with an exercise is likely to trigger avoidance behavior in blue whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether blue whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur. However, blue whales are not likely to respond to mid-frequency active sonar because they are not likely to hear those sonar transmissions.

Individual blue whales' may or may not respond to the vessels by changing their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005a; Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams and Ashe. 2006a). Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of individual exercises, the small number of large exercises, and the short duration of the unit- or intermediate-level training exercises, we do not expect these responses to reduce the fitness of the blue whales that occur along the Atlantic Coast and in the Gulf of Mexico.

Based on the evidence available, we conclude active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual blue whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 would not appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

6.7.2 Fin Whales

Based on the U.S. Navy’s exposure models, each year we would expect 970 instances annually (1,940 instances during the period the LOA is in effect) in which fin whales might be exposed to active sonar associated with AFAST training activities and be “taken” as a result of that exposure. Like blue whales, all of these exposure events are likely to occur in the Northeast Operating Area, which means they are likely to result from exposure to active sonar associated with submarines and maritime patrol aircraft.

As with blue whales, this estimate probably over-estimates the actual number of fin whales that might be exposed to active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico. Most marine mammals would only be exposed periodically or episodically, if at all, to the active sonar training activities the U.S. Navy plans to conduct in the Action Area and many exercises would occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations.

As discussed in the *Status of the Species* section of this opinion, fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Edds 1988; Thompson et al. 1992; Watkins 1981; Watkins et al. 1987). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton. 1964). Estimated source levels are as high as 190 dB (McDonald et al. 1995; Patterson and Hamilton. 1964; Thompson et al. 1992; Watkins et al. 1987). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 1995). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999). This information would lead us to conclude that fin whales exposed to these received levels of active mid-frequency sonar are not likely to respond physiologically or behaviorally.

Fin whales in the action area seem likely to respond to the ship traffic associated with active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico in ways that approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. Fin whales seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the information necessary to determine which of the many sounds associated with an exercise is likely to trigger avoidance behavior in fin whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether fin whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

Particular whales’ may or may not respond to the vessels by changing their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005a; Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams and Ashe. 2006a). Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the different exercises and the small number of times the exercises are likely to be repeated from January 2012 to January 2014, we do not expect these responses of fin whales to reduce the fitness of the fin whales that occur along the Atlantic Coast of the United States and in the Gulf of Mexico.

Based on the evidence available, we conclude that the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

6.7.3 Humpback Whales

Based on the U.S. Navy's exposure models, each year we would expect 4,622 instances annually (9,244 instances during the proposed LOA period) in which humpback whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Unlike blue and fin whales, some of these exposure events are likely to occur in all Operating Area along the Atlantic coast of the United States and in the Gulf of Mexico, which means they are likely to result from exposure to any of the active sonar training activities the U.S. Navy proposed to conduct in the Action Area.

Humpback whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Richardson et al. 1995a; Thompson et al. 1986; Winn et al. 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson et al. 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Silber 1986; Tyack 1981; Tyack and Whitehead. 1983).

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 sec and source levels of 175-192 dB (Richardson et al. 1995a; Thompson et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al. 1985; Sharpe and Dill. 1997). In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20Hz – 4 kHz with estimated source levels from 144 – 174 dB; these are mostly sung by males on the breeding grounds (Richardson et al. 1995a; Richardson et al. 1995b; Winn et al. 1970);

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Richardson et al. 1995a; Richardson et al. 1995b; Tyack and Whitehead. 1983); and

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated source levels in excess of 175 dB re 1 uPa-m (Richardson et al. 1995a; Richardson et al. 1995b; Thompson et al. 1986). Sounds often associated with possible aggressive behavior by males (Silber 1986; Tyack 1983) are quite different from songs, extending from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz. These sounds appear to have an effective range of up to 9 km (Tyack 1983).

