UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JAN 16 2008

**Memorandum For:** The Record

**From:** James H. Lecky
Director, Office of Protected Resources

**Subject:** Programmatic biological opinion on 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 2009 to January 2014 and the Permits Division's proposal to issue regulations to authorize the U.S. Navy to "take" marine mammals incidental to those training activities

Enclosed is the National Marine Fisheries Service's (NMFS) programmatic Biological Opinion, issued under the authority of section 7(a)(2) of the Endangered Species Act, on the effects of the National Marine Fisheries Service's Permits, Conservation, and Education Division's proposal to promulgate regulations that would authorize the division to allow the Navy to take marine mammals incidental to active sonar training activities along the Atlantic Coast of the United States and in the Gulf of Mexico from January 2009 to January 2014.

This Opinion concludes that the regulations and any take associated with activities authorized by those regulations are not likely to jeopardize threatened or endangered species in the action area during any single year or as a result of the cumulative impacts of annual authorizations. The Opinion also concluded that the proposed action is not likely to result in the destruction or adverse modification of critical habitat that has been designated for listed species in the Action Area. Because this is a programmatic Opinion, it does not include an incidental take statement; an incidental take statement would be attached to any biological opinion on any Letters of Authorization the Permits, Conservation, and Education Division decides to issue to the U.S. Navy.

This biological opinion was prepared under the standards in the 1986 regulations on interagency cooperation (50CFR402). Amendments to those regulations became effective on January 15, 2009. The amended regulations clarify the definition of "effects of the action" by adding a definition of "direct effects" and clarifying the definition of "indirect effects." I have reviewed this opinion in light of these changes and have concluded that application of the new definitions would not have changed the effects identified or the outcome of the analysis and conclusions in this opinion.

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

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|---|---|
| **Agencies:** | United States Navy<br>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 2009 to January 2014<br>Promulgation of regulations to authorize 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 January 2009 to January 2014 |
| **Consultation Conducted by:** | Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service |
| **Approved by:** | |
| **Date:** | JAN 16 2008 |

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 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 in this document, the action agencies are the United States Navy, which proposes to undertake the 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, Conservation, and Education Division, which proposes to promulgate regulations 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 Division. This document represents NMFS' final programmatic biological opinion (Opinion) on the effects of these proposals by the U.S. Navy and the National Marine Fisheries Service's Permits, Conservation, and Education 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 the proposed permits and permit amendments, published and unpublished scientific information on the biology and ecology of threatened and endangered whales, endangered and threatened sea turtles, Atlantic salmon, and shortnose sturgeon that occur along the Atlantic coast of the United States, and other sources of information which are discussed in greater detail in the *Approach to the Assessment* section of this Opinion.

**Consultation History**

On 4 February 4, 2008, the U.S. Navy submitted an application to the Permits Division that requested authorization for the "take" of 43 species of marine mammals incidental to active sonar training the U.S. Navy's Atlantic Fleet planned to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico over the course of five years. The Navy requested authorization to "take" individuals of 43 species of marine mammals by Level B Harassment (as the term "take" is defined by the Marine Mammal Protection Act); although the U.S. Navy did not anticipate it to occur, it requested authorization to take, by injury or mortality, up to 10 individual beaked whales over the course of the 5-year period.

On 14 October 2008, NMFS published a proposed rule in the Federal Register on the U.S. Navy's request for a letter of authorization to "take" marine mammals incidental to active sonar training activities the U.S. Navy planned to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico ((73 Federal Register 60754).

In December 2008, the U.S. Navy issued its Final Environmental Impact Statement and Overseas Environmental Impact Statement on Atlantic Fleet Active Sonar Training. The U.S. Navy's preferred alternative, on which this Opinion is based, was the no action alternative.

On 5 January 2008, NMFS provided the U.S. Navy and NMFS' Permits, Education, and Conservation Divisions with copies of the draft description of the proposed action for this Opinion. On 13 January 2008, NMFS provided the U.S. Navy and NMFS' Permits, Education, and Conservation Divisions with copies of the draft biological opinion on the suite of activities that would be authorized by the regulations the Permits Division proposed to issue pursuant to the Marine Mammal Protection Act. NMFS has reviewed all comments on those draft documents and, where appropriate, has incorporated them into this document.

## BIOLOGICAL OPINION

### 1.0 Description of the Proposed Action

The proposed action consists of two separate but related activities: (1) the U.S. Navy's proposal to continue[1] conducting mid- and high-frequency active sonar and improved extended echo ranging system training (which

[1] The activities involving active sonar described in this Opinion are not new and do not involve significant changes in systems, tempo, or intensity from past or current activities. As a result, the U.S. Navy is proposing to continue these activities.

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 Atlantic Fleet Active Sonar Training study area, which includes areas along the Atlantic coast of the United States and within the Gulf of Mexico from January 2009 to January 2014 and (2) the National Marine Fisheries Service's Permits, Conservation, and Education Division (Permits Division) proposal to promulgate regulations governing the take of marine mammals (50 CFR Part 216) to allow NMFS to issue annual letters of authorization that would allow the U.S. Navy to take marine mammals for a five-year period beginning in January 2009 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. 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.

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.

The remainder of this section of the Opinion 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 (U.S. Navy 2008).

## 1.1 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 (U.S. Navy 2008).

### 1.1.1 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 .

#### 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 operating 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.

### 1.1.2 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 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 destroyers 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. IAC consists of two phases, IAC Phase I and IAC Phase II. IAC Phase I is an approved Navy course of instruction consisting of five days of basic and intermediate level classroom training. IAC 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. IAC 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.

### 1.1.3 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 Group. 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, 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 represents 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 and 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 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 occurs 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 freeplay 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.

### 1.1.4 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.

### 1.1.5 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 1 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.

## 1.2 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) . 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). The active sources that would be used in training activities along the Atlantic Coast of the United States and in the Gulf of Mexico include:

#### 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. 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 (51 units) class vessels in the U.S. Navy (Polmar 2001, D`Spain *et al.* 2006). 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. AN/SQS-56 is installed on FFG-7 (33 units) class guided missile frigates in the U.S. Navy (Polmar 2001, D`Spain *et al.* 2006). 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**

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. 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 (Figure C-4) 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.

**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. 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 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. 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 under-water 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.

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.

**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.

### 1.2.2 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 majority of 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.

## 1.3 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:

### 1.3.1 Anti-submarine Warfare Training Areas

Anti-submarine warfare activities for all platforms could occur within and adjacent to 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.

### 1.3.2 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 North Atlantic right whale critical habitat.

### 1.3.3 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 critical habitat is located. Torpedo Exercise areas that meet current operational requirements for proximity to torpedo and target recovery support facilities were established during earlier Endangered Species Act Section 7 consultations with the National Marine Fisheries Service  As a result of these consultations, Torpedo Exercise activities in the northeast North Atlantic right whale critical habitat are limited to these established areas.

Torpedo firing activities would be occurring 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.

### 1.3.4 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.

### 1.3.5 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 North Atlantic right whale critical habitat. 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 North Atlantic right whale critical habitat.

### 1.3.6 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.

### 1.3.7 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.

## 1.4 Scope of the Proposed MMPA Regulations

The regulations the Permits Division proposes to promulgate 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. long. and south from the Atlantic and Gulf of Mexico Coasts to approximately 23 degrees N. lat., excluding the Bahamas (see Figure 1). The "taking" of marine mammals (as that term is defined for the purposes of the Marine Mammal Protection Act) by the Navy 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 amounts indicated below (+/- 10 percent):

1. AN/SQS-53 (hull-mounted sonar) – up to 16070 hours over the course of 5 years (an average of 3214 hours per year)
2. AN/SQS-56 (hull-mounted sonar) – up to 8420 hours over the course of 5 years (an average of 1684 hours per year)
3. AN/SQS-56 or 53 (hull mounted sonar in object detection mode) – up to 1080 hours over the course of 5 years (an average of 216 hours per year)
4. AN/BQQ-10 or 5 (submarine sonar) – up to 49880 pings over the course of 5 years (an average of 9976 pings per year)(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) – up to 14760 dips over the course of 5 years (an average of 2952 dips per year – 10 pings per five-minute dip)
6. SSQ-62 (Directional Command Activated Sonobuoy System (DICASS) sonobuoys) – up to 29265 sonobuoys over the course of 5 years (an average of 5853 sonobuoys per year)
7. MK-48 (heavyweight torpedoes) – up to 160 torpedoes over the course of 5 years (an average of 32 torpedoes per year)
8. MK-46 or 54 (lightweight torpedoes) – up to 120 torpedoes over the course of 5 years (an average of 24 torpedoes per year)
9. AN/SSQ-110A (IEER explosive sonobuoy) and AN/SSQ-125 (AEER sonar sonobuoy) – up to 4360 sonobuoys, between these 2 sources, over the course of 5 years (an average of 872 buoys per year)
10. AN/SQQ-32 (over the side mine-hunting sonar) – up to 22370 hours over the course of 5 years (an average of 4474 hours per year)
11. AN/SLQ-25 (NIXIE – towed countermeasure) – up to 1660 hours over the course of 5 years (an average of 332 hours per year)
12. AN/BQS-15 (submarine navigation) – up to 2250 hours over the course of 5 years (an average of 450 hours per year)
13. MK-1 or 2 or 3 or 4 (Submarine-fired Acoustic Device Countermeasure (ADC)) - up to 1125 ADCs over the course of 5 years (an average of 225 ADCs per year)
14. Noise Acoustic Emitters (NAE – Sub-fired countermeasure) - up to 635 NAEs over the course of 5 years (an average of 127 NAEs per year)

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

1. "Take" any marine mammal 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 proposed regulations or future Letters of Authorization issued under the proposed regulations.

## 1.5 Mitigation Measures Proposed by the U.S. Navy

As required to satisfy the requirements of the Marine Mammal Protection Act of 1972, as amended, the U.S. Navy's proposes to implement measures that would 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 the proposed exercises, readers should refer to the U.S. Navy's request for a letter of authorization and the Permit Division's proposed rule:

The U.S. Navy does not currently conduct active sonar training in North Atlantic right whale critical 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. As part of the proposed action, 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 nautical mile or nm) buffer. In addition, the U.S. Navy proposes to use the following measures:

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 Responsibilties

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 eyes do not see well when they are 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 EER/IEER Sonobuoys*

a. AN/SSQ-110A 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. 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. AN/SSQ-110A 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. 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. 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 are injected into planning processes for testing and training evolutions.

4.4 Helicopter Dipping Sonar in North Atlantic right whale Critical Habitat

4.4.1 Helicopter Dipping Sonar is one of the two activity types that has been identified as planned to occur in the southern North Atlantic right whale critical habitat. Historically, only maintenance of helicopter dipping sonars occurs within a portion of the North Atlantic right whale critical habitat. Tactical training with helicopter dipping sonar does not typically occur in the North Atlantic right whale critical habitat area at any time of the year. The critical habitat area is 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 critical habitat from November 15 to April 15.

4.5 Object Detection Exercises in North Atlantic right whale Critical Habitat

4.5.1 Object detection training requirements are another type of activity that have been identified as planned to occur in the southern North Atlantic right whale critical habitat. 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. 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 critical habitat 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 critical habitat.

4.5.3 Prior to conducting surface ship object detection exercises in the southeast North Atlantic right whale critical habitat during the time of November 15 to April 15, ships will contact FACSFAC JAX to obtain the latest right whale sighting information. FACSFAC JAX will advise ships of all reported whale sightings in the vicinity of the critical habitat 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 occuring 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 identifed 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 in and around a federally designated critical habitat off the coast of Georgia and Florida.

This critical 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 critical habitat also apply to an associated area of concern which extends 9 km (5 nm) seaward of the designated critical boundaries. Prior to transiting or training in the critical habitat or associated 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 the critical habitat or associated area of concern include the following:

5.2.1 When transiting within the critical habitat or associated 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 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 the critical habitat or associated 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 critical habitat areas, ships will obtain the latest right whale sightings and other information needed to make informed decisions regarding safe speed. The Great South Channel critical habitat 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 critical habitat is 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 cognizant 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 the critical habitat or associated area of concern include the following:

5.31 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 the 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.

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 critical habitats will obtain information on recent whale sightings in the vicinity of the critical habitat. 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 Critical Habitat. 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 critical habitat, 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 critical habitat, surface vessels and submarines shall maintain a speed of no more than 19 km/hr (10 kn) while not actively engaged in the exercise procedures.
- During TORPEX operations, a firing vessel will likely not exceed 19 km/hr (10 kn). When a submarine is used as a target, vessel speeds would not likely exceed 33 km/hr (18 kn). However, on occasion, when surface vessels are used as targets, the vessel may exceed 33 km/hr (18 kn) 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 .

## 1.5 Mitigation Requirements Proposed by NMFS' Permits Division

When the U.S. Navy conducts the training activities identified in the relevant regulations, the regulations that NMFS' Permits Division proposes to finalize requires the U.S. Navy to implement mitigation measures that include (but are not limited to) the following:

1 *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 have reviewed the MSAT material prior to a training event employing the use of mid-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 species are spotted.

vi On the bridge of surface ships, there shall 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 mid-frequency active sonar, 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 Lookouts 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 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.

xiii Commanding Officers shall 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.

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 mid-frequency active sonar training activities, 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 (182 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 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.

xx Safety Zones - When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that MFAS transmission levels are limited to at least 6 dB below normal operating levels if any detected marine mammals are within 1000 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 area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards (1828 m) beyond the location of the last detection.

(B) Should a marine mammal be detected within or closing to inside 457 m (500 yd) of the sonar dome, active sonar transmissions shall be limited to at least 10 dB below the equipment's normal operating level. 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 area, has not been detected for 30 minutes, or the vessel has transited more than 2000 yards (1828 m) beyond the location of the last detection.

(C) Should the marine mammal be detected within or closing to inside 183 m (200 yd) of the sonar dome, active sonar transmissions shall cease. Sonar shall not resume 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 (1828 m) beyond the location of the last detection.

(D) If the need for power-down should arise as detailed in "Safety Zones" above, Navy shall follow the requirements as though they were operating 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 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) - 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 Exercise 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) 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 mid-frequency 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 northeast North Atlantic right whale critical habitat (as designated in 50 CFR Part 226) shall implement the following measures.

(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 nm (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 northeastern North Atlantic right whale critical habitat, 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.

xxviii 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 of regulations) where feasible. Should national security require the conduct of more than four major exercises (COMPTUEX, 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 southeastern areas of North Atlantic right whale critical habitat (as designated in 50 CFR Part 226) from November 15 – April 15.

(E) Object Detection Exercises – The Navy shall implement the following measures regarding object detection activities in the southeastern areas of 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 southeastern areas of the North Atlantic right whale 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 critical habitat and associated areas of concern (which extend 9 km (5 nm) seaward of the designated 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 separation from any observed whale, consistent with the safety of the ship.

xxvii The Navy shall abide by the letter of the "Stranding Response Plan for Major Navy Training Exercises in the AFAST Study Area" to include the following measures:

(A) Shutdown Procedures– When an Uncommon Stranding Event (USE – as defined in the regulations) 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 in the regulations) 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 will maintain a dialogue, 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 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 or 17 nm, for East Coast and Gulf of Mexico, respectively) 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 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 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 (by requesting the Navy's assistance pursuant to the memorandum of agreement (MOA) 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 (for East Coast and Gulf of Mexico, respectively) 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 (by requesting the Navy's assistance pursuant to the MOA 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 shall 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 from the distressed animal(s), is likely contributing to the animals' refusal to return to the open water. If so, NMFS and the Navy will further coordinate to determine what measures are necessary to improve the probability that the animals will return to open water 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 hour period prior to the event will be provided as soon as it becomes available. The Navy will provide NMFS investigative teams with additional relevant unclassified information as requested, if available.

(C) Memorandum of Agreement (MOA) – The Navy and NMFS shall develop a MOA, or other mechanism consistent with federal fiscal law requirements (and all other applicable laws), that will establish a framework whereby the Navy can (and provide the Navy examples of how they can best) assist NMFS with stranding investigations in certain circumstances.

2 Mitigation for IEER - The following are protective measures for use with Improved Extended Echo Ranging (IEER) given an explosive source generates the acoustic wave used in this sonobuoy.

i Navy crews shall conduct aerial 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 detonation. This 30-minute observation period may include pattern deployment time.

iii For any part of the briefed pattern where a post (source/receiver sonobuoy pair) will be deployed within 1,000 yards (914 m) of observed marine mammal activity, the Navy shall deploy the receiver ONLY 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, co-locate the explosive source sonobuoy (AN/SSQ-110A) (source) with the receiver.

iv When operationally feasible, crews will conduct continuous visual and aural monitoring of marine mammal activity. This is to include monitoring of own-aircraft sensors from first sensor placement to checking off station and out of communication range of these sensors.

v Aural Detection: If the presence of marine mammals is detected aurally, then that shall cue the aircrew to increase the diligence of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the 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) intended for use, then that payload shall not be detonated. 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.

(B) 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 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.

3. 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 N. lat. 071-51.15 W. long. and 41-18.58 N. lat. 070-50.23 W. long): Sept-Oct and Mar-Apr

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

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

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

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

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

(B) During the months indicated in (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 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 457 m (1,500 ft) 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. North Atlantic right whale critical habitat is the area from 31-15 N. lat. to 30-15 N. lat. extending from the coast out to 28 km (15 nm), and the area from 28-00 N. lat. to 30-15 N. lat. from the coast out to 9 km (5 nm). All mitigation measures described here that apply to the critical habitat also apply to an associated area of concern which extends 9 km (5 nm) seaward of the designated critical habitat boundaries.

(A) Prior to transiting or training in the 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 critical habitat and an associated area of concern which extends 9 km (5 nm) seaward of the designated critical habitat boundaries:

(1) When transiting within the 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 then 12 hours old. Circumstances could arise where, in order to avoid North Atlantic right whale(s), speed reductions could mean 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 the ability to maneuver.