More recently, Au et al. (2006) conducted field investigations of humpback whale songs which led these investigators to conclude that humpback whales have an upper frequency limit reaching as high as 24 kHz. Based on this information, it is reasonable to assume that the active mid-frequency sonar the U.S. Navy would employ during the proposed active sonar training activities are within the hearing and vocalization ranges of humpback whales. There is limited information on how humpback whales are likely to respond upon being exposed to mid-frequency active sonar (most of the information available addresses their probable responses to low-frequency active sonar or impulsive sound sources). Humpback whales responded to sonar in the 3.1–3.6 kHz by swimming away from the sound source or by increasing their velocity (Maybaum 1989b; Maybaum 1993). The frequency or duration of their dives or the rate of underwater vocalizations, however, did not change.

Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme et al. 1985), and to conspecific calls at received levels as low as 102 dB (Frankel et al. 1995). Malme et al. (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 μPa. Studies of reactions to airgun noises were inconclusive (Malme et al. 1985). Humpback whales on the breeding grounds did not stop singing in response to underwater explosions (Payne and Mcvay. 1971). Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150dB re 1 μPa/Hz at 350Hz (Lien et al. 1993; Todd et al. 1996). However, at least two individuals were probably killed by the high-intensity, impulsed blasts and had extensive mechanical injuries in their ears (Ketten et al. 1993; Todd et al. 1996). The explosions may also have increased the number of humpback whales entangled in fishing nets (Todd et al. 1996). Frankel and Clark (1998) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60 - 90 Hz sounds with a received level of up to 190 dB. Although these studies have demonstrated that humpback whales will exhibit short-term behavioral reactions to boat traffic and playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

Because their hearing range appears to overlap with the frequency range of mid-frequency active, we assume that some of the humpback whales that are exposed to mid-frequency active sonar during one or more of the proposed exercises might experience acoustic masking, impairment of acoustic communication, behavioural disturbance, and physiological stress responses as a result of their exposure.

The evidence available suggests that humpback whales are likely to detect mid-frequency sonar transmissions. In most circumstances, humpback whales are likely to try to avoid that exposure or are likely to avoid specific areas. Those humpback whales that do not avoid the sound field created by the mid-frequency sonar might experience interruptions in their vocalizations. In either case, humpback whales that avoid these sound fields or stop vocalizing are not likely to experience significant disruptions of their normal behavior patterns because the Action Area represents only a small portion of their feeding range. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress.

The strongest evidence of the probable impact of the *Environmental Baseline* on humpback whales consists of the estimated growth rate of the humpback whale population in the Atlantic Ocean. The apparent increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the Atlantic Ocean have not prevented the population from increasing in the Action Area. As discussed in the *Environmental Baseline* section of this Opinion, humpback whales have been exposed to active sonar training activities along the Atlantic Coast of the United States and in the Gulf of Mexico, including vessel traffic, aircraft traffic, active sonar, and underwater detonations, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales in the North Atlantic Ocean would be higher absent their exposure to these activities, the rate at which humpback whales occur in the Gulf of Maine suggests that humpback whale numbers have increased substantially in these important calving areas despite exposure to earlier training regimes. Although the U.S. Navy proposes to increase the frequency of some of these activities, we do not believe those increases are likely to affect the population growth rate because the populations appears to be increasing in the presence of the stressors associated with the Navy's proposed activities.

Based on the evidence available, we conclude that the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 to January 2014 would not be expected to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

6.7.4 North Atlantic Right Whales

Based on the U.S. Navy's exposure models, each year we would expect 733 instances annually (1,466 during the effective period of the proposed LOA) in which North Atlantic right whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. All of these exposure events are likely to occur in Operating Areas located along the Atlantic Coast of the United States and are not likely to occur in the Gulf of Mexico. As a result, North Atlantic right whales are not likely to be exposed to active sonar associated with surface ship mine warfare exercises, RONEX, or Gulf of Mexico exercises, which only occur in the Gulf of Mexico.

North Atlantic right whales are not likely to respond to high-frequency sound sources associated with the proposed training activities, the evidence is equivocal on whether North Atlantic right whales are likely to respond upon being exposed to mid-frequency active sonar or the nature of any responses they might exhibit if they respond at all. The information available on right whale vocalizations suggests that right whales produce moans less than 400 Hz in frequency (Spero 1981; Thompson et al. 1979), However, Nowacek et al. (2004a) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB spl, mildly to conspecific signals, and not at all to ship sounds or actual vessels. Although the alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface, Nowacek et al. (Nowacek et al. 2004a) offer no information on whether the whales were probably responding to the low- or mid-frequency components of the signals.

Although North Atlantic right whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, the limited evidence available suggests that sounds in this frequency range appear to lie at the periphery of their hearing range. The tonal vocalizations right whales produce can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls (Parks and Clark 2007). Most of these sounds range in frequency from 0.02 to 15 kHz, with dominant frequency ranges from 0.02 to less than 2 kHz with some sounds having multiple harmonics (Parks and Tyack. 2005). Assuming that right whales will focus their attentional resources on the frequency ranges of their vocalizations, right whales seem less likely to devote attentional resources to stimuli in the frequency ranges of mid-frequency active sonar. As a result, they are not likely to respond physiologically or behaviorally to sounds in this frequency range.

Based on the evidence available, we conclude that the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual North Atlantic right whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 would not be expected to appreciably reduce the North Atlantic right whales’ likelihood of surviving and recovering in the wild.

6.7.5 Sei Whales

Based on the U.S. Navy’s exposure models, each year we would expect 1,163 instances annually (2,326 instances over the period the LOA is in effect) in which sei whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like North Atlantic right whales, sei whales are not likely to be exposed to active sonar associated with surface ship mine warfare exercises, RONEX, or Gulf of Mexico exercises, which only occur in the Gulf of Mexico.

Like fin whales, sei whales in the action area seem likely to respond to the ship traffic associated with the activities the U.S. Navy plans to conduct in the Action Area in ways that approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. Sei whales also seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the information necessary to determine which of the many sounds associated with an exercise is likely to trigger avoidance behavior in sei whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether fin whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

Particular whales' may or may not respond to the vessels by changing their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions(Amaral and Carlson 2005a; Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams and Ashe. 2006a). (Amaral and Carlson 2005b; Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002)Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the different exercises and the small number of times the exercises are likely to be repeated from January 2012 to January 2014, we do not expect these responses of sei whales to reduce the fitness of the sei whales that occur along the Atlantic Coast and in the Gulf of Mexico.

Based on the evidence available, we conclude that the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sei whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 would not be expected to appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

6.7.6 Sperm Whales

Based on the U.S. Navy's exposure models, each year we would expect 10,734 instances annually (21,468 over the period the LOA would be in effect) in which sperm whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure. Like humpback whales, some of these exposure events are likely to occur in all Operating Area along the Atlantic coast of the United States and in the Gulf of Mexico, which means they are likely to result from exposure to any of the active sonar training activities the U.S. Navy proposed to conduct in the Action Area.

If exposed to mid- and high-frequency active sonar transmissions, sperm whales are likely to hear and respond to those transmissions. The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway. 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales also produce loud broad-band clicks from about 0.1 to 20 kHz (Goold and Jones. 1995; Weilgart et al. 1993; Weilgart and Whitehead. 1997). These have source levels estimated at 171 dB re 1 μPa (Levenson 1974). Current evidence suggests that the disproportionately large head of the sperm whale is an adaptation to produce these vocalizations (Cranford 1992; Norris and Harvey. 1972). This suggests that the production of these loud low frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Goold and Jones. 1995; Weilgart and Whitehead. 1993). Long series of monotonous regularly spaced clicks are associated with feeding and are thought to be produced for echolocation. Distinctive, short, patterned series of clicks, called codas, are associated with social behavior and interactions within social groups (Weilgart and Whitehead. 1993).

Based on the frequencies of their vocalizations, which overlap the frequency range of mid- and high-frequency active sonar, sonar transmissions might temporarily reduce the active space of sperm whale vocalizations. Most of the energy of sperm whale clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, which overlaps with the mid-frequency sonar. Other studies indicate sperm whales’ wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones 1995; Weilgart et al. 1993)). Ridgway and Carder (Ridgway and Carder 2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.