(4) Ships shall not transit through the 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 whale (i.e., adult/calf).

iii Northeast Atlantic, Offshore of the Eastern United States

(A) Prior to transiting the Great South Channel or Cape Cod Bay critical habitat areas, ships shall obtain the latest North Atlantic right whale sightings and other information needed to make informed decisions regarding safe speed. The Great South Channel critical habitat is defined by the following coordinates: 41-00 N. lat., 69-05 W. long.; 41-45 N. lat, 69-45 W. long; 42-10 N. lat., 68-31 W. long.; 41-38 N. lat., 68-13 W. long.. The Cape Cod Bay critical habitat is defined by the following coordinates: 42-04.8 N. lat., 70-10 W. long.; 42-12 N. lat., 70-15 W. long.; 42-12 N. lat., 70-30 W. long.; 41-46.8 N. lat., 70-30 W. long.

(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 Patrol and Reconnaissance Wing (COMPATRECONWING). 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 to the cognizant regional environmental coordinator. 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 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 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.

(2) When transiting within the 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 Cape Cod Bay and Great South Channel critical habitats shall obtain information on recent whale sightings in the vicinity of the critical habitat. 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.

The Permits Division proposes include the following monitoring and reporting requirements in the proposed regulations:

a As outlined in the AFAST tranding Communication Plan, the Navy must notify NMFS immediately (or as soon as clearance procedures allow) if the specified activity identified in § 218.80(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 § 218.82(c).

b The Navy must conduct all monitoring and required reporting under the Letter of Authorization, including abiding by the letter of the AFAST Monitoring Plan.

c The Navy shall complete an Integrated Comprehensive Monitoring Plan (ICMP) in 2009. This planning and adaptive management tool shall include:

(1) A method for prioritizing monitoring projects that clearly describes the characteristics of a proposal that factor into its priority.

(2) A method for annually reviewing, with NMFS, monitoring results, Navy R&D, and current science to use for potential modification of mitigation or monitoring methods.

(3) A detailed description of the Monitoring Workshop to be convened in 2011 and how and when Navy/NMFS will subsequently utilize the findings of the Monitoring Workshop to potentially modify subsequent monitoring and mitigation.

(4) An adaptive management plan

(5) A method for standardizing data collection for AFAST across Range Complexes

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 a report annually on October 1 describing the implementation and results (through August 1 of the same year) of the AFAST Monitoring Plan, described above. Data collection methods will be standardized across range complexes to allow for comparison in different geographic locations. Although additional information will 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 the data required in 218.85(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 an Annual AFAST Exercise Report on October 1 of every year (covering data gathered through August 1 of the same year). This report shall contain information identified in subsections 218.85(f)(1) – (f)(5).

(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 <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 hullmounted, 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 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 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 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 southern NARW 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 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

g 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, or SEASWITI) indicating:

(1) Location of the exercise

(2) Beginning and end dates of the exercise

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

i 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 and explosive 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.

j Comprehensive National ASW Report - By June 2014, the Navy shall submit a draft Comprehensive 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 the AFAST, SOCAL, the HRC, the Marianas Range Complex, the Northwest Training Range, the Gulf of Alaska, and the East Coast Undersea Warfare Training Range.

k The Navy shall respond to NMFS comments and requests for additional information or clarification on the AFAST Comprehensive Report, the draft 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.

q In 2011, the Navy shall convene a Monitoring Workshop in which the Monitoring Workshop panelists 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.

# 2.0 Approach to the Assessment

## 2.1 Overview of NMFS' Assessment Framework

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[2] 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

[2] Although section 7(a)(2) of the Endangered Species Act of 1973, as amended, requires us to use the best scientific and commercial data available, at this stage of our analyses, we consider all lines of evidence. We summarize how we identify the "best scieitific and commercial data available" in a subsequent subsection titled "Evidence Available for the Consultation"

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, 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 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.

RISK ANALYSES FOR DESIGNATED CRITICAL HABITAT. Our "destruction or adverse modification" determinations must be based on an action's effects on the conservation value of habitat that has been designated as critical to threatened or endangered species[3]. If an area encompassed in a critical habitat designation is likely to be exposed to the *direct or indirect consequences of the proposed action on the natural environment*, we ask if primary or secondary constituent elements included in the designation (if there are any) or physical, chemical, or biotic phenomena that give the designated area value for the conservation are likely to respond to that exposure.

In this step of our assessment, we must identify (a) the spatial distribution of stressors and subsidies produced by an action; (b) the temporal distribution of stressors and subsidies produced by an action; (c) changes in the spatial distribution of the stressors with time; (d) the intensity of stressors in space and time; (e) the spatial distribution of constituent elements of designated critical habitat; and (f) the temporal distribution of constituent elements of designated critical habitat.

If primary or secondary constituent elements of designated critical habitat (or physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) are likely to respond given exposure to

[3] We are aware that several courts have ruled that the definition of destruction or adverse modification that appears in the section 7 regulations at 50 CFR 402.02 is invalid and do not rely on that definition for the determinations we make in this Opinion. Instead, as we explain in the text, we use the "conservation value" of critical habitat for our determinations which focuses on the designated area's ability to contribute to the conservation or the species for which the area was designated.

the *direct or indirect consequences of the proposed action on the natural environment*, we ask if those responses are likely to be sufficient to reduce the quantity, quality, or availability of those constituent elements or physical, chemical, or biotic phenomena.

In this step of our assessment, we must identify or make assumptions about (a) the habitat's probable condition before any exposure as our point of reference (that is part of the impact of the *Environmental Baseline* on the conservation value of the designated critical habitat); (b) the ecology of the habitat at the time of exposure; (c) where the exposure is likely to occur; and (d) when the exposure is likely to occur; (e) the intensity of exposure; (f) the duration of exposure; and (g) the frequency of exposure.

In this step of our assessment, we recognize that the conservation value of critical habitat, like the base condition of individuals and populations, is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, etc. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also consider how designated critical habitat is likely to respond to any interactions and synergisms between or cumulative effects of pre-existing stressors and proposed stressors.

If the quantity, quality, or availability of the primary or secondary constituent elements of the area of designated critical habitat (or physical, chemical, or biotic phenomena) are reduced, we ask if those reductions are likely to be sufficient to reduce the conservation value of the designated critical habitat for listed species in the action area. In this step of our assessment, we combine information about the contribution of constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species, particularly for older critical habitat designations that have no constituent elements) to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the *conservation value* of those areas of designated critical habitat that occur in the action area as our point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species, that limited value is our point of reference for our assessment.

If the conservation value of designated critical habitat in an action area is reduced, the final step of our analyses ask if those reductions are likely to be sufficient to reduce the conservation value of the entire critical habitat designation. In this step of our assessment, we combine information about the constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species, particularly for older critical habitat designations that have no constituent elements) that are likely to experience changes in quantity, quality, and availability given exposure to an action with information on the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the conservation value of the entire designated critical habitat as our point of reference for this comparison. For example, if the designated critical habitat has limited current value or potential value for the conservation of listed species, that limited value is our point of reference for our assessment.

## 2.2 Application of this Approach in this Consultation

The primary stressors he 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 involves 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.

### 2.2.1 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.

#### Exposure to Active Sonar

Despite the numerous surveys that have been conducted along the Atlantic Coast of the United States and in the Gulf of Mexico, including reports from whale-watch vessels along those coasts, there is almost no empirical information on the distribution and abundance of marine mammals relative to active sonar associated with Navy training exercises. We do not know whether or to what degree the distribution or abundance of marine animals changes before, during, or after an exercise or whether those changes follow the same pattern or whether the pattern varies from species to species. As a result, we cannot rely on empirical observations to estimate the number of endangered or threatened marine animals that might be exposed to active sonar during the training activities the U.S. Navy plans to conduct in waters off the Atlantic Coast of the United States and in the Gulf of Mexico over the five-year period beginning in January 2009. Instead, 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, computer simulations, or some kind of mathematical algorithm to estimate the number of animals that might be exposed to a sound source. All of these approaches rely on assumptions that oversimplify the circumstances that determine whether marine animals are likely to be exposed to an area ensonified by active sonar in the marine environment, although the reasons for that oversimplification are understandable.

In this Opinion, we relied on the method the U.S. Navy used to develop the "take" (as that term is defined pursuant to the MMPA) estimates that were necessary to apply for an authorization to take marine mammals incidental to

training activities pursuant to the MMPA and for the effects analyses in the Environmental Impact Statement the U.S. Navy and NMFS' Permits Division prepared for 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. The incidental "take" the Permits Division proposes to authorize in the proposed 5-year regulations reflect these "take" estimates. Although this was designed to estimate the number of times marine mammals might be "taken" (as that term is defined pursuant to the MMPA) as a result of their exposure to active sonar or underwater detonations during training activities, which is a subset of the number of animals that might be respond given exposure, we did not have an opportunity to pursue alternative approaches in this consultation. 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 Final Environmental Impact Statement for the Atlantic Fleet Active Sonar Training; U.S. Navy 2008).

The U.S. Navy's updated approach 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 5 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), 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, 2003, 2005; Finneran and Schlundt 2004; Schlundt *et al.* 2000), (2) data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromm 2004, Department of the Navy 2003), and (3) a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek *et al.* 2004). The U.S. Navy and NMFS' Permits Division estimated the proportion of a population that is 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."

This approach would also tend to overestimate the number of marine mammals that might be exposed, because 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 this approach would be conservative, in the sense that they would tend to overestimate the number of animals that are likely to be "taken" by the activities the U.S. Navy plans to conduct along the Atlantic Coast of the United States and in the Gulf of Mexico.

### 2.2.2 Response Analyses

As discussed in the introduction to this section of this Opinion, our response analyses are designed to identify the physical, physiological, and behavioral responses of endangered or threatened species that are likely to be exposed to stressors produced by an action. Because the responses of animals to a potential stressor are influenced by the animal's pre-existing physical, physiological, or behavioral state, our response analyses consider the *Status of the Species* and the impacts of the *Environmental Baseline*.

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 produce 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: Animal Does Not Respond, Stress Response, and Behavioral Response). For example, an animal's behavioral response to active sonar or an approaching vessel will depend on whether (a) an animal detects the some physical, visual, or acoustic cue from the sonar or vessel and (b) the animal classifies those cues as a potential threat (Blumstein and Bouskila 1996). The results of that assessment, which is influenced by the animal's physical and physiological state, can trigger physiological stress responses or lead to the animal to execute a behavioral response from its behavioral repertoire using a decision-making process that weighs the costs and benefits of alternative behaviors and recognizes the existing of trade-offs (Beale 2007, Blumstein and Bouskila 1996).
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, Mask Signal Reception, and Impair Call/Song Transmission).

Figure 1 illustrates the structure of our response analyses and shows the relationships between exposures, responses, and potential fitness consequences to individual animals that experience or exhibit particular responses or sets of responses (also see Southall *et al*. 2008 for an earlier version of this figure). This figure, and the analyses that are based on it, was derived from an extensive review of the scientific and commercial data available from published and unpublished documents (we present the specific references in our *Response Analyses*). The procedures we used to identify those data are presented in a subsequent sub-section of thissection; the specific studies, papers, and data that support our response analyses are presented in the *Response Analyses* section of this Opinion.

We used empricial 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

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

Where *R* represents the set of mutually exclusive and exhaustive physical, physiological, and behavioral responses to an exposure with probabilities, $\Pr(R_i)$, $\Pr(R_j)$ represents alternatives to that particular response, and D represents the data on responses. In this formulation, $\Pr(R_i)$ 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

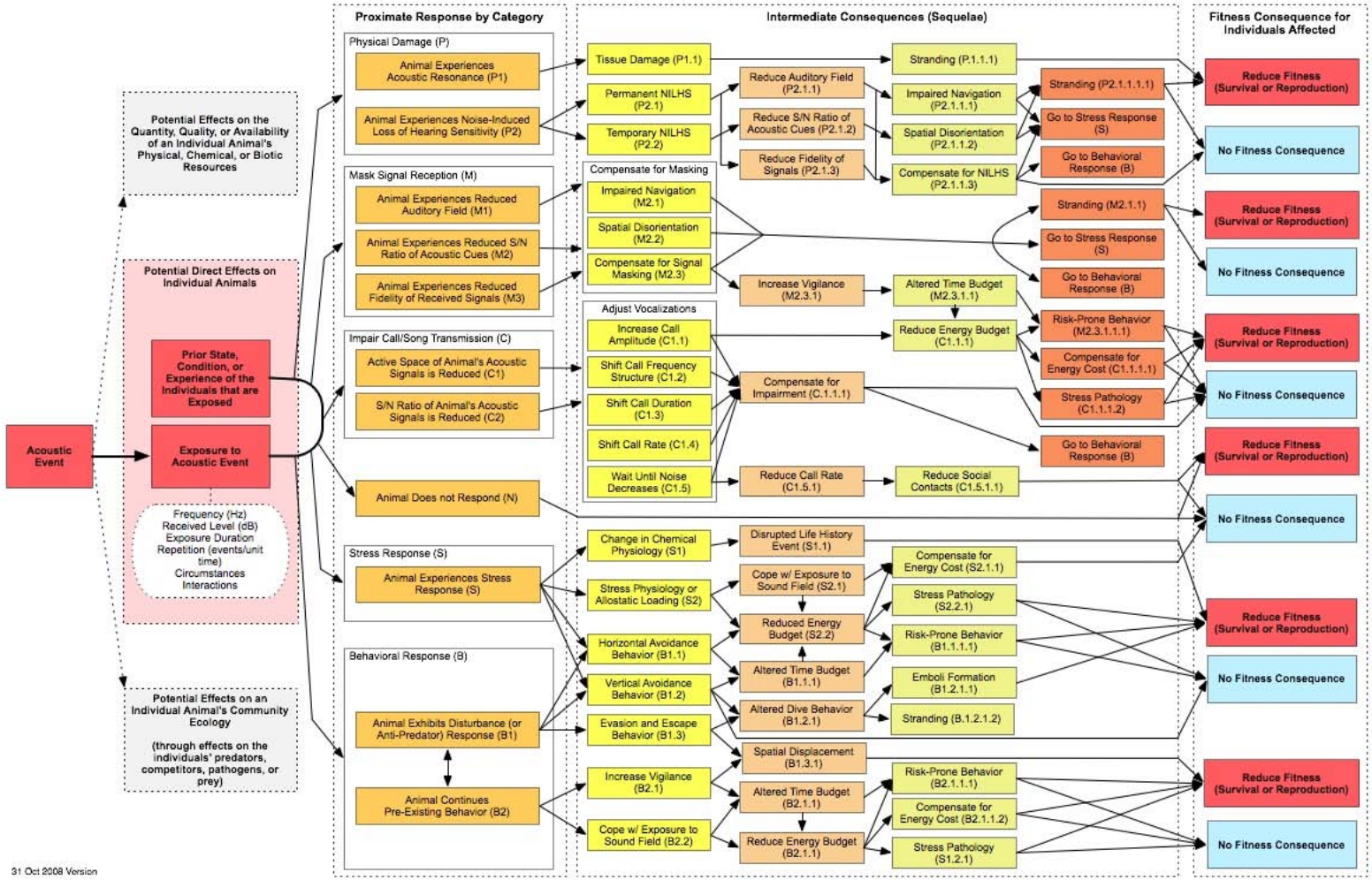


**Figure 1. Conceptual model of the potential responses of endangered and threatened species upon being exposed to active sonar and the pathways by which those responses might affect the fitness of individual animals that have been exposed. See text contained in "Application of this Approach" and "Response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

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.

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 1). 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* (2004) reported one instance in which North Atlantic right whales exposed to alarm stimuli did not repond 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 1. 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 | Siignal 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 Resoinse |
| 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 |

### 2.2.3 Risk Analyses

As discussed in the Introduction to this section, the final steps of our analyses — establishing the risks those responses pose to endangered and threatened species or designated critical habitat — 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). 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.

## 2.3 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 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, Abgrail *et al.* 2008, Bowles *et al.* 1994; Croll *et al.* 1999, 2001; Frankel and Clark 1998; Gisiner 1998, McCauley and Cato 2001; NRC 1994 1996, 2000, 2003, 2005; Norris 1994; Reeves 1992, Richardson *et al.* 1995, Southall *et al*. 2007, Tyack 2000, 2007; Wright *et al.* 2007).

To supplement that body of knowledge, we conducted electronic literature searches using the Library of Congress' *First Search* and *Dissertation Abstracts* databases, SCOPUS, *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. The *First Search* databases provide access to general biological literature, master's theses, and doctoral dissertations back to 1980; ASFA provides access to journal articles, magazine articles, and conference proceedings back to 1964. Our searches specifically focus on the *ArticleFirst*, *BasicBiosis*, *Dissertation Abstracts*, *Proceedings* and *ECO* databases, which index the major journals dealing with issues of ecological risk (for example, the journals *Environmental Toxicology and Chemistry*, *Human and Ecological Risk Assessment*), marine mammals (*Journal of Mammalogy*, *Canadian Journal of Zoology*, *Journal of Zoology*, *Marine Mammal Science*), sea turtles (*Copeia*, *Herpetologia*, *Journal of Herpetology*), ecology (*Ambio*, *Bioscience*, *Journal of Animal Ecology*, *Journal of Applied Ecology*, *Journal of the Marine Biological Association of the UK*, *Marine Pollution Bulletin*, *Oikos*), bioacoustics (*Bioacoustics*, *Journal of the Acoustical Society of America*), and animal behavior (*Advances in the Study of Behavior*, *Animal Behavior*, *Behavior*, *Behavioral Ecology and Sociobiology*, *Ethology*). We manually searched issues of the *Journal of Cetacean Research and Management* and *Reports of the International Whaling Commission*.

Our prior experience demonstrated that electronic searches produce the lowest number of false positive results (references produced by a search that are not relevant) and false negative results (references not produced by a search that are relevant) if we use paired combinations of the keywords: sonar, mid-frequency sonar, acoustic, marine acoustic, military exercises, sound, and noise paired with the keywords cetacean, dolphin, marine mammal, pinniped, porpoise, sea turtle, seal, and whale. To expand these searches, we modified these keyword pairs with the keywords effect, impact, mortality event, response, behavior (including the spelling "behaviour" as well as "behavior"), stranding, unusual mortality event. To collect data for our exposure analyses, we used the keyword: encounter rate paired with marine mammal, cetacean, and whale.