There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999; Watkins 1975), pingers (Watkins 1975), the Heard Island Feasibility Test (Bowles 1994), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins et al. 1993). Goold (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also stopped vocalizing for brief periods when codas were being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones. 1995).As discussed previously, sperm whales have been reported to have reacted to military sonar, apparently produced by a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins et al. 1985). Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway et al. 1997; Schlundt et al. 2000a), and to shorter broadband pulsed signals (Finneran et al. 2002a; Finneran et al. 2000). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002a; Schlundt et al. 2000a). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran et al. 2002a; Finneran et al. 2000). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002a). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000a). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans occasionally avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway et al. (1997) and Schlundt et al. (2000a).

Published reports identify instances in which sperm whales may have responded to an acoustic source and other instances in which they did not appear to respond behaviorally when exposed to seismic surveys. Mate et al. (1994) reported an opportunistic observation of the number of sperm whales to have decreased in an area after the start of airgun seismic testing. However, Davis et al. (2000) noted that sighting frequency did not differ significantly among the different acoustic levels examined in the northern Gulf of Mexico, contrary to what Mate et al. (1994) reported. Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles et al. 1994).

A recent study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall Howard 1999). Data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003). However, the compilation and analysis of the data led the author to conclude that seismic surveys did not result in observable effects to sperm whales (Stone 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995).

As stated previously, an experimental study of sperm whale reactions to seismic surveys in the Gulf of Mexico and a study of the movements of sperm whales with satellite-linked tags in relation to seismic surveys show that during two controlled exposure experiments in which sperm whales were exposed to seismic pulses at received levels up to 147 dB re 1 μPa over octave band with most energy, the whales did not avoid the vessel or substantially alter their feeding behavior (Miller et al. 2009).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 μPa from impulsive sounds produced by 1 g tnt detonators (Madsen and Mohl 2000). Richardson et al. (1995a) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre et al. (1997) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 db re 1 μPa at the source), but not to the other sources played to them.

These studies suggest that the behavioral responses of sperm whales to anthropogenic sounds are highly variable, but do not appear to result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. Responses of sperm whales to anthropogenic sounds probably depend on the age and sex of animals being exposed, as well as other factors. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not.

The evidence available suggests that sperm whales are likely to detect mid-frequency sonar transmissions. In most circumstances, sperm whales are likely to try to avoid that exposure or are likely to avoid areas specific areas. For example, sperm whales have moved out of areas after the start of air gun seismic testing (Davis et al. 1995). Those sperm whales that do not avoid the sound field created by the mid-frequency sonar might interrupt communications, echolocation, or foraging behavior. In either case, sperm whales that avoid these sound fields, stop communicating, echolocating or foraging might experience significant disruptions of normal behavior patterns that are essential to their individual fitness. Because of the relatively short duration of the acoustic transmissions associated with the active sonar training the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico, we do not, however, expect these disruptions to result in the death or injury of any individual animal or to result in physiological stress responses that rise to the level of distress.

Like fin and sei whales, individual sperm whales are also likely to respond to the ship traffic associated with the maneuvers in ways that might approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer sperm whales are to these maneuvers and the greater the number of times they are exposed (using the Navy's estimates of the cumulative exposures to sounds equivalents > 173 dB as an index of potential exposures), the greater their likelihood of being exposed and responding to that exposure. Particular whales' might not respond to the vessels, while in other circumstances, sperm whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions(Amaral and Carlson 2005a; Au and Green 2000; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986). Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the exercise, we do not expect these responses to continue long enough to have fitness consequences for individual sperm whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and those of a stress physiology.

Based on the evidence available, we conclude that the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual sperm whales would not be likely to reduce the viability of the populations those individual whales represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 would not be expected to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

6.7.7 Sea Turtles

The information available has not allowed us to quantitatively estimate the probability of the different sea turtles being exposed to mid-frequency active sonar, vessel traffic, or explosions associated with the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014.

Further, although the information on the hearing capabilities of sea turtles is limited, the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz) (Bartol et al. 1999; Lenhardt 1994; Lenhardt et al. 1983; Ridgway et al. 1969) . Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999).

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

We assume that these sensitivities to sound apply to the four hardshell turtles (i.e., green, loggerhead, Kemp's ridley, and hawksbill sea turtles). No audiometric data are available for leatherback sea turtles, but we assume that they have hearing ranges similar to those of other sea turtles (or at least, their hearing is more likely to be similar to other sea turtles than marine mammals). Based on this information sea turtles exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency sounds (sounds between 1 kHz and 10 kHz); therefore, they are not likely to respond physiologically or behaviorally to those received levels.

Because the sonar that would be used during the proposed exercises transmits at frequencies above hearing thresholds for sea turtles, sea turtles that are exposed to those transmissions are not likely to respond to that exposure. As a result, those activities would not be expected to appreciably reduce the likelihood of green, hawksbill, leatherback, Kemp’s ridley, or loggerhead sea turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution

Sea turtles along the Atlantic Coast or in the Gulf of Mexico might encounter one or more parachutes after they have been jettisoned from these sonobuoys and could become entangled as a result. Despite a very small probability, an interaction could be fatal to the sea turtle if it was entangled and drowned or if it swallowed a parachute. We cannot, however, determine whether such interactions are probable, given the relatively small number of sonobuoys that would be employed in each of the exercises, the relatively large geographic area involved, and the relatively low densities of sea turtles that are likely to occur in the Action Area. Given the large size of the Action Area, the relatively small number of sonobuoys that would be employed in an exercise, and the relatively low densities of sea turtles, an interaction between sea turtles and parachutes seems to have a very small probability.

We conclude that the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast and in the Gulf of Mexico from January 2012 through January 2014 have a very small probability of interacting with adult or sub-adult sea turtles, if they interact with any sea turtles at all, to reduce the viability of the nesting aggregations those sea turtles represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, those activities would not be expected to appreciably reduce the likelihood of green, hawksbill, leatherback, Kemp’s ridley, or loggerhead sea turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution.

6.8 Conclusion for Listed Resources

After reviewing the current status of endangered blue whales, fin whales, humpback whales, North Atlantic right whales, sei whales, sperm whales, green sea turtles, hawksbill sea turtles, leatherback sea turtles, Kemp’s ridley, and loggerhead sea turtles, the environmental baseline for the action area, the effects of NMFS Permits and Conservation Division’s proposal to issue a two-year Letter of Authorization to the U.S. Navy to take marine mammals for the period beginning in January 2012 and ending in January 2014 incidental to the U.S. Navy’s active sonar training activities along the Atlantic Coast and the Gulf of Mexico and the U.S. Navy’s proposal to conduct mid- and high-frequency active sonar and improved extended echo ranging system training, maintenance, and research, development, test, and evaluation activities within and adjacent to naval operating areas along the Atlantic coast of the United States and within the Gulf of Mexico from January 2012 to January 2014, and cumulative effects, it is NMFS’ biological opinion that the National Marine Fisheries Service’s Permits and Conservation Division’s proposal to permit the U.S. Navy to “take” marine mammals incidental to major training exercises, unit-level and intermediate-level training activities, and research, development, test and evaluation activities along the Atlantic coast of the United States and in the Gulf of Mexico and the U.S. Navy's proposal conduct those training activities is not likely to jeopardize the continued existence of these threatened and endangered species under NMFS' jurisdiction.

7 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The instances of take by harassment identified in the following list would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent significant disruptions of the normal behavioral patterns of the animals that have been exposed. The "take" estimates that follow grouped responses to active sonar and responses to vessel traffic and other environmental cues associated with the surface vessels involved in major training exercises because we assume animals would respond to a suite of environmental cues that include sound fields produced by active sonar, sounds produced by the engines of surface vessels, sounds produced by displacement hulls, and other sounds associated with training exercises. That is, we assume endangered marine mammals will perceive and respond to all of the environmental cues associated with an exercise rather than the single stimulus represented by active sonar. Further, we assume endangered marine mammals would recognize cues that suggest that ships are moving away from them rather than approaching them and they would respond differently to both situations.