We supplemented the results of these electronic searches by acquiring all of the references we had gathered that, based on a reading of their titles or abstracts, appeared to comply with the keywords presented in the preceding paragraph. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We continued this process until we gathered all (100 percent) of the relevant references cited by the introduction and discussion sections of the relevant papers, articles, books, and, reports and all of the references cited in the materials and methods, and results sections of those documents. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

To supplement our searches, we examined the literature that was cited in documents and any articles we collected through our electronic searches. If, based on a reading of the title or abstract of a reference, the reference appeared to comply with the keywords presented in the preceding paragraph, we acquired the reference. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We continued this process until we identified all (100 percent) of the relevant references cited by the introduction and discussion sections of the relevant papers, articles, books, and, reports and all of the references cited in the materials and methods, and results sections of those

documents. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

From each document, we extracted the following: when the information for the study or report was collected, the study design, which species the study gathered information on, the sample size, acoustic source(s) associated with the study (noting whether it was part of the study design or was correlated with an observation), other stressors associated with the study, study objectives, and study results, by species. We estimated the probability of responses from the following information: the known or putative stimulus; exposure profiles (intensity, frequency, duration of exposure, and nature) where information is available; and the entire distribution of responses exhibited by the individuals that have been exposed. Because the response of individual animals to stressors will often vary with time (for example, no responses may be apparent for minutes or hours followed by sudden responses and vice versa) we also noted any temporal differences in responses to an exposure.

We ranked the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. We ranked carefully-designed field experiments (for example, experiments that control variables, such as other sources of sound in an area, that might produce the same behavioral responses) higher than field experiments were not designed to control those variables. We ranked carefully-designed field experiments higher than computer simulations. Studies that were based on large sample sizes with small variances were generally ranked higher than studies with small sample sizes or large variances.

Despite the information that is available, this assessment involved 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 these unknowns).

### 2.4 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 (for example, see NRDC 2007 and Ocean Mammal Institute 2007). 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 of 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.

## 2.5 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.* 1995).

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 lower frequencies below 1000 Hz; however, is quite poor. On the other hand, the hearing sensitivity of most sea turtles appear 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 loud, low frequency noise than would dolphins.

Because ears adapted to function underwater are physiologically different from human ears, comparisons using decibels would still not be adequate to describe the effects of a sound on a whale. 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 signal will be at given range along a particular transmission path).

Sound tends to follow many paths through the ocean, so that a listener would hear multiple, delayed copies of transmitted signals (Richardson *et al.* 1995). 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. These are called acoustic rays. 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 are curved.

Sound speed in seawater is general 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.

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. As sound travels through the ocean, the intensity associated with the wavefront diminishes, or attenuates. 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 somple 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).

## 2.6 Action Area

The action area for this biological 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, Cheery 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**

# 3.0 Status of Listed Resources

NMFS has determined that the following species and critical habitat designations may occur in this action area for the proposed Atlantic Fleet Active Sonar Training Exercises:

| | | |
|---|---|---|
| Blue whale | *Balaenoptera musculus* | Endangered |
| Fin whale | *Balaenoptera physalus* | Endangered |
| Humpback whale | *Megaptera novaeangliae* | Endangered |
| North Atlantic right whale | *Eubalaena japonica* | Endangered |
| Sei whale | *Balaenoptera borealis* | Endangered |
| Sperm whale | *Physeter macrocephalus* | Endangered |
| Green sea turtle | *Chelonia mydas* | Threatened |
| Hawksbill sea turtle | *Eretmochelys imbricate* | |
| | Endangered | |
| Leatherback sea turtle | *Dermochelys coriacea* | Endangered |
| Loggerhead sea turtle | *Caretta caretta* | Threatened |

Critical habitat has also been designated for the northern right whale in the Atlantic Ocean in Cape Cod Bay, Great South Channel, and off Georgia and Florida (50 CFR 226.13). 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).

## 3.1 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 2009 to January 2014. The first criterion was *exposure* or some reasonable expectation of a co-occurrence betweeon 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 critical habitat is not likely to be adversely affected 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.

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 Atlantic Fleet Active Sonar Training exercises and, therefore, are not likely to be adversely affected by the proposed exercises.

**Critical Habitat**

Critical habitat has also been designated for the northern right whale in the Atlantic Ocean in Cape Cod Bay, Great South Channel, and off Georgia and Florida (50 CFR 226.13). 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 Atlantic Fleet Active Sonar Training. 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 biological opinion. We consider the critical habitat that has been designated for northern right whales further in this consultation.

## 3.2 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 2001, 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 is 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 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 2001). 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 2001). 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 3).

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 *et al.* 2001, McCarthy *et al.* 2001, Parry *et al.* 2007). 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 2. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from IPCC 2001 and Campbell-Lendrum Woodruff 2007)**

| 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 (2001) 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% 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 se 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 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.* 1986, 1990 and Weinrich 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 influences the abundance of marine mammal prey such as zooplankton and fish. In the 1970s and 1980s, the North Atlantic Oscillation Index have been positive and sea surface temperatures increased. These increased 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 NAO 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 (Pershing *et al.* 2001, Drinkwater *et al.* 2003). 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 NAO 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.

## 3.3 Introduction to this Status of Listed Species

The rest of this section of our Opinion consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the Atlantic Fleet 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 from January 2009 to Januiary 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 and critical habitat can be found in a number of published documents including status reviews, recovery plans for the blue whale (NMFS 1998a), fin whales (2007), fin and sei whale (NMFS 1998b, NMFS 2007), humpback whale (NMFS 1991a), right whale (NMFS 1991b), a status report on large whales prepared by Perry *et al.* (1999), recovery plans for sea turtles (NMFS and USFWS 1998a, 1998b, 1998c, 1998d, and 1998e), and recovery plans for listed salmon. Richardson *et al.* (1995) 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 (1994, 1996, 2000, 2003, 2005), and Richardson *et al.* (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this Opinion.

### 3.3.1 Blue whale

#### Distribution

Blue whales are found along the coastal shelves of North America and South America (Rice 1974; Donovan 1984; Clarke 1980) 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 (Gambell 1985).

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, Wenzel *et al.*1988, Yochem and Leatherwood 1985, Gagnon and Clark 1993). 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 *et al.* 1987). In the eastern north Atlantic Ocean, blue whales have been observed off the Azores Islands, although Reiner *et al.* (1993) 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).

In the North Pacific Ocean, blue whales have been recorded off the island of Oahu in the main Hawai'ian Islands and off Midway Island in the western edge of the Hawai'ian Archipelago (Barlow *et al.* 1994b; Northrop *et al.* 1971; Thompson and Friedl 1982), although blue whales are rarely sighted in Hawai'ian waters and have not been reported to strand in the Hawai'ian Islands. Nishiwaki (1966) reported that blue whales occur in the Aleutian Islands and in the Gulf of Alaska. Although blue whales have not been observed off Alaska since 1987 (Leatherwood *et al.* 1982; Stewart *et al.* 1987; Forney and Brownell 1996). No distributional information exists for the western region of the North Pacific.

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 ddistinct (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 edge of Antarctic ice (south of 58° S) with concentrations between 60°-80° E and 66°-70° S (Kasamatsu *et al.* 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 Cole (1957, Futuyma (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 more than there may be more than one blue whale population in the Pacific Ocean (Gilpatrick *et al.* 1997, Barlow *et al.* 1995, Mizroch *et al.* 1984a, Ohsumi and Wada 1974). 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 (the southern whales forage off California; Sears *et al.*1987; Barlow *et al.*1997; Calambokidis *et al.* 1990).

A population or "stock" of endangered blue whales occurs in waters surrounding the Hawai'ian archipelago (from the main Hawai'ian 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 1998). However, acoustic monitoring has recorded blue whales off Oahu and the Midway Islands much more recently (Barlow *et al.* 1994, 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 (Thompson and Friedl 1982; McDonald and Fox 1999). Twelve aerial surveys were flown within 25 $nm^2$ of the main Hawai'ian 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 whales strandings in Hawai'ian 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 includes predation and disease (not necessarily in their order of importance). Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1920), 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.* 1999).

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 (Tønnessen and Johnsen 1982, Cherfas 1989). 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 1995).

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (NMFS 1998). Evidence of a population decline were evident 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.* 1984a).

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 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 have been implicated in the deaths of blue whales off California (Barlow *et al.* 1997). 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 *et al.* 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, Macfarlane 1981). The number of blue whales struck and killed by ships is unknown because the whales do not always strand or examinations of blue whales that have stranded did not identify the traumas that could have been caused by ship collisions. In the California/Mexico stock, annual incidental mortality due to ship strikes averaged 0.2 whales during 1991B1995 (Barlow *et al.* 1997), but we cannot determine if this reflects the actual number of blue whales struck and killed by ships.

**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 (Baillie and Groombridge 1996). 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 population 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 population numbers 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; U. S. Department of Commerce 1983). 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 between 1,400 to 1,900. Barlow and Calambokidis (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 1974) to 1,000 to 2,000 individuals (Sigurjónsson 1995). Gambell (1976) estimated there were between 1,100 to 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 (review by 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, Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales might 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

Generally, blue whales make 5-20 shallow dives at 12-20 second intervals followed by a deep dive of 3-30 minutes (Mackintosh 1965; Leatherwood *et al.* 1976; Maser *et al.* 1981; Yochem and Leatherwood 1985; Strong 1990; Croll *et al.* 1999). Croll *et al.* (1999) found that the dive depths of blue whales foraging off the coast of California during the day averaged 132 m (433 ft) with a maximum recorded depth of 204 m (672 ft) and a mean dive duration of 7.2 minutes. Nighttime dives are generally less than 50 m (165 ft) in depth (Croll *et al.* 1999).

Blue whales are usually found swimming alone or in groups of two or three (Ruud 1956, Slijper 1962, Nemoto 1964, Mackintosh 1965, Pike and MacAskie 1969, Aguayo 1974). However, larger foraging aggregations and aggregations mixed with other species like fin whales are regularly reported (Schoenherr 1991, Fiedler *et al.* 1998). 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, 1977; Edds 1982, Thompson and Friedl 1982; Edds-Walton 1997). Blue whales produce a variety of low frequency sounds in the 10-100 Hz band (Cummings and Thompson 1971, Edds 1982, Thompson and Friedl 1982, McDonald *et al.* 1995, Clark and Fristrup 1997, Rivers 1997). 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, 1977, 1994; Cummings and Fish 1972; Thompson *et al.* 1996; Rivers 1997; Tyack and Clark 1997; Clark *et al.* 1998).

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 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 blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Payne and Webb 1971, Edds-Walton 1997). 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.

### 3.3.1 Fin whale

#### 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 1985).

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 1985).

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 1985).

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 are 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.

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.

#### Population Structure

Fin whales have two recognized subspecies: *Balaoptera physalus physalus* (Linnaeus 1758) 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 demonstrate that individual fin whales migrate between management units (Mitchell 1974; Gunnlaugsson and Sigurjónsson 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 have lower genetic diversity, which suggests that these fin whales might represent an isolated population.

In its draft recovery plan for fin whales, NMFS recognized three populations in U.S. Pacific waters: Alaska (Northeast Pacific), California/Oregon/Washington, and Hawai'i (Barlow *et al.* 1997; Hill *et al.* 1997). We assume that individuals from the latter "population" of fin whales are the whales that would be exposed to the activities considered in this consultation.

### 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. Although 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, as cited in Perry *et al.* 1999). Killer whale or shark attacks may injure or kill very young or sick whales (Perry *et al.* 1999, Tomilin 1967).

ANTHROPOGENIC THREATS. Three human activities are known to threaten fin whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of fin whales and was ultimately responsible for listing fin whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing fin, blue (*Balaenoptera musculus*), and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. After blue whales were depleted in most areas, fin whales became the focus of whaling operations and more than 700,000 fin whales were landed in the Southern Hemisphere alone between 1904 and 1979 (IWC 1995).

As its legacy, whaling has reduced fin whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push fin whales closer to extinction. Otherwise, whaling currently does not threaten every fin whale population, although it may threaten specific populations.

From 1904 to 1975, the International Whaling Commission estimates that 703,693 fin whales captured and killed in Antarctic whaling operations (IWC 1990). Whaling in the Southern Oceans originally targeted humpback whales, but by 1913, those whales had became rare so whalers shifted their focus to fin and blue whales (Mizroch *et al.* 1984b). From 1911 to 1924, whalers killed 2,000–5,000 fin whales each year. After the introduction of factory whaling ships in 1925, the number of whales killed each year increased substantially: from 1931 to 1972, whalers killer about 511,574 fin whales (Kawamura 1994). In 1937 alone, whalers are reported to have killed more than 28,000 fin whales. From 1953 to 1961, the number of fin whales killed each year averaged around 25,000. In 1962, whalers appeared to shift their focus to sei whale as fin whales became scarce. By 1974, whalers killed fewer than 1,000 fin whales.

Recently released Soviet whaling records indicate a discrepancy between reported and actual fin whale catch numbers by whalers from the former USSR in southern waters between 1947 and 1980 (Zemsky *et al.* 1995). The former USSR previously reported 52,931 whales caught; however, the data that was released recently suggests that only 41,984 were killed.

In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit. The Japanese whalers plan to kill 50 fin whales per year starting in the 2007-2008 season and continuing for the next 12 years.

Fin whales are also hunted in subsistence fisheries off West Greenland. In 2004, 5 males and 6 females were killed and landed; 2 other fin whales were struck and lost in the same year. In 2003 2 males and 4 females were landed and 2 other fin whales 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 (IWC 2005), however, the IWC's Scientific Committee recommended limiting the number of fin whale killed in this fishery to 1 to 4 individuals until accurate population estimates are produced.

Despite anecdotal observations from fishermen which suggest that large whales swim through their nets rather than get caught in them (NMFS 2000), fin whales have been entangled by fishing gear off Newfoundland and Labrador in small numbers: a total of 14 fin 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 14 fin whales, 7 are known to have died as a result of that capture, although most of the animals that died were less than 15 meters in length (Lien 1994). Between 1999 and 2005, there were 10 confirmed reports of fin whales being entangled in fishing gear 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, Fin whales were injured in 1 of the entanglements and killed in 3 entanglements. These data suggest that, despite their size and strength, fin whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

Fin whales are also killed and injured in collisions with vessels more frequently than any other whale. Of 92 fin whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 31 (33%) showed evidence of collisions with ships (Laist *et al.* 2001). Between 1999 and 2005, there were 15 reports of fin 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 11 fin whales.

Ship strikes were identified as a known or potential cause of death in 8 (20%) of 39 fin whales that stranded on the coast of Italy in the Mediterranean Sea between 1986 and 1997 (Laist *et al.* 2001). Throughout the Mediterranean Sea, 46 of the 287 fin whales that are recorded to have stranded between 1897 and 2001 were confirmed to died from injuries sustained by ship strikes (Panigada *et al.* 2006). Most of these fin whales (n = 43), were killed between 1972 and 2001 and the highest percentage (37 of 45 or ~82%) killed in the Ligurian Sea and adjacent waters, where the Pelagos Sanctuary for Marine Mammals was established. In addition to these ship strikes, there are numerous reports of fin whales being injured as result of ship strikes off the Atlantic coast of France and the United Kingdom (Jensen and Silber 2003).

#### Status

Fin whales were listed as endangered under the ESA in 1970. In 1976, the IWC protected fin whales from commercial whaling (Allen 1980). Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). 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 population prior to whaling and (2) estimates of the current size of the different fin whale populations vary widely (NMFS 2007). We may never know the size of the fin whale population 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% 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 2007); however, the recovery plan also states that this estimate, which is based on 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 2006, 2007). 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% since the early 1980s.

The East Greenland-Iceland fin whale population was estimated at 10,000 animals (95 % 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% 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% 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, 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 dive lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985). 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 1981).

In waters off the Atlantic Coast of the U.S. individual fin whales or pairs represented about 75% 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% 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 (Watkins 1981; Watkins *et al.* 1987a; Edds 1988; Thompson *et al.* 1992). 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; Watkins *et al.* 1987a; Thompson *et al.* 1992; McDonald *et al.* 1995). 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 (Clark 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, Clark personal communication, McDonald personal communication). 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.* 1987a), while the individual counter-calling data of McDonald *et al.* (1995) suggest that the more variable calls are contact calls. Some authors feel there is 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 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 (Payne and Webb 1971; Edds-Walton 1997). 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).

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.

### 3.3.2 Humpback Whale

#### 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 (Tomlin 1967, Nemoto 1957, Johnson and Wolman 1984 as cited in NMFS 1991b). 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 coast of Norway in the Barents Sea. These humpback whales migrate to the western coast of Africa and the Caribbean Sea during the winter.

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).

#### 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.

NORTH PACIFIC OCEAN. 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 Hawai'ian 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.

A "population" of humpback whales winters in an area extending from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Based on whaling records, humpback whales wintering in this area have also occurred in the southern Marianas through the month of May (Eldredge 1991). There are several recent records of humpback whales in the Mariana Islands, at Guam, Rota, and Saipan during January through March (Darling and Mori 1993; Eldredge 1991, 2003; Taitano 1991). During the summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2007, Calambokidis 1997, 2001).

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.* 1999). The principal breeding range for these whales lies from the Antilles and northern Venezuela to Cuba (Winn *et al.* 1975, Balcomb and Nichols 1982, Whitehead and Moore 1982). 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, Clapham *et al.* 1993b, Mattila *et al.* 1994, Palsbøll *et al.* 1997, Smith *et al.* 1999, Stevick *et al.* 2003a). 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 (Winn *et al.* 1975, Levenson and Leapley 1978, Swartz *et al.* 2003). Winter aggregations also occur at the Cape Verde Islands in the Eastern North Atlantic (Reiner *et al.* 1996, Reeves *et al.* 2002, Moore *et al.* 2003). 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 (Dolphin 1989, Florez-González *et al.* 1984, 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.* 1999). 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 Hawai'ian 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 Hawai'ian waters; 16 of these reports were from 2005 and 2006.

Many of the entangled humpback whales observed in Hawai'ian 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 Hawai'ian Islands have been confirmed to have been entangled in gear from Alaska. Nevertheless, humpback whales are also entangled in fishing gear in the Hawai'ian Islands. Since 2001, there have been 5 observed interactions between humpback whales and gear associated with the Hawai'i-based longline fisheries (NMFS 2008). 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%) 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 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, South Africa,

#### Status

Humpback whales were listed as endangered under the ESA in 1973. Humpback whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). 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% 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; Darling and Morowitz 1986; Baker and Herman 1987). 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.* 1999).