7.1 Amount or Extent of Take Anticipated

The section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by proposed actions while the extent of take or "the extent of land or marine area that may be affected by an action" if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953). The amount of take resulting from the Navy's activities was difficult to estimate because we have no empirical information on (a) the actual number of listed species that are likely to occur in the different sites, (b) the actual number of individuals of those species that are likely to be exposed, (c) the circumstances associated with any exposure, and (d) the range of responses we would expect different individuals of the different species to exhibit upon exposure.

The instances of harassment identified in Table 9 would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Therefore, they would represent significant disruptions of the normal behavioral patterns of the animals that are expected to be exposed to the U.S. Navy's AFAST activities.

Table 9. Expected number of instances in which individual members of endangered or threatened species are likely to be "taken" as a result of their exposure to active sonar during the Atlantic Fleet Active Sonar Training (AFAST) activities.

Species	Estimated Number of Instances in Which Species Would be "Taken"		Form of the "Take"
	Annually	Total	
Blue whale	881	1,762	Harassment
Fin whale	970	1,940	Harassment
Humpback whale	4,622	9,244	Harassment
North Atlantic right whale	733	1,466	Harassment
Sei whale	1,163	2,326	Harassment
Sperm whale	10,734	21,468	Harassment

No whales would die or be wounded as a result of their exposure to U.S. Navy active sonar training activities along the Atlantic Coast and in the Gulf of Mexico. Because of their hearing sensitivities, we generally expect blue, fin, and sei whales to change their behavior in response to cues from the vessels rather than to the sound field produced by active sonar and the estimates in this list reflect that expectation. We assume that humpback and sperm whales would changes their behavior in response to the sound field produced by active sonar as well as cues from the vessels involved in training exercises.

Based on the hearing sensitivities of sea turtles, no "take" of sea turtles is anticipated due to active sonar. The probability of "take" of a sea turtle due to encounters with parachutes or other expended materials, particularly materials associated with sonobuoys is very low. "Take" of sea turtles will have been exceeded if the monitoring program associated with the U.S. Navy's AFAST activities detects any individuals of these species that have been harmed, injured, or killed as result of the proposed AFAST activities.

7.2 Effect of the Take

In the accompanying Opinion, NMFS determined that the number of individuals that might be exposed to mid-frequency active sonar associated with the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico and are likely to respond to that exposure in ways that would classify as "take" as that term is defined pursuant to section 3 of the Endangered Species Act is not likely to jeopardize the continued existence of blue, fin, North Atlantic right, humpback, sei, or sperm whales, or endangered or threatened sea turtles. Although the biological significance of the animal's behavioral responses remains unknown, exposure to active sonar transmissions could disrupt one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population. For the proposed action, behavioral responses that result from active sonar transmissions and any associated disruptions are expected to be temporary and would not affect the reproduction, survival, or recovery of these species.

7.3 Reasonable and Prudent Measures

The National Marine Fisheries Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. The U.S. Navy shall submit annual reports that identify the general location, timing, number of sonar hours, and other aspects of the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico over the next two years.

7.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Endangered Species Act of 1973, as amended, NMFS Permits Division and the U.S. Navy must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outlines the reporting requirements required by the section 7 regulations (50 CFR 402.14(i)).

7.4.1 Annual Atlantic Fleet Active Sonar Training (AFAST) Report

The Navy shall submit an Annual AFAST Exercise Report on October 1 of every year (covering data gathered through August 1 of the same year).