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 Hawai'ian 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% 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, 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 Hawai'ian 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). Dives on feeding grounds ranged from 2.1-5.1 min in the north Atlantic (Goodyear unpublished manuscript). 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). In the Gulf of California humpback whale dive times averaged 3.5 min (Strong 1989). 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 (1986) 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, 1996), and calving areas (Tyack 1981). 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). Intermale 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 B 4 kHz with estimated source levels from 144 B 174 dB, which are mostly produced by males on breeding areas (Payne 1970, Winn *et al.* 1970, Richardson *et al.* 1995); (2) social sounds in breeding areas that extend from 50 Hz B more than 10 kHz with most energy below 3 kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); 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 (Thompson *et al.* 1986, Richardson *et al.* 1995). 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 (Tyack 1983, Silber 1986). 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 fin 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 2000; U.S. Navy 2006a; Payne 1970; Winn *et al.* 1970a; Richardson *et al.* 1995)
2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3 kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); 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 μPa-m (Thompson *et al.* 1986; Richardson *et al.* 1995).

Helwig *et al.* (2000) produced a mathematical model of a humpback whale's 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.

## North Atlantic Right Whale

### 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 *et al.* 1986, Payne *et al*. 1990), and off Georgia and Florida from mid-November through March (Slay *et al*. 1996). 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*. 1999).

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

NATURAL THREATS. 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 (1975) 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 (1975) 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 fin whales and was ultimately responsible for listing fin 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 (n = 18; 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 (n = 18; Cole *et al*. 2005, Nelson *et al*. 2007). Of the 17 reports that NMFS could confirm, right whales were injured 2 of the ship strikes and killed in 9.

**Status**

Right whales (both *E. glacialis* and *E. australis*) were listed as endangered under the ESA in 1970. In April, 2008, NMFS divided right whales into three separate listings: Northern 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 northern 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 and the MMPA. NMFS designated critical habitat for the North Atlantic population of right whales on 3 June 1994 (59 FR 28793).

In the Atlantic Ocean, Knowlton *et al*. (1994) concluded, based on data from 1987 through 1992, that the western North Atlantic right whale population was growing at a net annual rate of 2.5% (coefficient of variation = 0.12). This rate was also used in NMFS' marine mammal Stock Assessment Reports (e.g., Blaylock *et al*. 1995; Waring *et al.*, 1997). Since then, the data used in Knowlton *et al.* (1994) have been re-evaluated, and new attempts to model the trends of the western North Atlantic right whale population have been published (e.g., Kraus 1997, Caswell *et al*. 1999).

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% 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 Caswell *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*. (2008) reviewed the data from the recapture database and estimated that the right whale population in the western North Atlantic Ocean numbers about 325 whales. Nevetheless, a population of about 300 individuals is sufficiently small for the population to experience demographic phenomena such as demographic stochasticity, inbreeding depression, 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 northern 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 northern 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 northern 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.* 1994). 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).

Northern 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 (Matthews et al., 2001; Laurinolli et al., 2003; Vanderlaan et al., 2003; Parks et al., 2005; Parks and Tyack, 2005). 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 ommunication 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 range 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 (2005) 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 a*l. 2004, Parks and Tyack 2005, Parks *et al*. 2007). In addition, Parks *et al*. (2007) estimated the functional hearing range for right whales to be 15 Hz to 18 kHz.

### 3.3.3 Sei Whale

#### 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.* 1999). 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.* 2004).

In the western Atlantic Ocean, sei whales occur from Labrador, Nova Scotia,and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985, 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 1985).

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; Gambell 1985). Horwood (1987) reported that 75 - 85% 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 1975).

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 (Horwood 1987, Perry *et al.* 1999). 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 more scarce. 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 3 sei whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 2 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 fin whales were given full protection in 1976 (Allen 1980). 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 (Baillie and Groombridge 1996). 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 Fukuda (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 (IWC 1977, Mitchell and Chapman 1977).

About 50 sei whales are estimated to occur in the North Pacific "stock" with another 77 sei whales in the Hawai'ian "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 (1975) 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, Allee effects, among others, that cause their population size to become a threat in and of itself) or if sei whales might 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. Several authors have reported "invasion years" in which large numbers of sei whales appeared off areas like Norway and Scotland, followed the next year by sudden decreases in population numbers (Jonsgård and Darling 1974).

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 and Holmes 2006, Fagan *et al.* 1999, 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 1985). 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 1985).

#### 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 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*. 1995).

During visual and acoustic surveys conducted in the Hawai'ian 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 vocalization 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 Hawai'ian 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 2007a). 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*. 2001)

A general description of the anatomy of the ear for cetaceans is provided in the preceding description of the fin whale.

### 3.3.4 Sperm Whale

#### 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 (Gunnlaugsson and Sigurjonsson 1990, Oien 1990, Christensen *et al.* 1992).

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 Demma 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 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. However, 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 migrate into the Aleutian Islands, Gulf of Alaska, and the Bering Sea.

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 (135-180 feet; Scott and Sadove 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

The population structure of sperm whales is largely unknown. Lyrholm and Gyllenstein (1998) reported moderate, but statistically significant, differences in sperm whale mitochondrial (mtDNA) between ocean basins, although sperm whales throughout the world appear to be homogenous genetically (Whitehead 2003). Genetic studies also suggest that sperm whales of both genders commonly move across over ocean basins and that males, but not females, often breed in ocean basins that are different from the one in which they were born (Whitehead, 2003).

Sperm whales may not form "populations" as that term is normally conceived. Jaquet (1996) outlined a hierarchical social and spatial structure that includes temporary clusters of animals, family units of 10 or 12 females and their young, groups of about 20 animals that remain together for hours or days, "aggregations" and "super-aggregations"

of 40 or more whales, and "concentrations" that include 1,000 or more animals (Peterson 1986, Whitehead and Wiegart 1990, Whitehead *et al.* 1991). The "family unit" forms the foundation for sperm whale society and most females probably spend their entire life in the same family unit (Whitehead 2002). The dynamic nature of these relationships and the large spatial areas they are believed to occupy might complicate or preclude attempts to apply traditional population concepts, which tend to rely on group fidelity to geographic distributions that are relatively static over time.

### 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 (1975) reported one sperm whale that was tagged on the Scotian Shelf and killed about 7 years later off Spain. 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 (Schmidly 1981, Fritts 1983, and Hansen *et al.* 1995), although the International Whaling Commission groups 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 and Demma 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.

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.* 1999).

Pacific Ocean

Several authors have proposed population structures that recognize at least three sperm whales populations in the North Pacific for management purposes (Kasuya 1991, Bannister and Mitchell 1980). 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 Hawai'ian Islands throughout the year and are the most abundanct large whale in waters off Hawai'i during the summer and fall (Rice 1960, Shallenberger 1981, Lee 1993, and Mobley *et al.* 2000). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawai'ian 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 Hawai'ian 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.*1999, Forney *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 Hawai'ian 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 Hawai'ian 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 (Rice 1977, Wade and Gerrodette 1993, and Dufault and Whitehead 1995).

**Threats to the Species**

NATURAL THREATS. 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, Rice 1989, Weller *et al.* 1996, Whitehead 1995). Sperm whales have been observed with bleeding wounds their heads and tail flukes after attacks by these species (Arnbom *et al.* 1987, Dufault and Whitehead 1995). 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 (Lambertson *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 (Smith and Latham 1978, Lambertsen *et al.* 1987). In some instances, these diseases have been demonstrated to affect 10 percent of the sperm whales sampled (Lambertsen *et al.* 1987).

ANTHROPOGENIC THREATS. 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.* (1999) 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 and Zemsky 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 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. Berzin noted in a report he wrote in 1977, "the result of this was that some breeding areas for sperm whales became deserts" (Berzin 2007).

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. The consequences of these deaths on the status and trend of sperm whales remains uncertain, given that they probably have not recovered from the legacy of whaling; however, the renewal of a program that intentionally targets and kills sperm whales before we can be certain they recovered from a history of over-harvest places this species at risk in the foreseeable future.

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 *et al.* 1997). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). 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 and DeMaster 1998). 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 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.* 1999), 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.* 1999). 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 (2002) is about 20% 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.

Barlow and Taylor (2005) derived two estimates of sperm whale abundance in a 7.8 million $km^2$ study area in the northeastern temperate Pacific: when they used acoustic detection methods they produced an estimate of 32,100 sperm whales (coefficient of variation = 0.36); when they used visual surveys, they produced an estimate of 26,300 sperm whales (coefficient of variation = 0.81). Caretta *et al.* (2005) concluded that the most precise estimate of sperm whale abundance off California, Oregon, and Washington was 1,233 (coefficient of variation = 0.41; based on ship surveys conducted in the summer and fall of 1996 and 2001). Their best estimate of the abundance of sperm whales in Hawai'i was 7,082 sperm whales (coefficient of variation = 0.30) based on ship-board surveys conducted in 2002.

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% 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.

The information available on the status and trend of sperm whales do not allow us to make 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 female 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 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).

#### 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 (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). 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 (Norris and Harvey 1972; Cranford 1992; but see Clarke 1979). 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 (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). 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 and Schevill 1975; Watkins *et al.* 1985). 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.

### 3.3.6 Green Sea Turtle

#### 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°C 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. An east Pacific green turtle equipped with a satellite transmitter was tracked along the California coast and showed a distinct preference for waters with temperatures above 20°C (Eckert, unpublished data).

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 1998). 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 2000).

#### 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; Seminoff 2002, NMFS and USFWS 1998a).

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 (Seminoff 2002).

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 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 like 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 Hawai'ian 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). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs *et al.* 1998). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawai'ian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a

tumor promoter, okadaic acid (Landsberg *et al.* 1999). Fibropapillomatosis is considered to decrease growth rates in afflicted turtles and may inhibit the growth rate of Hawai'ian green turtle populations (Balazs *et al.* 1998).

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 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 (Bräutigam and Eckert 2006); the turtle fishery along the Caribbean coast of Nicaragua, by itself, captures more than 11,000 green sea turtles each year for the past 10 years (Bräutigam 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 1998a).

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 (see Table X). 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.

### 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% to 58% over the last three generations (approximately 150 years) although actual declines may be closer to 70% to 80%. 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% 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% and 88% since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50% 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 2002).

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 2002). 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 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, Allee effects, among others, that cause their population size to become a threat in and of itself) or if green sea turtles might 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 Hawai'ian 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.

### 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 1998). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson 1967 *in* 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 (2006) 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 freqnencies 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966).

### 3.3.7 Leatherback Sea Turtle

#### 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.

Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale *et al.* 1994, Eckert 1998, Eckert 1999a). 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 1998). 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 1996). 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, and the Andaman and Nicobar Islands.

#### 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. 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.

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 1997).

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% mortality rate (or 33% 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 2008). 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 (Castroviejo *et al.* 1994; Graff 1995). 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 *et al.* 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio, 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% (Eckert and Lien, 1999). 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 (NMFS 2001). 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% of the eggs laid have been harvested. Eckert (1996) and Spotila *et al.* (1996) 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.

**Status**

The leatherback turtle is listed as endangered under the ESA throughout its 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% 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 and Girondot, 1998). 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 1996), but is now estimated to number less than 3,000 total adult and subadult animals (Spotila 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% 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 2000). In the western Pacific, the decline is equally severe. Current nestings at Terengganu, Malaysia represent 1% 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 % 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 (Spotila *et al.* 1996, NMFS and USFWS 1998, 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 (Sarti *et al.* 1996, Eckert, 1997).

Based on recent modeling efforts, some authors concluded that leatherback turtle populations cannot withstand more than a 1% 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 internesting intervals and during the 1995 through 1998 nesting seasons. The turtles dived continuously for the majority of their time at sea, spending 57 - 68% 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% 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, Ridgway *et al.* 1969).

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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966).

### 3.3.8 Loggerhead Sea Turtle

#### 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 (*in* NMFS and USFWS 1998).

#### 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 are usually based on the distribution of their nesting aggregations (see Table 5). 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% of the loggerhead nests in the western North Atlantic, comprise more between 25 and 59% of the loggerhead sea turtles captured in foraging areas from Georgia to waters of the northeastern United States (Bass *et al.* 1998, Norrgard 1995, Rankin-Baransky 1997, Sears 1994, Sears *et al.* 1995). About 10% 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% of the loggerhead sea turtles captured) and the Mediterranean Sea (where they represent about 45-47% of the loggerhead sea turtles captured).

**Table 5. Nesting populations of loggerhead sea turtles that have been identified using molecular genetics (after Hutchinson and Dutton 2007)**

| Ocean Basin | Population |
|---|---|
| **Atlantic (eastern)** (the Cape Verde rookeries appear to be genetically distinct, the other rookeries listed have not been evaluated) | |
| 1 | Cape Verde |
| 2 | Greece |
| 3 | Libya |

| | |
|---|---|
| 4 | Turkey |
| 5 | West African coast |
| **Atlantic (western) and Caribbean** | |
| 6 | Northern (U.S.) including rookeries from southern Virginia south to Florida |
| 7 | Florida peninsula which includes rookeries from the northeastern border of Florida south to southwestern Florida |
| 8 | Dry Tortugas, which includes the islands of Key West |
| 9 | Northern Gulf of Mexico, which extends from northwestern Florida into Texas |
| 10 | Cay Sal bank in thee western Bahamas |
| 11 | Quintana Roo, which includes all rookeries on Mexico's Yucatan Peninsula |
| 12 | Brazil |
| 13 | Additional rookeries in Caribbean Central America, the Bahamian Archipelago, Cuba, Colombia, Venezuela, and the eastern Caribbean Islands have not been classified |
| **Indian Ocean** (none of these rookeries have been evaluated genetically) | |
| 14 | Oman |
| 15 | Yemen |
| 16 | Sri Lanka |
| 17 | Madagascar |
| 18 | South Africa and (possibly) Mozambique |
| **Pacific Ocean** | |
| 19 | Western Australia |
| 20 | Eastern Australia, which may include rookeries from New Caledonia |
| 21 | North Pacific or Japan, which includes all rookeries in the Japanese Archipelago |
| 22 | Solomon Islands |

### Threats to the Species

NATURAL THREATS. 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 hawksbill 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 growth of populations 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 represents 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 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 combine to capture about 2,000 loggehead 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.* 1994, Crouse 1999). 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.

**Table 4. Number of different species of sea turtles that NMFS expected to be "taken" (generally captured and harassed, harmed, wounded, or killed) and the number that are expected to be killed in commercial fisheries managed by NMFS off the Atlantic Coast, based on numbers contained in incidental take statements in biological opinions on those fisheries. Numbers are generally annual estimates (after Griffin *et al*. 2006)**

| Fishery | NMFS Region | Loggerhead | | Leatherback | | Green | | Hawksbill | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Take | # Killed | Total Take | # Killed | Total Take | # Killed | Total Take | # Killed | Total Take | # Killed |
| Bluefish | NER | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 3 |
| Deep-sea red crab | NER | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 2 |
| Herring | NER | 6 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 8 | 5 |
| Jonah crab | NER | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 2 |
| Lobster | NER | 2 | 2 | 5 | 5 | 0 | 0 | 0 | 0 | 7 | 7 |
| Mackerel, squid, butterfish | NER | 6 | 3 | 1 | 1 | 2 | 2 | 0 | 0 | 9 | 6 |
| Monkfish | NER | 4 | 1 | 2 | 1 | 2 | 1 | 0 | 0 | 8 | 3 |
| Multispecies | NER | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 3 | 3 |
| Pound net (Virginia) | NER | 507 | 2 | 2 | 2 | 3 | 2 | 0 | 0 | 512 | 6 |
| Sea scallop | NER | 754 | 484 | 2 | 2 | 2 | 2 | 0 | 0 | 760 | 490 |
| Skate | NER | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 3 | 3 |
| Spiny dogfish | NER | 3 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 5 | 4 |
| Summer flounder, scup, sea bass | NER | 19 | 5 | 0 | 0 | 2 | 2 | 0 | 0 | 21 | 7 |
| Tilefish | NER | 6 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 7 | 4 |
| Dolphin fish and wahoo | SER | 12 | 2 | 12 | 1 | 2 | 1 | 2 | 1 | 28 | 5 |
| Atlantic pelagic | SER | 623 | 146 | 660 | 183 | 35 | 8 | 35 | 8 | 1353 | 345 |
| Sargassum | SER | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| Shark bottom longline and drift gillnet | SER | 274 | 151 | 34 | 18 | 6 | 1 | 6 | 1 | 320 | 171 |
| Pamlico Sound gillnet | SER | 41 | 3 | 2 | 2 | 168 | 46 | 2 | 2 | 213 | 53 |
| Shrimp trawling | SER | 163160 | 3948 | 3090 | 80 | 18757 | 514 | 0 | 640 | 185007 | 5182 |
| **Totals** | | **165429** | **4756** | **3778** | **292** | **18931** | **573** | **45*** | **652** | **188183** | **6273** |

***** The biological opinion on shrimp trawl fisheries did not estimate the number of hawksbill sea turtles that might be captured in the fisheries, although it estimated the number that might be killed. Obviously, the fisheries would have to capture at least 640 hawksbill sea turtles to kill that many sea turtles

**Status**

The most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year: South Florida (U.S.) and Masirah Island (Oman). The status of the Oman nesting colony has not been evaluated recently so the current size of this population and its trend are unknown. Nesting colonies in the U.S. have been reported to produce 68,000 to 90,000 nests per year. Recent analyses of nesting data from southeast Florida nesting colonies, which are the largest nesting colonies in the western Atlantic Ocean, suggest that this nesting population is declining. Long-term nesting data suggest similar declines in loggerhead nesting in North Carolina, South Carolina, and Georgia.

In the Eastern Atlantic, the Cape Verde Islands support an intermediately-sized loggerhead nesting colony. In 2000, researchers tagged over 1,000 nesting females on just 5 km (3.1 mi) of beach on Boavista Island (Ehrhart *et al.* 2003). In the Western Atlantic (excluding the U.S.), Brazil supports an intermediately-sized loggerhead nesting assemblage. Published and unpublished reports provide an estimate of about 4,000 nests per year in Brazil (Ehrhart *et al.* 2003). Loggerhead nesting throughout the Caribbean is sparse.

In the Mediterranean, loggerhead nesting is confined almost exclusively to the eastern portion of the Mediterranean Sea. The main nesting assemblages occur in Cyprus, Greece, and Turkey. However, small numbers of loggerhead nests have been recorded in Egypt, Israel, Italy, Libya, Syria, and Tunisia. Based on the recorded number of nests per year in Cyprus, Greece, Israel, Tunisia, and Turkey, loggerhead nesting in the Mediterranean ranges from about 3,300 to 7,000 nests per season (Margaritoulis *et al.* 2003). Loggerheads nest throughout the Indian Ocean and, with the exception of Oman, the number of nesting females is small. Most trends in loggerhead nesting populations in the Indian Ocean are unknown.

Loggerhead populations in Honduras, Mexico, Colombia, Israel, Turkey, Bahamas, Cuba, Greece, Japan, and Panama have been declining. Balazs and Wetherall (1991) speculated that 2,000 to 3,000 female loggerheads may nest annually in all of Japan; however, more recent data suggest that only approximately 1,000 female loggerhead turtles may nest there (Bolten *et al.* 1996; Sea Turtle Association of Japan 2002). Monitoring of nesting beaches at Gamoda (Tokushima Prefecture) has been ongoing since 1954. Surveys at this site showed a marked decline in the number of nests between 1960 and the mid-1970s. Since then, the number of nests has fluctuated, but has been downward since 1985 (Bolten *et al.* 1996; Sea Turtle Association of Japan 2002). Monitoring on several other nesting beaches, surveyed since the mid-1970s, revealed increased nesting during the 1980s before declining during the early 1990s. The number of nests at Gamoda remains very small, fluctuating between near zero (1999) to about 50 nests (1996 and 1998; Kamezaki *et al.* 2003).

Scattered nesting has also been reported on Papua New Guinea, New Zealand, Indonesia, and New Caledonia; however, population sizes on these islands have not been ascertained. Survey data are not available for other nesting assemblages in the south Pacific (NMFS and USFWS 1998). In addition, loggerheads are not commonly found in U.S. Pacific waters, and there have been no documented strandings of loggerheads off the Hawai'ian Islands in nearly 20 years (1982-1999 stranding data, G. Balazs, NMFS, personal communication, 2000). There are very few records of loggerheads nesting on any of the many

islands of the central Pacific, and the species is considered rare or vagrant on islands in this region (NMFS and USFWS 1998).

For several years, NMFS' biological opinions have established that most loggerhead sea turtles populations 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 loggerhead 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.

The information available suggests that loggerhead 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 nesting aggregations of loggerhead sea turtles in the Pacific Ocean 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) as evidenced by biases in the male to female ratios in the Pacific. These small sizes would increase the extinction probability of these nesting aggregations.

The status of loggerhead sea turtles in the Atlantic Ocean remains uncertain and controversial. For years, the south Florida nesting aggregation, which is the only major nesting aggregation in the western Atlantic Ocean, had been assumed to be stable or increasing. However, more recent data demonstrate that this nesting population is currently declining and probably has been declining for several years. Between 1998 and 2007, nest counts of loggerhead sea turtles in the State of Florida have declined by almost 50 percent to the lowest levels in the 19 years of Florida's monitoring program (Fish and Wildlife Research Institute 2007). Given that (1) the nesting aggregations that account for almost 90 percent of loggerhead nesting in the western Atlantic Ocean are declining, (2) the other nesting aggregations in the western Atlantic Ocean are substantially much smaller, and (3) large numbers of sea turtles from these smaller populations are captured or killed in commercial and other fisheries in the United States each year, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic Ocean are only slightly lower than those of populations in the Pacific Ocean. The principle difference between the Atlantic and the Pacific may be this: loggerhead sea turtle populations in the Atlantic Ocean may currently be large enough to avoid the small population dynamics we have discussed previously, but the intensity of the anthropogenic pressure on their populations (in the form of numbers captured and killed in fisheries alone) appear to be large enough to accelerate the extinction probabilities of these populations.

#### 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 (Sakamoto *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. Analysis of the dive data indicate that most of the dives were very shallow - 70% of the dives were no deeper than 5 meters. In addition, the loggerheads spent approximately 40% of their time in the top meter and nearly all of their time at depths shallower than 100 meters. On 5% 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966).

### 3.3.9 Designated Critical Habitat for North Atlantic Right Whales

Five areas have been reported to be critical to the survival and recovery of North Atlantic right whales: (1) coastal Florida and Georgia; (2) the Great South Channel, which lies east of Cape Cod; (3) Cape Cod and Massachusetts Bays; (4) the Bay of Fundy; and (5) Browns and Baccaro Banks off southern Nova Scotia. The first three areas occur in U.S. waters and have been designated by NMFS as critical habitat (59 FR 28793). 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 *et al*. 1986, Payne *et al*. 1990), and off Georgia/Florida from mid-November through March (Slay *et al*. 1996). Right whales also frequent the Bay of Fundy, Browns and Baccaro Banks (in Canadian waters), Stellwagen Bank and Jeffrey's Ledge in spring and summer months and use

mid-Atlantic waters as a migratory pathway between winter calving grounds and their spring and summer nursery/feeding areas in the Gulf of Maine. A recent review and comparison of sighting data suggests that Jeffrey's Ledge may also be regularly used by right whales in late fall (October through December; Weinrich *et al*. 2000).

The availability of dense concentrations of zooplankton blooms in Cape Cod Bay in late winter and the Great South Channel in spring is described as the key factor for right whale utilization of these areas. Kraus and Kenney (1991) provide an overview of data regarding right whale use of these areas. Important habitat components in Cape Cod Bay include seasonal availability of dense zooplankton patches and protection from weather afforded by land masses surrounding the bay. The spring current regime and bottom topography of the Great South Channel result in nutrient rich upwelling conditions. These conditions support the dense plankton and zooplankton blooms utilized by right whales. The combination of highly oxygenated water and dense zooplankton concentrations are optimal conditions for the small schooling fishes (sand lance, herring and mackerel) that prey upon some of the same zooplankton as right whales. Therefore, the abundance of these fishes, in turn, may affect and be affected by the distribution of several piscivorous marine mammal species such as humpback, fin, minke, and pilot whales, Atlantic whitesided dolphins, and harbor porpoise (CeTAP 1982).

Overfishing has severely reduced the stocks of several groundfish species such as cod, haddock, and yellowtail flounder. Recovery of commercially targeted finfish stocks from their current overfished condition may reduce the biomass of small schooling fish that feed directly on zooplankton resources throughout the region. It is unknown whether zooplankton densities that occur seasonally in Cape Cod Bay or the Great South Channel could be expected to increase significantly. However, increased predation by groundfish on small schooling fish in certain areas and at specific critical periods may allow the necessary high zooplankton densities to be maintained in these areas for longer periods, or accumulate in other areas at levels acceptable to right whales.

Fishing is allowed within the Cape Cod Bay and Great South Channel right whale critical habitat. Lobster trap gear and anchored gillnet gear are believed to pose the most serious risks of entanglement and serious injury to right whales frequenting these waters. As a result, regulations developed under the ALWTRP restrict the use of lobster and anchored gillnet gear in Cape Cod Bay and Great South Channel critical habitat. The most restrictive measures apply during peak right whale abundance: January 1 to May 15 in Cape Cod Bay, and April 1 to June 30 in the Great South Channel critical habitat. Measures include prohibitions on the use of lobster trap gear and anchored gillnet gear in the Great South Channel critical habitat during periods of peak right whale abundance (with the exception of gillnet gear in the Great South Channel Sliver Area), and, for Cape Cod Bay critical habitat, anchored gillnet gear prohibitions and lobster trap restrictions during peak right whale abundance. During non-peak periods of right whale abundance, lobster trap and gillnet fishers must modify their gear by using weak links in net and/or buoy lines, follow gillnet anchoring requirements and meet mandatory breaking strengths for buoy line weak links, amongst others. Additional measures (i.e., gear marking requirements, and prohibitions on the use of floating line and the wet storage of gear) apply within as well as outside of critical habitat. All of these measures are

intended to reduce the likelihood of whale entanglements or the severity of an entanglement should an animal encounter anchored gillnet or lobster gear.

The critical habitat identified in the Southeast U.S. is used primarily as a calving and nursery area. The nearshore waters of northeast Florida and southern Georgia were formally designated as critical habitat for right whales on June 3, 1994 (59 FR 28793); ten years after they were first identified as a likely calving and nursery area for right whales. Since that time, 74 percent of all known, mature female North Atlantic right whales have been documented in this area (Kraus et al., 1993). While sightings off Georgia and Florida include primarily adult females and calves, juveniles and adult males have also been observed.

# 4.0 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 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 populations. The following discussion summarizes the principal phenomena that are known to affect the likelihood that these endangered whales will survive and recover in the wild.

**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 (Lambertson *et al.* 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). Evidence of ice entrapment and predation by killer whales has been documented in almost every population of bowhead whales although the percentage of whales entrapped in ice is considered to be small in this strongly ice-associated species (Tomilin 1957; Mitchell and Reeves 1982; Nerini *et al.* 1984; Philo *et al.* 1993). 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 Hawai'ian 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.* occurred between 1957 and 1959, 3 of 8 occurred in 1976, and 1 occurred in 1981). Nevertheless, we discuss possible relationships between stranding events in Hawai'i and the Rim of the Pacific exercises in the *Effects of Action* section of this biological opinion.

### Human-Induced Mortality

#### Commercial Whaling and Subsistence Hunting

Large whale population numbers in the proposed action areas 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.* 1999). Sei whales are estimated to have been reduced to 20% (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 (Rice 1984); and 25,800 sperm whales (Barlow *et al* 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 proposed action areas, historical whaling may have altered the age structure and social cohesion of these species in ways that continue to influence them.

#### 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 each year and kill about 5,000 of the turtles captured. Loggerhead sea turtles account for most of this total: each 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 coast of the southeast coast Sorth Carolina and 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 1 northern right whale, 2 humpback whales, and two sperm whales. Between 1992 ad 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 (see Table 4), 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.

### 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 Specifically, 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 support 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.[1] This amount of traffic increases the probability of collisions between commercial ships, whales, and sea turtles.

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

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.* 1991 1994).

Very little is known about baseline levels and physiological effects of environmental contaminants on marine turtle populations (Witkowski and Frazier 1982, Bishop *et al.* 1991). There are a few isolated studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Davenport and Wrench 1990, Aguirre *et al.* 1994). 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 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 (Ross *et al*. 1995, Harder *et al.* 1992, De Swart *et al.* 1996). 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 (Borell, 1993, O'Shea and Brownell 1994, O'Hara and Rice 1996, O'Hara *et al.* 1999).

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*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. Annual capture levels from 1994 - 1997 have ranged from almost 200 to almost 700 green turtles and from about 150 to over 350 loggerheads. Almost all of the turtles are caught and released alive; NMFS estimates the survival rate at 98.5% or greater (1997e). 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, that 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.* 1995).

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 1994, 1996, 2000, 2003, 2005; Richardson *et al.* 1995). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). 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 2003). 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.* 1995). 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, Hall 1982, Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta *et al.* (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 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. Ross (1976) 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 21$^{st}$ century. NRC (1997) 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.

Michel *et al.* (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with shipping. At lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background.

*US Navy Activities*. In 1997, NMFS issued a biological opinion on Navy training activities within and in the vicinity of the Atlantic Ocean right whale critical habitat 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 leatherbacks, and 12 greens or Kemp's ridley, in combination (NMFS 1997). The Navy ship-shock trials for the USS WINSTON S CHURCHILL was conducted in the proposed Action Area, 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.

*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. Annual capture levels from 1994 - 1997 have ranged from almost 200 to almost 700 green turtles and from about 150 to over 350 loggerheads. Almost all of the turtles are caught and released alive; NMFS estimates the survival rate at 98.5% or greater (1997e). 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, that 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.

*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.

#### 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 proposed action area. 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 (CMC and 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 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

#### Recovery Actions

Several agencies have engaged in 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.

#### 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.

These fisheries 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 of that capture; about 19,000 leatherback sea turtles would be captured, with about 1,500 of them dying; 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. Given that we are certain that nest counts of species like loggerhead sea turtles have been declining and are currently declining, these additional mortalities seem likely to increase the rate at which nesting aggregations of this species are declining. Even if these mortalities did not increase the rate at which these nesting aggregations are declining, merely continuing the rate at which they are currently declining would be sufficient to increase the probability of nest counts in these nesting aggregations to decline to zero. Because we know that populations of sea turtles cannot increase over time if the number of nest counts decline, the mortalities associated with these fisheries are likely to increase probability of these populations of sea turtles becoming extinct in the wild.

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 Northern 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 an 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 remains 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 be 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 (Richardson et. al, 1985; Malme *et al*. 1983). 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 *et 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 (2004) 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.

# 5.0 Effects of the Proposed Action

In *Effects of the Action* sections of Opinions, NMFS presents the results of its assessment of the probable direct and indirect effects of federal actions that the subject of a consultation as well as the direct and indirect effects of interrelated, and interdependent actions on threatened and endangered species and designated critical habitat. As we described in the *Approach to the Assessment* section of this Opinion, we organize our effects' analyses using an 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 Base* 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.

Before we begin, we need to address a few definitions. 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 disrupts or is likely to disturb a marine mammal or marine mammal stock by causing disruption 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.[3]

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 concerned about changes in animal behavioral that is likely to result in animals that fail to

[3] 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)

feed, fail to breed successfully, or fail to complete their life history because those changes may have adverse consequences for populations of those species.

## 5.1 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. As a result, it is more accurate to say that 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) System; (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.

### 5.1.1 Surface Vessel Traffic

Most of the activities the U.S. Navy proposes to active sonar training activities 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 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 seem fairly small given the measures that are in place, 20 to 60 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. Particularly 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*. Studies of interactions between surface vessels and marine mammals have demonstrated that surface vessels represent a source of acute and chronic disturbance for marine mammals (Au and Green 1990, Au and Perryman 1982, Bain *et al.* 2006, Bauer 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, Erbé 2000, Félix 2001, Goodwin and Cotton 2004, Hewitt 1985, Lemon *et al.* 2006, Lusseau 2003, 2006; Lusseau and Bejder 2007, Magalhães *et al.* 2002, Ng and Leung 2003, Nowacek *et al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *et al.* 1998). Specifically, in some circumstances, marine mammals respond to vessels with the same behavioral repertoire and tactics they employ when they encounter predators.

These studies establish that free-ranging cetaceans 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 (Goodwin and Green 2004; Lusseau 2006). Several, authors, however, suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jackson 1994, Evans *et al.* 1992, 1994), so we may not be able to treat the effects of vessel traffic as independent of engine and other sounds associated with the vessels.

For surface vessels, the set of variables that help determine whether marine mammals are likely to be disturbed 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. 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 vertical avoidance behavior (see Response Analyses for further discussion);

2. *the distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction;

3. *the vessel's speed and vector*;

4. *the predictability of the vessel's path*. That is, whether the vessel stays on a single path or makes continuous course changes;

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);

7. *the type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability.

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, IAC, and SEASWITI), 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.

Much of the increase in ambient noise levels in the oceans over the last 50 years has been attributed to increased shipping, primarily due to the increase in the number and tonnage of ships throughout the world, as well as the growth and increasing interconnection of the global economy and trade between distant nations (National Resource Council 2003). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (National Resource Council 2003). Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, and tonal, and sound pressure levels at a source will vary according to speed, burden, capacity and length (Richardson *et al.* 1995). Vessels ranging from 135 to 337 meters (*Nimitz*-class aircraft carriers, for example, have lengths of about 332 meters) generate peak source sound levels from 169-200 dB between 8 Hz and 430 Hz. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139-463 kilometers away (Ross 1976 *in* Polefka 2004).

Because the U.S. Navy does not propose to conduct active sonar training in North Atlantic right whale critical habitat (with exceptions that have been noted elsewhere in this Opinion) and 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 nautical mile or nm) buffer. we assume that any whales in these areas are not likely to be exposed to vessel traffic associated with active sonar training.

The U.S. Navy proposes to reduce the time spent conducting object detection exercises in the North Atlantic right whale critical habitat (Item 4.5.2 of the Navy's proposed mitigation measures). Specifically, the Navy proposes to require ships to contact FACSFAC JAX to obtain the latest right whale sighting

**Table 5. 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% in search mode and 30% track mode | 3214 | Hours |
| AN/SQS-56 | 7.5 | 225 | FFG hull-mounted sonar (surface ship) | ASW search, detection, & localization; Utilized 70% in search mode and 30% track mode | 1684 | Hours |
| AN/SQS-53 and AN/SQS-56 (Kingfisher) | MF | Classified | DDG, CG, and FFG hull-mounted sonar (object detection) | Only used when entering and leaving port | 216 | Hours |
| AN/BQQ-5 or 10**** | MF | Classified | Submarine hull-mounted sonar | ASW search and attack (approximately one ping per two hours when in use) | 9976 | Pings |
| AN/AQS-13 | 10 | 215 | Helicopter dipping sonar | ASW sonar lowered from hovering helicopter (approximately 10 pings/dip, 30 seconds between pings) | 1476 | Dips |
| AN/AQS-22 | 4.1 | 217 | Helicopter dipping sonar | ASW sonar lowered from hovering helicopter (approximately 10 pings/dip, 30 seconds between pings) | 1476 | Dips |
| MK-48 Torpedo | HF | Classified | Submarine fired exercise torpedo | ASW sonar lowered from hovering helicopter (approximately 10 pings/dip, 30 seconds 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 secs between pings) | 5853 | Buoys |
| IEER (AN/SSQ-110A) | Impulsive - Broadband | Classified | MPA deployed | ASW system consists of explosive acoustic source buoy (contains two 4.1 lb charges) and expendable passive receiver sonobuoy | 872 | 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) | 332 | Hours |
| AN/SQQ-32 | HF | Classified | MCM over the side system (mine-hunting) | Used during mine warfare training events detect, classify, and localize bottom and moored mines | 4474 | 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 (approximately 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 | MF | Classified | MPA deployed | ASW system consists of active sonobuoy and expendable passive receiver sonobuoy | 872*** | Buoys |

information. FACSFAC JAX will advise ships of all reported whale sightings in the vicinity of the critical habitat and Associated Area of Concern prior to conducting surface ship object detection exercises in the southeast North Atlantic right whale critical habitat 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.