MFAS/HFAS Major Training Exercises

This section shall contain the following information for Major Training Exercises conducted the active sonar training activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico:

(i) Exercise Information (for each MTE):

- (A) Exercise designator
- (B) Date that exercise began and ended
- (C) Location
- (D) Number and types of active sources used in the exercise
- (E) Number and types of passive acoustic sources used in exercise
- (F) Number and types of vessels, aircraft, etc., participating in exercise
- (G) Total hours of observation by watchstanders
- (H) Total hours of all active sonar source operation
- (I) Total hours of each active sonar source (along with explanation of how hours are calculated for sources typically quantified in alternate way (buoys, torpedoes, etc.)).

(J) Wave height (high, low, and average during exercise)

(ii) Individual marine mammal sighting info (for each sighting in each MTE)

(A) Location of sighting
(B) Species (if not possible – indication of whale/dolphin/pinniped)
(C) Number of individuals
(D) Calves observed (y/n)
(E) Initial Detection Sensor
(F) Indication of specific type of platform observation made from (including, for example, what type of surface vessel, i.e., FFG, ddg, or cg)
(G) Length of time observers maintained visual contact with marine mammal
(H) Wave height (in feet)
(I) Visibility
(J) Sonar source in use (y/n).
(K) Indication of whether animal is <200yd, 200-500yd, 500-1000yd, 1000-2000yd, or >2000yd from sonar source in (x) above.
(L) Mitigation Implementation – Whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was.
(M) If source in use (J) is hull mounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel)
(N) Observed behavior – Watchstanders shall report, in plain language and without trying to categorize in any way, the observed behavior of the animals (such as animal closing to bow ride, paralleling course/speed, floating on surface and not swimming, etc.)

(iii) An evaluation (based on data gathered during all of the MTEs) of the effectiveness of mitigation measures designed to avoid exposing to mid-frequency sonar. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

Anti-Submarine Warfare (ASW) Summary

This section shall include the following information as summarized from both MTES and non-major training exercises (i.e., unit-level exercises):

(i) Total annual hours of each type of sonar source (along with explanation of how hours are calculated for sources typically quantified in alternate way (buoys, torpedoes, etc.))

(ii) Cumulative Impact Report - To the extent practicable, the Navy, in coordination with NMFS, shall develop and implement a method of annually reporting non-major (i.e., other than Exercises) training exercises utilizing hull-mounted sonar. The report shall present an annual (and seasonal, where practicable) depiction of non-major training exercises geographically across the Atlantic Coast of the United States and in the Gulf of Mexico. The Navy shall include (in the AFAST annual report) a brief annual progress update on the status of development until an agreed-upon (with NMFS) method has been developed and implemented.

IEER Summary

This section shall include an annual summary of the following IEER information:

(i) Total number of IEER events conducted in AFAST

(ii) Total expended/detonated rounds (buoys)

(iii) Total number of self-scuttled IEER rounds

7.4.2 Sonar Exercise Notification

The Navy shall submit to the NMFS Office of Protected Resources (specific contact information to be provided in LOA) either an electronic (preferably) or verbal report within fifteen calendar days after the completion of any major exercise (COMPTUEX, JTFEX. etc) indicating:

(1) Location of the exercise

(2) Beginning and end dates of the exercise

(3) Type of exercise (e.g., COMPTUEX, JTFEX, etc.)

8 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following conservation recommendations would provide information for future consultations involving the issuance of marine mammal permits that may affect endangered whales as well as reduce harassment related to research activities:

1. *Cumulative Impact Analysis.* The U.S. Navy should work with NMFS Endangered Species Division and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, sea turtles, and other marine animals. This includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species.

In order to keep NMFS ESA Interagency Cooperation Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits Division of the Office of Protected Resources should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

9 REINITIATION NOTICE

This concludes formal consultation on the National Marine Fisheries Service's Permits Division's proposal to issue a Letter of Authorization pursuant to the Marine Mammal Protection Act regulations at 50 CFR § 216.248218 that would allow the U.S. Navy to "take" marine mammals annually incidental to active sonar training along the Atlantic coast of the United States and in the Gulf of Mexico between January 2012 and January 2014 and the U.S. Navy's proposal to conduct that training. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

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