### 5.1.2 High-frequency active sonar

Several of the torpedoes and the AN/BQS-15 sonar system, which Navy submarine use for under-ice navigation and mine-hunting, produce high-frequency sounds (see Table 5). 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.

### 5.1.3 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).

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 (51 units) class vessels in the U.S. Navy (Polmar 2001, D`Spain *et al.* 2006). 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. 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 (Polmar 2001, D`Spain *et al.* 2006). 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 (Figure C-4) 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 under-water 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.

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.

**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.

#### Mine Warfare Sonar Systems

As discussed in the *Description of the Proposed Action*, 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 majority of 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 exercise 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.* 2006). 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.* 2006). Both sonar 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.* 2006). Waveforms of both sonar systems are frequency modulated with continuous waves (D'Spain *et al.* 2006).

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 are 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.

### 5.1.4 Explosive Charges

One of the systems the U.S. Navy proposes to employ as part of the proposed active sonar training include 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 signal 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 often 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.

### 5.1.5 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 squared 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.

## 5.2 Exposure Analysis

As discussed in the *Approach to the Assessment* section of this opinion, 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.

Based on the limited empirical information available, we cannot use that information to 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 along the Atlantic Coast of the United States and in the Gulf of Mexico from January 2009 through January 2014. 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, 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 area encompassed by sound fields produced by activities like active sonar transmissions are so large that it would be almost impossible to identify or estimate the number of different marine species that are actually be 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 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.

### 5.2.1 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 RDT&E 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.

### 5.2.2 Exposure to Active Sonar

The empirical information available does not allow us to empirically estimate the number of marine mammals that might be exposed to mid-frequency active sonar during the activities that are proposed to occur along the Atlantic Coast of the United States and in the Gulf of Mexico that might compare with counts reported by an observer with perfect knowledge of patterns of marine mammal abundance in the along the Atlantic Coast of the United States and in the Gulf of Mexico.

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) in their 2008 Environmental Impact Statement on Atlantic Fleet Active Sonar Training to estimate the number of marine mammals that might be "taken" (as that term is defined pursuant to the MMPA) during active sonar training activities the U.S. Navy proposes to conduct and NMFS' Permits Division. The "take" the Permits Division proposes to authorize using the Letters of Authorization would reflect these "take" estimates.

MITIGATION MEASURES TO MINIMIZE THE LIKELIHOOD OF EXPOSURE TO MID-FREQUENCY ACTIVE SONAR. The Navy proposes to implement a suite of mitigation measures to prevent marine mammals from being exposed to mid frequency active sonar at high received levels. As discussed in the *Description of the Proposed Action*, these measures are centered on safety zones that trigger reductions in maximum transmission levels depending on the proximity of one or more marine mammals to surface vessels, helicopters, and submarines that might be transmitting active sonar or preparing to transmit.

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 critical 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 designated critical habitat off Massachusetts would not be exposed to high received levels of active sonar.

These other measures the U.S. Navy proposes to implement rely primarily on Navy watchstanders, helicopter pilots, and other Navy assets detecting 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 might 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 *et al.* 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 a proposed 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 (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, 2001, 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.

### Exposure Estimates for Atlantic Fleet Active Sonar Training

Over the past year, the U.S. Navy updated 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 each 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 (U.S. Navy and 2008).

The U.S. Navy's updated approach 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 5 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 metric is either energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. By multiplying impact volumes with 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 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 used 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 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), was estimated using three data sources: 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, 2003, 2005; Finneran and Schlundt 2004; Schlundt *et al.* 2000), data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromm 2004, Department of the Navy 2003), and a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek *et al.* 2004).

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 in the 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 about 800 instances in which blue whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

FIN WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 880 instances in which fin whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

**Table 6. Number of exposure events that are likely to result in the "take" of endangered species of whale by operating area**

| Species | Operating Areas Offshore of the Southeastern United States | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Virginia Capes | | | Cherry Point | | | Jacksonville - Charleston | | |
| | PTS | TTS | Dose-Function | PTS | TTS | Dose-Function | PTS | TTS | Dose-Function |
| **Blue whale** | - | - | - | - | - | - | **-** | **-** | **-** |
| **Fin whale** | 0 | 1 | 68 | 0 | 1 | 10 | **-** | **-** | **-** |
| **Humpback whale** | 0 | 4 | 403 | 0 | 6 | 686 | **0** | **19** | **2371** |
| **North Atlantic right whale** | 0 | 1 | 45 | 0 | 0 | 30 | **0** | **3** | **363** |
| **Sei whale** | 0 | 1 | 10 | 0 | 1 | 10 | **-** | **-** | **-** |
| **Sperm whale** | 0 | 36 | 3087 | 0 | 4 | 317 | **0** | **17** | **1517** |

| Species | Northeast | | | Gulf of Mexico | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|
| | PTS | TTS | Dose-Function | PTS | TTS | Dose-Function | PTS | TTS | Dose-Function |
| **Blue whale** | 0 | 0 | 801 | - | - | - | **0** | **0** | **801** |
| **Fin whale** | 0 | 0 | 802 | - | - | - | **0** | **2** | **880** |
| **Humpback whale** | 0 | 0 | 702 | 0 | 1 | 10 | **0** | **30** | **4172** |
| **North Atlantic right whale** | 0 | 0 | 224 | - | - | - | **0** | **4** | **662** |
| **Sei whale** | 0 | 0 | 1035 | - | - | - | **0** | **2** | **1055** |
| **Sperm whale** | 0 | 1 | 4404 | 0 | 5 | 370 | **0** | **63** | **9695** |

HUMPBACK WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 4,172 instances in which humpback whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

NORTH ATLANTIC RIGHT WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 660 instances 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 (see Table 6). 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 (see Table 7).

SEI WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 1,055 instances in which sei whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

SPERM WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 9,690 instances in which sperm whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

### 5.2.3 Analyses of Probable Exposure of Sea Turtles to Sonobuoys

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 squared 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

**Table 7. Training scenarios and the number of activities associated with those scenarios, but operating area**

| Training Scenario | Operating Area | | | | | |
|---|---|---|---|---|---|---|
| | Northeast | Virginia Capes | Cherry Point | Jacksonville – Charleston | Gulf of Mexico | Totals |
| **Independent Unit-Level Training** | | | | | | |
| Surface Ship ASW | - | 69 | 91 | 292 | 5 | **457** |
| Surface Ship Object Detection/Navigational Sonar | - | 68 | - | 40 | - | **108** |
| Helicopter ASW | - | 25 | 25 | 115 | - | **165** |
| Submarine ASW | 30 | 10 | 14 | 45 | 1 | **100** |
| Submarine Object Detection/Navigational Sonar | 165 | 78 | - | 57 | - | **300** |
| Maritime Patrol Aircraft ASW (tonal sonobuoy) | 238 | 79 | 111 | 356 | 7 | **791** |
| Maritime Patrol Aircraft ASW (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** |

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.

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.

## 5.3 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. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

It is important to begin these analyses by stating that, to the best of our knowledge, no data or other information are available from actual exposures of endangered or threatened marine mammals to mid-frequency active sonar in either captive or natural settings. We are aware of the studies of the behavioral responses of small cetaceans given exposed to mid-frequency active sonar that are being conducted at the U.S. Navy's instrumented training range in the Bahamas (the AUTEC range); however, those studies are still in the infancy and no data from them are available at the time of this writing. We are also aware of and have cited initial data available from controlled exposure experiments that are being conducted on killer whales by the Norwegian Defense Ministry; we will incorporate additional information from those studies as the information becomes available.

Without empirical information on the actual responses of endangered and threatened species to mid-frequency active sonar, we reviewed the best scientific and commercial data available to assess the probable responses of endangered and threatened species to mid-frequency active sonar. In the narratives that follow this introduction, we summarize the best scientific and commercial data on the responses of marine animals to mid-frequency active sonar. Then we use that information to make inferences about the probable responses of the endangered and threatened we are considering in this Opinion.

### 5.3.1 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 (Goodwin and Green 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jackson 1994, Evans *et al.*

1992, 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels is 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 Green 1990, Au and Perryman 1982, Bain *et al.* 2006, Bauer 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, David 2002, Erbé 2000, Félix 2001, Magalhães *et al.* 2002, Goodwin and Cotton 2004, Hewitt 1985, Lusseau 2003, 2006; Lusseau and Bejder 2007, Ng and Leung 2003, Nowacek *et al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *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[4]. 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 vertical avoidance behavior (Bryant *et al.* 1984, Cope *et al.* 2000, David 2002, Lusseau 2003, Kruse 1991, 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, 2006; Williams *et al.* 2002, 2006a, 2006b) than when it engages in frequent course changes (Evans *et al. 1*994, 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, 2006);

7. *the type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004);

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[4] 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 (1984): "avoidance" is a shift in position by prey before a potential predator begins an attack; "evasion" is an response by potential prey to an perceived attack from a potential predator; and "escape" is the most acute form of evasive behavior.

8. the behavioral state of the marine mammals (David 2002, Lusseau 2003, 2006; Würsig *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, 2005*a*; Notarbartolo di Sciara *et al.* 1996, 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 move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Edds and Macfarlane 1987, Baker and Herman 1989, Kruse 1991, Polacheck and Thorpe 1990, Evans *et al. 1*992, Lütkebohle 1996, Nowacek *et al. 1*999). 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 (Stewart *et al.* 1982, Kruse 1991). 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.* 1996, 2002). Baker *et al.* (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km. Richardson *et al.* (1985) 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 distances 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, 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 and 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 Holmes *et al.* 1993, Lord *et al.* 2001). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts such as causing marine mammals to avoid an area (Salden 1988, Lusseau 2005) 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, 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.

### 5.3.2 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 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 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.

The information that follows is presented as if 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 when, in fact, any individuals that occur in the area of a training event would be exposed to multiple potential stressors and would be responding to a wide array of cues from their environment including natural cues from other members of their social group, from predators, and other living organisms. However, 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. We present the information from studies that investigated the responses of animals to one or two stressors, but we remain aware that we might observe very different results if we presented those same animals with the suite of stressors and cues they would encounter in the wild.

#### 5.3.3.1 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 (Box P1 of Figure 1 illustrates the potential conesquences of acoustic resonance; see Rommel *et al.* 2007). 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 (Ketten 2004, Cudahy and Ellison 2001) and tissue damage resulting from "gas and fat embolic syndrome" (Fernandez *et al.* 2005, Jepson *et al.* 2003, 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 (2001) 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 the evidence available in Schlundt *et al.* 2000) 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 (1996) 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, 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[5] or "threshold shift" refers to an ear's reduced sensitivity to sound following exposure to loud noises: when an ear's sensitivity to sound has

[5] Animals can experience losses in hearing sensitivity through other mechanisms. The processes of aging and several diseases cause some humans to experience permanent losses in their hearing sensitivity. Body burdens of toxic

been reduced, sounds must be louder for the individual affected to detect and recognize it. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected. Although noise-induced losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting, only a few investigators have reported the frequency range affected by a hearing loss.

An animal can experience either temporary threshold shift (TTS) or permanent threshold shift (PTS). TTS can last from minutes or hours to days. When PTS occurs, there is physical damage to the sound receptors in the ear. This can result in total or partial deafness, or an animal's hearing can be impaired in specific frequency ranges (Box P2 of Figure 1 illustrates the potential consequences of noise-induced loss in hearing sensitivity).

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 non-human animals. Richardson *et al* (1995) concluded that there was no empirical evidence that exposure to active sonar transmissions with the kind of intensity can cause PTS in any marine mammals; instead the probability of PTS has been inferred from studies of TTS. Richardson *et al.* (1995) hypothesized that marine mammals within less than 100 meters of a sonar dome might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 μPa which might cause TTS. Erbe (2002). argued that killer whales would have to stay within 50 meters of a single boat for 8 hours a day, 5 days a week, for up to 50 years to experience a permanent threshold shift of 2 – 5 dB as a result of exposure to engine noise, although exposing killer whales to multiple vessels could cumulatively produce temporary or permanent threshold shifts.

Schlundt *et al.* (2000; see also Finneran *et al.* 2001, 2003) 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.* (2000) 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.* (2001, 2003) 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. The signal was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and SPL of approximately 100 dB re 1 μPa. 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.

Based on the information available, and given the speeds at which Navy vessels operate during the activities they proposed to conduct along the Atlantic coast of the U.S. and in the Gulf of Mexico, the protective measures the Navy proposes to employ during an exercise, and the probable avoidance responses of those animals upon exposure,

chemicals can also cause animals, including humans, to experience permanent and temporary losses in their hearing sensitiviy (for example, see Mills and Going 1982 and Fechter and Pouyanos 2005).

we think it is highly unlikely that large whales would routinely accumulate acoustic energy sufficient to cause noise-induced loss of hearing sensitivity. At the ship speeds involved, collisions would present a greater risk than noise-induced hearing loss; as we have discussed previously, the Navy's protective measures, which are designed to detect large whales (and other objects) in their path to protect the ships from being damaged during a collision, are also likely to prevent large whales from being exposed to received levels sufficient to cause hearing losses.

#### 5.3.3.2 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.* (1995b) 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 (i.e., vocalizations from other members of its species, surf noise, prey noise, etc.; Richardson *et al.* 1995).

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins *et al.* 1985). 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 son 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, 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 *et al.* (1974, 1985, 1993) 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 to communication (Zaitseva *et al.* 1980).

Based on the evidence available, the endangered baleen whales that are considered in this Opinion — fin, 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.

#### 5.3.3.3 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, Stokes 1971), acquiring mates (Patricelli *et al.* 2006, Ryan 1985, Stokes 1971), assessing other members of their species (Owings *et al.* 2002, Parker 1974, Sullivan 1984), evading predators (Greig-Smith 1980, Marler 1955, Vieth *et al.* 1980), and defending resources (Alatalo *et al.* 1990, Falls 1963, Zuberbuehler *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 cues 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 (Brenowitz 2004, Brumm *et al.* 2004, Lohr *et al.* 2003). Animals are also aware of environmental conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brenowitz 1982, Brumm *et al.* 2004, Dooling 2004, Marten and Marler 1977, Patricelli *et al.* 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 *et al.* 2004, Cody and Brown 1969, Egnor *et al.* 2006, Patricelli *et al.* 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, bocalizing 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 (2003) 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, Tonkinson 1990).

Other species experience the same phenomenon when they vocalize in the presence of high levels of background sound. Brumm (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% 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 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% 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 needs 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 behaviours 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 behaviours) 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.* (2007) 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 sining 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 *et al.* 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 *et al.* (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, the 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 2003, 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.

However, 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, three 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 Guadalupe fur seals and 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 Southern California Range Complex 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 (Weilgart and Whitehead 1993, Goold and Jones 1995). Ridgway 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.

#### 5.3.3.4 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 *et al.* 2005, Seyle 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 1987, Rivier 1995, Box S1.1 of Figure 1) and altered metabolism (Elasser *et al.* 2000), reduced immune competence (Blecha 2000) and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals; see Romano *et al.* 2004) have been equated with stress for many years.

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 which impairs 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 diversts 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" (*sensu* 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 (for examples see, Holberton *et al.* 1996, Hood *et al.* 1998, Jessop *et al.* 2003, Krausman *et al.* 2004, Lankford *et al.* 2005, Reneerkens *et al.* 2002, Thompson and Hamer 2000). 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). Jones

(1998) reported on reductions in human performance when faced with acute, repetitive exposures to acoustic disturbance. Trimper *et al.* (1998) reported on the physiological stress responses of osprey to low-level aircraft noise while Krausman *et al.* (2004) reported on the auditory and physiology stress responses of endangered Sonoran pronghorn to military overflights. Smith *et al.* (2004a, 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 2003). 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.

#### 5.3.3.5 Behavioral Responses

When an animal encounters humans or human activities, ranging from low-flying helicopter to the quiet wildlife photographer, an animal's response appears to follow the same economic principles used by prey when they encounter predators (Beale and Monaghan 2004, Berger *et al.* 1983, Frid 2003, Frid and Dill 2002, Gill *et al.* 2000, 2001; Gill and Sutherland 2000, 2001; Harrington and Veitch 1992, Lima 1998, Madsen 1994, Romero 2004). The level of perceived risk may result from a combination of factors that characterize disturbance stimuli, along with factors related to natural predation risk (e.g., Frid 2001, Papouchis *et al.* 2001). In response to that 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 *et al.* 2000, Walker *et al.* 2005).

The behavioral response of animals to human disturbance have been documented to 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, Mullner *et al.* 2004, Waunters *et al.* 1997), 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 exhibit behaviors associated with "allostasis" or physiological stress responses (see the preceding discussion under Allostasis and Boxes B1 or B2 and S of Figure 1, which illustrates the potential consequences of behavioral responses to stress);

2 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 (Box B1 of Figure 1) or may abandon an area;

3 they may respond to an acoustic exposure using evasive or escape behaviors, which a more extreme form of avoidance that is probably accompanied by physiological stress responses (see Box B2 of Figure 1);

4 they may continue their pre-exposure behavior and cope with the behavioral consequences of continued exposure (Box B2 of Figure 1), and

5 they may habituate to a sound or series of sounds or they might not perceive a potential sound as threatening (Box N of Figure 1).

In every instance, we are generally concerned about changes in an animals' pre-disturbance behavior — for example, a change from resting or foraging to horizontal or vertical avoidance — because we would generally conclude that animals that do not change their behavioral state or change the rate of particular behavioral acts are either not responding to a stimulus or any responses are physiological (for example, allostasis) rather than behavioral.

After being exposed to Navy vessels, sound field associated with active sonar, or both, marine animals might experience one or more of these behavioral responses or they might exhibit a sequence of several of the behaviors presented in the preceding list (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.* (1995) 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 Hawai'ian 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, 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 (IWC 2005). 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). 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 are 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 like delaying their migration south, delaying reproduction, reducing growth, or migrating with reduced energy reserves.

Captive bottlenose dolphins and a white 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 *et al.* 1997, Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). 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.* 2000, Finneran *et al.* 2002). 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 responses to shorter pulses were higher (Finneran *et al.* 2000, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000). 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 *et al.* (1997) and Schlundt *et al.* (2000).

Richardson *et al.* (1995a) and Richardson (1997, 1998) 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.* (1995) 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.* 1995). 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.* (2004) 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 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 1988).

Nowacek *et al.* (2004) 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.* (2006) 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 (Lusseau 2004, Allen and Read 2000). 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 (1988) suggested that humpback whales avoid some nearshore waters in Hawai'i for the same reason.

As Bejder *et al.* (2006) 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 (citing Beale and Monaghan 2004a, 2004b; Gill *et al.* 2001, Frid and Dill 2002, Lima and Dill 1990). When animals shift from one site to an alternative site, we should assume that the costs of tolerating a disturbance have exceeded any benefits of remaining in the location they are leaving.

The evidence available suggests that most marine mammals will try to avoid continued exposed to mid-frequency active sonar (or, at least, some components of the sound source), the ships associated with the active sonar, or both. However, the process of avoiding exposures can be costly to marine animals if (a) they are forced to abandon a site that is important to their life history (for example, if they are forced to abandon a feeding or calving area), (b) their flight response disrupts and important life history event (for example, reproduction), or (c) their diving pattern becomes sufficiently erratic, or if they strand or experience higher predation risk during the process of abandoning a site.

The evidence available also suggests that marine mammals might experience more severe consequences if they are compelled to avoid continued exposure to active sonar, but circumstances do not allow them to avoid or "escape"

further exposure. At least six circumstances might prevent an animal's 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 and D'Amico 2006), 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, which 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 protection marine mammals against nitrogen gas supersaturation (alveolar collapse and elective circulation; Kooyman *et al.* 1972; 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, Mullner *et al.* 2004, Waunters *et al.* 1997), 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 the 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, 1990, Cooper 1997, 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 2001*a*, 2001*b*), 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, however, 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 the 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 vessel 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 *et al.* (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, 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 area 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 abd 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, van Rij 2007). 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 1998, Treves 2000). 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 (Saino 1994, Beauchamp and Livoreil 1997, Fritz *et al.* 2002).

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 2001, 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 1994, White 1983). For example, Madsen (1994) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46% 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% 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 $10^3$kJ/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 1998, Cowlishaw *et al.* 2004, Lima 1988). 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 (Box B2 of Figure 1). Under some circumstances, some of individuals that are exposed to active sonar transmissions will continue their normal behavioral activities; in other circumstances, individual animals will become aware of the sonar transmissions at lower received levels and move to avoid additional exposure or exposures at higher received levels (Richardson *et al.* 1995).

It is difficult to distinguish between animals that continue their pre-disturbance behavior without stress responses, animals that continue their behavior but experience stress responses (that is, animals that cope with disturbance), animals that habituate to disturbance (that is, they may have experienced low-level stress responses initially, but those responses abated over time), and animals that do not respond to the potential disturbance.

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. 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 have 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).

#### 5.3.3.6 Stranding Events

In what follows, we address the evidence bearing on assertions from several NGOs 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, 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, Frantis 1998) asserting low-frequency active sonar as 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 1991).

Marine mammals are known to strand for a variety of reasons, although the cause or causes of most stranding are unknown (Geraci *et al.* 1976, Eaton 1979, Odell *et al.* 1980, Best 1982). 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 the 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 (Chroussos 2000, Creel 2005, DeVries *et al.* 2003, Fair and Becker 2000, Foley *et al.* 2001, Moberg 2000, Relyea 2005a, 2005b, 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 (Hildebrand 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 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 (Franzis 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 Scientific Committee 2005).

Between 1960 and 2006, 48 (68%) involved beaked whales, 3 (4%) involved dolphins, and 14 (20%) involved whale species. Cuvier's beaked whales were involved in the greatest number of these events (48 or 68%), followed by sperm whales (7 or 10%), and Blainville and Gervais' beaked whales (4 each or 6%). Naval activities that might have involved active sonar are reported to have coincided with 9 (13%) or 10 (14%) 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) and 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%) 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 (SACLANTCEN 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 North Atlantic Treaty Organisation (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. Fox *et al.* (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* (U.S. Department of Commerce and Secretary of the Navy 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 sonar 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- 10kHz, D'Spain *et al.* 2006; 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 haemorrhages, especially in the fat in the jaw, around the ears, in the brain (e.g. multifocal subarachnoid haemorrhages) and in the kidneys (Fernandez, 2004; Fernandez *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 (Jepson *et al.* 2003; Fernandez, 2004; Fernandez *et al.* 2004; 2005). 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 (Martín *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 (3.5kHz, 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. Anonymous 2001, Evans and Miller 2004), 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. This paper 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 Hawai'ian 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 was probably a contributing factor 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 Hawai'ian 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.* 2006). Although Cuvier's beaked whales have been the most common species involved in these stranding events (81% of the total number of stranded animals and see Figure 1), other beaked whales (including *Mesoplodon europeaus*, *M. densirostris*, and *Hyperoodon ampullatus*) comprise 14% 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 Hawai'ian 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 Hawai'ian 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 Hawai'ian 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 Hawai'ian 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 Hawai'ian 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 Hawai'ian 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 Hawai'ian 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 Hawai'ian 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*).

**The Probable Responses of Listed Species 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 each year from January 2009 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.* 1995). 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 ASW exercises that the U.S. Navy plans to conduct along the Atlantic Coast of the U.S. and in the Gulf of Mexico.

BLUE WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 800 instances in which blue whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

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 whales vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). 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.

PROBABLE RESPONSE OF FIN WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 880 instances in which fin whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

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 (Watkins 1981; Watkins *et al.* 1987a; Edds 1988; Thompson *et al.* 1992). 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; Watkins *et al.* 1987a; Thompson *et al.* 1992; McDonald *et al.* 1995). 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 (Clark 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 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 about 4,172 instances in which humpback whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

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 (Payne 1970, 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 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 grounds (Payne 1970; Winn *et al.* 1970a; Richardson *et al.* 1995)

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

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated sources levels in excess of 175 dB re 1 uPa-m (Thompson *et al.* 1986, Richardson *et al.* 1995). 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 and Whitehead 1983).

More recently, Au *et al.* (2006) conducted field investigations of humpback whale songs 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 1990, 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 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 (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 the frequency range humpback whales to which are likely to focus attentional resources appears to overlap with the frequency range of mid-frequency active, we assume that in about 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 about 660 instances 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 (see Table 6). 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 (see Table 7).

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 (Watkins and Schevill 1972; Thompson *et al.* 1979; Spero 1981), However, Nowacek *et al.* (2004) 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*. 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 about 1,055 instances in which sei whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

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 about 9,690 instances in which sperm whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (see Table 7).

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 (Weilgart and Whitehead 1993, Goold and Jones 1995). 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 and Scheville1975, Watkins *et al.* 1985), pingers (Watkins and Scheville 1975), the Heard Island Feasability 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 Scheville 1975). 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.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). 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 (Schlundt *et al.* 2000, Finneran *et al.* 2002). 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, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times 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.* (2000).

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.* (1995) 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 *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. 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, 1998, 2000, 2001, 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.

Preliminary data from 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 148 dB re 1 μPa over octave band with most energy, the whales did not avoid the vessel or change their feeding

efficiency (National Science Foundation 2003). Although the sample size is small (4 whales in 2 experiments), the results are consistent with those off northern Norway.

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. *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) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O'Hara and Wilcox 1990). 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966). We assume that these sensitivities to sound apply to all four of the hardshell turtles (i.e., the green, hawksbill, 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 $_{rms}$ 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.

**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 (for example, see NRDC 2007 and Ocean Mammal Institute 2007). 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 proposed 2008 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 (2001, 2003, 2005) 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 five years would add thousands of 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 are 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 the 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 (for example, aminoglycoside antibiotics; see Mills and Going 1982) 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 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 whales 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.

**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.

## 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 2000, Mills and Beatty 1979, Brandon 1978, Stearns 1977, 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.

BLUE WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 800 instances in which blue whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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, 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 whales vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). 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' might not respond to the vessels, while in other circumstances, whales are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *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 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 of blue whales to reduce the fitness of the fin 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 each year from January 2009 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 each year from January 2009 through January 2014 would not appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

FIN WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 880 instances in which fin whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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. these estimates probably over-estimate 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 (Watkins 1981; Watkins *et al.* 1987a; Edds 1988; Thompson *et al.* 1992). 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; Watkins *et al.* 1987a; Thompson *et al.* 1992; McDonald *et al.* 1995). 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 (Clark 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' might not respond to the vessels, while in other circumstances, fin 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 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *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 2009 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 each year from January 2009 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 each year from January 2009 through January 2014 are not likely to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

HUMPBACK WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 4,172 instances in which humpback whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (Payne 1970; Winn *et al.* 1970a; Thompson *et al.* 1986). 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 (Tyack 1981; Tyack and Whitehead 1983, Silber 1986).

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 (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 (Payne 1970; Winn *et al.* 1970a; Richardson *et al.* 1995)
2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and
3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated sources levels in excess of 175 dB re 1 uPa-m (Thompson *et al.* 1986; Richardson *et al.* 1995). Sounds often associated with possible aggressive behavior by males (Tyack 1983; Silber 1986) 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 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 1990, 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 areas 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 that 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. Despite small numbers that are entangled in fishing gear in the action area, this increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the Atlantic Ocean have not prevented these whales from increasing their numbers 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 rate at which humpback whale counts in the North Atlantic Ocean are increasing.

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 each year from January 2009 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 2009 to January 2014 would not be expected to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

NORTH ATLANTIC RIGHT WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 660 instances 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 (see Table 6). 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 whales vocalizations suggests that right whales produce moans less than 400 Hz in frequency (Watkins and Schevill 1972; Thompson *et al.* 1979; Spero 1981), However, Nowacek *et al.* (2004) 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*. 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 each year from January 2009 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 2009 through January 2014 would not be expected to appreciably reduce the North Atlantic right whales' likelihood of surviving and recovering in the wild.

SEI WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 1,055 instances in which sei whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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' might not respond to the vessels, while in other circumstances, sei 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 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *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 physiologyical 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 December 2008 to December 2013, 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 each year from January 2009 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 2009 through January 2014 would not be expected to appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

SPERM WHALES. Based on the U.S. Navy's exposure models, each year we would expect about 9,690 instances in which sperm whales might be exposed to active sonar associated with AFAST training activities and be "taken" as a result of that exposure (see Table 6). 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 (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). 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 (Norris and Harvey 1972; Cranford 1992; but see Clarke 1979). 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 (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). 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 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 (Weilgart and Whitehead 1993, Goold and Jones 1995). 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 and Scheville1975, Watkins *et al.* 1985), pingers (Watkins and Scheville 1975), the Heard Island Feasability 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 Scheville 1975). 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.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). 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 (Schlundt *et al.* 2000, Finneran *et al.* 2002). 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, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times 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.* (2000).

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. 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, 1998, 2000, 2001, 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 and Schevill 1975; Watkins *et al.* 1985). 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).

Preliminary data from 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 148 dB re 1 μPa over octave band with most energy, the whales did not avoid the vessel or change their feeding efficiency (National Science Foundation 2003). Although the sample size is small (4 whales in 2 experiments), the results are consistent with those off northern Norway.

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.* (1995) 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 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 be 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 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *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 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 each year from January 2009 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 2009 through January 2014 would not be expected to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

SEA TURTLES. The information available has not allowed us to 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 each year from January 2009 through January 2014.

Further, although the information on the hearing capabilities of sea turtles is limited, but the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O'Hara and Wilcox 1990). 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966). We assume that these sensitivities to sound apply to the three hardshell turtles (i.e., green, loggerhead , and Pacific ridley 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 $_{rms}$ 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.

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. 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; however, 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.

Nevertheless, 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 each year from January 2009 through January 2014 are not likely to interact with sufficient number of 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, or loggerhead sea turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution.

NORTH ATLANTIC RIGHT WHALE CRITICAL HABITAT. Because the U.S. Navy does not propose to conduct active sonar training in North Atlantic right whale critical habitat (with exceptions that have been noted elsewhere in this Opinion) and 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 nautical mile or nm) buffer. we assume that these areas are not likely to be exposed to vessel traffic associated with active sonar training. Therefore, the conservation value of these areas should not be affected by vessel traffic.

The U.S. Navy also proposes to reduce the time spent conducting object detection exercises in the North Atlantic right whale critical habitat (Item 4.5.2 of the Navy's proposed mitigation measures). Specifically, the Navy proposes to require ships to contact FACSFAC JAX to obtain the latest right whale sighting information. FACSFAC JAX will advise ships of all reported whale sightings in the vicinity of the critical habitat and Associated Area of Concern prior to conducting surface ship object detection exercises in the southeast North Atlantic right whale critical habitat 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 the Navy's mitigation measures, the northern units of right whale critical habitat 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 North Atlantic right whales are not likely to respond to high-frequency sound sources associated with the proposed training activities, high-frequency sound sources associated with the Navy's active sonar training activities should not reduce the conservation value of the designated critical habitat. 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 conservation value of the designated critical habitat for right whales.

# CONCLUSION

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, and loggerhead sea turtles, the environmental baseline for the action area, the effects of the proposed research program, and the cumulative effects, it is NMFS' biological opinion that the Navy's proposal to conduct 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 each year for a five-year period beginning in January 2009 are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

The opinion also concluded that the active sonar training activities along the Atlantic Coast of the United States and in the Gulf of Mexico are not likely to result in the destruction or adverse modification of critical habitat that has been designated for endangered or threatened species in the action area.

# 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 National Marine Fisheries Service is not including an incidental take authorization for marine mammals at this time because the incidental take of marine mammals has not been authorized under section 101(a)(5) of the Marine Mammal Protection Act of 1972, as amended. NMFS will prepare a biological opinion to address the effects associated with issuing a LOA and will include an incidental take statement for the endangered and threatened species that have been considered in this opinion, as appropriate.

## 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 Endangered Species Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits, Conservation and Education Division of the Office of Protected Resources should notify the Endangered Species Division of any conservation recommendations they implement in their final action.

## REINITIATION NOTICE

This concludes formal consultation on the U.S. Navy's proposed Atlantic Fleet Active Sonar Training along the Atlantic coast of the United States and in the Gulf of Mexico between 2009 and 2014 and the National Marine Fisheries Service's Permits, Conservation, and Education Division's proposal to promulgate regulations that would allow them to authorize the U.S. Navy to "take" marine mammals incidental to this 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.

## Literature Cited

Adler-Fenchel, H.S. 1980. Acoustically derived estimate of the size distribution for a sample of sperm whales (*Physeter catodon*) in the Western North Atlantic. Canadian Journal of Fisheries and Aquatic Sciences 37:2358-2361.

Adler-Fenchel, H.S. 1980. Acoustically derived estimate of the size distribution for a sample of sperm whales (*Physeter catodon*) in the Western North Atlantic. Canadian Journal of Fisheries and Aquatic Sciences 37: 2358-2361.

Advanced Research Projects Agency, and NOAA, National Marine Fisheries Service. 1995. Final Environmental Impact Statement/Environmental Impact Report for the Kauai Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program, Vols. I and II. Advanced Research Projects Agency, Arlington, Virginia; NOAA, National Marine Fisheries Service, Silver Spring, Maryland.

Agler, B.A., R.L. Schooley, S.E. Frohock, S.K. Katona, and I.E. Seipt. 1993. Reproduction of photographically identified fin whales, *Balaenoptera physalus*, from the Gulf of Maine. Journal of Mammology 74:577-587.

Aguayo L.A. 1974. Baleen whales off continental Chile. Pages 209-217. In: W.E. Schevill (editor) The whale problem: a status report. Harvard University Press, Cambridge, Massachusetts.

Aguilar, A., and C. Lockyer. 1987. Growth, physical maturity, and mortality of fin whales (*Balaenoptera physalus*) inhabiting the temperate waters of the northeast Atlantic. Canadian Journal of Zoology 65:253-264.

Allen, K.R. 1980. Conservation and management of whales. University of Washington Press, Seattle; Washington.

Allen, K.R. 1980. Size distribution of male sperm whales in the pelagic catches. Reports of the International Whaling Commission Special Issue 2: 51-56.

Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs 70:445-470.

André, M., M. Terada and Y. Watanabe. 1997. Sperm whale (*Physeter macrocephalus*) behavioral response after the playback of artificial sounds. Reports of the International Whaling Commission 47: 499 - 504.

Andrews, R.C. 1916. The sei whale (*Balaenoptera borealis* Lesson). Memoir of the American Museum of Natural History New Series 1(6):291-388.

Apple, T.C. 2001. Spatial and temporal variation of sperm whale (*Physeter macrocephalus*) codas in the northern Gulf of Mexico. The Journal of the Acoustical Society of America 109(5 2): 2390.

Arnbom, T., V. Papstavrou, L.S. Weilgart and H. Whitehead. 1987. Sperm whales react to an attack by killer whales. Journal of Mammalogy 68(2): 450-453.

Ashford, J.R. and A.R. Martin. Interactions between cetaceans and longline fishery operations around South Georgia. Marine Mammal Science 12(3):452-457.

Atkins, N., and S. L. Swartz (eds.). 1989. Proceedings of the workshop to review and evaluate whale watching programs and management needs. November 14-16, 1988, Monterey, California. Center for Marine Conservation., Washington D.C.

Au, W. W. L. 1997. Some hot topics in animal bioacoustics. The Journal of the Acoustical Society of America 101:10.

Au, W. W. L., A. Frankel, D. A. Helweg, and D. H. Cato. 2001. Against the humpback whale sonar hypothesis. IEEE Journal of Oceanic Engineering 26:5.

Au, W. W. L., A.A. Pack, M.O. Lammers, L.M. Herman, M.H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. The Journal of the Acoustical Society of America 120: 1103 – 1110.

Au, W. W. L., and K. J. Benoit-Bird. 2003. Automatic gain control in the echolocation system of dolphins. Nature 423:861-863.

Au, W. W. L., and P. E. Nachtigall. 1997. Acoustics of echolocating dolphins and small whales. Marine Behavior and Physiology 29:36.

Au, W. W. L., L. N. Andersen, A. R. Rasmussen, H. L. Roitblat, and P. E. Nachtigall. 1995. Neural network modeling of a dolphin's sonar discrimination capabilities. The Journal of the Acoustical Society of America 98:8.

Au, W., and M. Green. 2000. Acoustic interaction of humpback whales and whale-watching boats. Marine Environmental Research 49:469-481.

Au, W.W.L., P. Nachtigall, and J.L. Pawloski. 1997. Acoustic effects of the ATOC signal (75 Hz, 195 dB) on dolphins and whales. Journal of the Acoustical Society of America 101:2973-2977.

Backus, R.H. and W.E. Schevill. 1966. Physeter clicks. p.510-528 In: K.S. Norris (editor) Whales, Dolphins, and Porpoises. University of California Press; Berkeley, California.

Baker, C.S. and L.M. Herman. 1987. Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. Canadian Journal of Zoology 65(11): 2818-2821.

Baker, C.S. L.M. Herman, B.G. Bays and G.B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Report submitted to the National Marine Mammal Laboratory, Seattle, Washington.

Baker, C.S., A. Perry and L.M. Herman. 1987. Reproductive histories of female humpback whales (*Megaptera novaeangliae*) in the North Pacific. Marine Ecology Progress Series 41: 103-114.

Baker, C.S., A. Perry, J.L. Bannister, M.T. Weinrich, R.B. Abernethy, J. Calambokidis, J. Lien, R.H. Lambertsen, J. Urban Ramirez, O. Vasquez, P.J. Clapham, A. Alling, S.J. O'Brien and S.R. Palumbi. 1993. Abundant mitochondrial DNA variation and world-wide population structure in humpback whales. Proceedings of the National Academy of Science of the United States of America 90(17): 8239-8243.

Baker, C.S., D.A. Gilbert, M.T. Weinrich, R.H. Lambertsen, J. Calambokidis, B. McArdle, G.K. Chambers and J. O'Brien. 1993. Population characteristics of DNA fingerprints in humpback whales (*Megaptera novaeangliae*). Journal of Heredity 84: 281-290.

Baker, C.S., R.W. Slade, J.L. Bannister, B. Abernethy, M.T. Weinrich, J. Lien, J. Urban, P.J. Corkeron, J. Calambokidis, O. Vasquez and S.R. Palumbi. 1994. Hierarchical structure of mitochondrial DNA gene flow among humpback whales *Megaptera novaeangliae*, world-wide. Molecular Ecology 3: 313-327.

Baker, C.S., S.R. Palumbi, R.H. Lambertsen, M.T. Weinrich, J. Calambokidis and J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344(15): 238-240.

Balcomb, K.C. 1987. The whales of Hawai'i, including all species of marine mammals in Hawai'ian and adjacent waters. Marine Mammal Fund Publication; San Francisco, California.

Ballance, L.T., R.C. Anderson, R.L. Pitman, K. Stafford, A. Shaan, Z. Waheed and R.L. Brownell, Jr. 2001. Cetacean sightings around the Republic of the Maldives, April 1998. Journal of Cetacean Research and Management 3(2): 213 - 218.

Bannister, J.L. 1994. Continued increase in humpback whales off Western Australia. Reports of the International Whaling Commission 44: 309-310.

Bannister, J.L. and E. Mitchell. 1980. North Pacific sperm whale stock identity: distributional evidence from Maury and Townsend charts. Reports of the International Whaling Commission Special Issue No. 2: 219-223

Bannister, J.L., G.P. Kirkwood and S.E. Wayte. 1991. Increase in humpback whales off western Australia. Reports of the International Whaling Commission 41: 461-465.

Barlow, J. 1994. Abundance of large whales in California coastal waters: a comparison of ship surveys in 1979/80 and in 1991. Report of the International Whaling Commission 44. 399-406.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall 1991. Fishery Bulletin 93: 1-14.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessment: 1996. NOAA Technical Memorandum NMFS-SWFSC-248. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center; La Jolla, California.

Barlow, J., R.L. Brownell, D.P. DeMaster, K.A. Forney, M.S. Lowry, S. Osmek, T.J. Ragen, R.R. Reeves, and R.J. Small. 1995. U.S. Pacific marine mammal stock assessments 1995. NOAA Technical Memorandum NMFS-SWFSC-219. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center; La Jolla, California.

Barthol, S.M., J. Musick, and M.L. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 1999(3): 836-840.

Bartol, S.M. and D.R. Ketten. 2006. Turtle and tuna hearing. In: *Sea turtle and pelagic fish sensory biology: developing techniques to reduce sea turtle bycatch in longline fisheries*. Edited by Y. Swimmer and R. Brill. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center; Honolulu, Hawaii.

Bass, A.L., S.P. Epperly, J. Braun, D.W. Owens and R.M. Patterson. 1998. Natal origin and sex ratios of foraging sea turtles in the Pamlico-Albemarle Estuarine Complex. NOAA Technical Memorandum NMFS-SEFSC-415. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center; Miami, Florida.

Bauer, G.B. 1986. The behavior of humpback whales in Hawai'i and modification of behavior induced by human interventions. Unpublished doctoral dissertation; University of Hawai'i, Honolulu.

Bauer, G.B. and L.M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawai'i. Report Submitted to NMFS Southwest Region, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Western Pacific Program Office; Honolulu, Hawai'i.

Beach, D.W., and M.T. Weinrich. 1989. Watching the whales: Is an educational adventure for humans turning out to be another threat for endangered species? Oceanus 32(1):84-88.

Beale, C. M., and P. Monaghan. 2004. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335-343.

Berzin, A.A. 2007. Scientific report for "Dalniy Vostok" and "Vladivostok" for 1971. Page 23. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Berzin, A.A. 2007. Subject No. 12. Whale stock status in the North Pacific in 1973. Pages: 26-27. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Berzin, A.A. 2007. Whale stock status in the North Pacific and Antarctica in 1977. Page 33. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Berzin, A.A. 2007. Whale stock status in the North Pacific in 1975. Pages: 30-32. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National

Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Bowles, A.E., M. Smultea, B. Wursig, D.P. DeMaster, D. Palka. 1994. Abundance of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America 96(4):2469-2482.

Branch, T.A. and D.S. Butterworth. 2001. Estimates of abundance south of 60°S for cetacean species sighted frequently on the 1978/79 to 1997/98 IWC/IDCR-SOWER sighting surveys. Journal of Cetacean Research and Management 3(3): 251 - 270.

Bräutigam, A. and K.L. Eckert. 2006. Turning the tide: exploitation, trade and management of marine turtles in the Lesser Antilles, Central America, Colombia and Venezuela. TRAFFIC International and the Secretariat of the Convention on International Trade in Endangered Species; Cambridge, United Kingdom.

Buck, J.R., and P.L. Tyack. 2000. Response of gray whales to low-frequency sound. Journal of the Acoustical Society of America 107 (5): 2744.

Carder, D.A. and S.H. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale Physeter spp. Journal of the Acoustical Society of America Supplement 1:88.

Carretta, J.V., and K.A. Forney. 1993. Report on two aerial surveys for marine mammals in California coastal waters utilizing a NOAA DeHavilland Twin Otter aircraft: March 9- April 7, 1991 and February 8-April 6, 1992. NOAA Technical Memorandum NMFS-SWFSC-185; La Jolla, California.

Caswell, H. 1980. On the equivalence of maximizing reproductive value and maximizing fitness. Ecology 6:19-24.

Caswell, H. 1982. Optimal life histories and the maximization of reproductive value: a general theorem for complex life cycles. Ecology 63:1218-1222.

Caswell, H. 2001, Matrix population models. Sunderland, Massachusetts, Sinauer Publishers, Inc.

Cato, D.H. and R.C. McCauley. 2001. Ocean ambient noise from anthropogenic and natural sources in the context of marine mammal acoustics. Journal of the Acoustical Society of America 110: 2751.

Caut, S., E. Guirlet, E. Angular, K. Das and M. Girondot. 2008. Isotope analysis reveals foraging area dichotomy for Atlantic leatherback turtles. Public Library of Science (PLoS) One 3(3):e1845.

Cetacean and Turtle Assessment Program. 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. Outer Continental Shelf. Report prepared by the University of Rhode Island School of Oceanography for the U.S. Department of the Interior, Bureau of Land Management; Washington, D.C.

Charif, R.A., D.K. Mellinger, K.J. Dunsmore, and C.W. Clark. Submitted. Source levels and depths of fin whale (*Balaenoptera physalus*) vocalizations from the eastern North Pacific.

Cherfas, J. 1989. The hunting of the whale. Viking Penguin Inc.; New York, New York.

Christal, J. and H. Whitehead. 1997. Aggregations of mature male sperm whales on the Galapagos Islands breeding ground. Marine Mammal Science 13(1): 11.

Christal, J. and H. Whitehead. 2001. Social affiliations within sperm whale (*Physeter macrocephalus*) groups. Ethology 107(4): 18.

Christal, J., H. Whitehead and E. Lettevall. 1998. Sperm whale social units: variation and change. Canadian Journal of Zoology 76(8): 10.

Clapham, P.J. 1999. *Megaptera novaeangliae*. Mammalian Species 604: 1-9.

Clapham, P.J. and D.K. Mattila. 1993. Reaction of humpback whales to skin biopsy sampling on a West Indies breeding ground. Marine Mammal Science, 9(4):382-391.

Clapham, P.J., and R.L. Brownell, Jr. 1996. Potential for interspecific competition in baleen whales. Reports of the International Whaling Commission 46:361-367.

Clark, C.W. and K.M. Firstrup. 2001. Baleen whale responses to low-frequency human-made underwater sounds. Journal of the Acoustical Society of America 110: 2751.

Clark, C.W. and K.M. Fristrup. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. Reports of the International Whaling Commission 47: 583-600.

Clark, C.W., C.J. Gagnon and D.K. Mellinger. 1993. Whales '93: Application of the Navy IUSS for low-frequency marine mammal research. Invited paper, abstract published in Tenth Biennial conference on the Biology of Marine Mammals abstracts, 11-15 November 1993, Galveston, Texas. (Abstract)

Clark, C.W., Tyack P., Ellison W.T. 1998. Low-frequency sound scientific research program. Phase I: Responses of blue and fin whales to SURTASS LFA, southern California Bight. Quick Look Report. Marine Acoustics Inc.; Washington, D.C.

Clarke, J.T. and S.A. Norman. 2005. Results and evaluation of the US Navy shock trial environmental mitigation of marine mammals and sea turtles. Journal of Cetacean Research and Management 7(1): 43 - 50.

Clarke, M.R. 1976. Observation on sperm whale diving. Journal of the Marine Biology Association UK 56: 809-810.

Clarke, M.R. 1979. The head of the sperm whale. Scientific American 240(1): 106-117.

Clarke, R. 1956. Sperm whales of the Azores. Discovery Reports 28, 237-298.

Coakes, A. and H. Whitehead. 2004. Social structure and mating system of sperm whales off northern Chile. Canadian Journal of Zoology 82: 10.

Conner, R.C. and R.S. Smolker. 1985. Habituated dolphins (*Tursiops* sp.) in western Australia. Journal of Mammalogy 66(2):398-400.

Couch, L.K. 1930. Humpback whale killed in Puget Sound, Washington. The Murrelet 11(3): 75.

Cowlishaw, g., M.J. Lawes, M. Lightbody, A. Martin, R. Pettifor and J.M. Rowcliffe. 2004. A simple rule for the costs of vigilance: empirical evidence from a social forager. Proceedings of the Royal Society of London, Series B: Biological Sciences 271:27-33.

Cranford, T.W. 1992. Directional asymmetry in the Odontocete forehead. American Zoologist 32(5): 140A.

Croll, D.A., B.R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Unpublished technical report for the U.S. Navy's Environmental Impact Statement on Low Frequency Active Sonar. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California, Santa Cruz; Santa Cruz, California.

Crum, L.A. and Y. Mao. 1996. Acoustically enhanced bubble growth at low frequencies and implication for human diver and marine mammal safety. Journal of the Acoustical Society of America 99: 2898-2907.

Cudahy, E., and W.T. Ellison. 2001. A review of the potential for in vivo tissue damage by exposure to underwater sound. Unpublished report prepared for National Marine Fisheries Service, Office of Protected Resources. Silver Spring, Maryland.

Cummings, W.C. and P.O. Thompson. 1971. Underwater sounds from the blue whale *Balaenoptera musculus*. Journal of the Acoustical Society of America50(4):1193-1198.

Cummings, W.C. and P.O. Thompson. 1977. Long 20-Hz sounds from blue whales in the northeast Pacific. Abstracts of the Second Conference on the Biology of Marine Mammals, San Diego, USA, December 1977.

Cummings, W.C. and P.O. Thompson. 1994. Characteristics and seasons of blue and finback whale sounds along the U.S. west coast as recorded at SOSUS stations. Journal of the Acoustical Society of America 95: 2853.

Curtis, K.R., B.M. Howe, and J.A. Mercer. 1999. Low-frequency ambient sound in the North Pacific: long time series observations. Journal of the Acoustical Society of America 106: 3189-3200.

D'Spain, G. D., A. D'Amico, and D. M. Fromm. 2006. Properties of the underwater sound fields during some well documented beaked whale mass stranding events. Journal of Cetacean Research and Management 7:223 - 238.

Donovan, G. P. 1984. Blue whales off Peru, December 1982, with special reference to pygmy blue whales. Reports of the International Whaling Commission 34: 473-476.

Donovan, G.P. 1991. A review of IWC stock boundaries. Reports of the International Whaling Commission, Special Issue 13:39- 68.

Drouot, V., A. Gannier and J.C. Goold. 2004. Summer social distribution of sperm whales (*Physeter macrocephalus*) in the Mediterranean Sea. Journal of the Marine Biological Association of the UK 84(3): 6.

Drouot, V., M. Berube, A. Gannier, J.C. Goold, R.J. Reid and P.J. Palsboll. 2004. A note on genetic isolation of Mediterranean sperm whales (Physeter macrocephalus) suggested by mitochondrial DNA. Journal of Cetacean Research and Management 6(1): 29 - 32.

Dufault, S. and H. Whitehead. 1995. An encounter with recently wounded sperm whales (Physeter macrocephalus). Marine Mammal Science 11(4): 4.

Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence Estuary. Bioacoustics 1: 131-149.

Edds, P.L. 1982. Vocalizations of the blue whale *Balaenoptera musculus*, in the St. Lawrence River. J.ournal of Mammalogy 63(2):345-347.

Edds, P.L. and J.A.F. MacFarlane. 1987. Occurrence and general behavior of balaenopterid cetaceans summering in the St. Lawrence Estuary, Canada. Canadian Journal of Zoology 65(6):1363-1376.

Edds-Walton, P.L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics 8: 47-60.

Erbe, C. 2000. Detection of whale calls in noise: Performance comparison between a beluga whale, human listeners and a neural network. Journal of the Acoustical Society of America108:297-303.

European Cetacean Society. 2003. Program for the Seventeenth Annual Conference: Marine Mammals and Sound. Las Palmas De Gran Canaria, Spain; 9 – 13 March 2003.

Evans, K., M. Morrice, M. Hindell and D. Thiele. 2002. Three mass strandings of sperm whales (*Physeter macrocephalus*) in southern Australian waters. Marine Mammal Science 18(3): 22.

Faerber, M.M. and R.W. Baird. 2007. Beaked whale strandings in relation to military exercises: a comparison between the Canary and Hawaiian Islands. Poster presentation. The 21st annual European Cetacean Society conference, 22 - 27 April 2007. San Sebastian, Spain.

Fagan, W.F. and E.E. Holmes. 2006. Quantifying the extinction vortex. Ecology Letters 9: 51 - 60.

Fagan, W.F., E. Meir and J.L. Moore. 1999. Variation thresholds for extinction and their implications for conservation strategies. The American Naturalist 154(5): 510-520.

Fagan, W.F., E. Meir, J. Prendergast, A. Folarin and P. Karieva. 2001. Characterizing population vulnerability for 758 species. Ecology Letters 4(2): 132 - 138.

Fechter, L.D. and B. Pouyatos. 2005. Ototoxicity. Environmental Health Perspective 113(7):A443-444.

Félix, F. 2001. Observed changes of behavior in humpback whales during whalewatching encounters off Ecuador. 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Ferber, D. 2005. Sperm whales bear testimony to worldwide pollution. Science 309(5738): 1166.

Fernandez, A. 2004. Pathological findings in stranded beaked whales during the naval military manoeuvers near the Canary Islands. Pages 37-40. European Cetacean Society Newsletter.

Fernandez, A., J. F. Edwards, F. Rodriguez, A. Espinosa de los Monteros, P. Herraez, P. Castro, J. R. Jaber, V. Martin, and M. Arbelo. 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (Family *Ziphiidae*) exposed to anthropogenic sonar signals. Veterinary Pathology 42:12.

Fernandez, A., M. Arbelo, R. Deaville, I. A. P. Patterson, P. Castro, J. R. Baker, E. Degollada *et al*. 2004. Pathology: Whales, sonar and decompression sickness (reply). Nature 428:n.

Fernandez, A., M. Arbelo, R. Deaville, I. A. P. Patterson, P. Castro, J. R. Baker, E. Degollada, H. M. Ross, P. Herraez, A. M. Pocknell, F. Rodriguez, F. E. Howie, A. Espinosa, R. J. Reid, J. R. Jaber, V. Martin, A. A. Cunningham, and P. D. Jepson. 2004. Beaked whales, sonar and decompression sickness. Nature 428:U1 - 2.

Ferrero, R. C., J. Hodder, and J. Cesarone. 1994. Recent strandings of rough-toothed dolphins (*Steno bredanensis*) on the Oregon and Washington coasts. Marine Mammal Science 10:114-115.

Finneran, J. J. 2003. Whole-lung resonance in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). The Journal of the Acoustical Society of America 114:7.

Finneran, J. J., and M. C. Hastings. 2000. A mathematical analysis of the peripheral auditory system mechanics in the goldfish (*Carassius auratus*). The Journal of the Acoustical Society of America 108:14.

Finneran, J. J., C. E. Schlundt, D. A. Carder, and S. H. Ridgway. 2002. Auditory filter shapes for the bottlenose dolphin (*Tursiops truncatus*) and the white whale (*Delphinapterus leucas*) derived with notched noise. The Journal of the Acoustical Society of America 112:7.

Finneran, J. J., C. E. Schlundt, R. Dear, D. A. Carder, and S. H. Ridgway. 2000. Masked temporary threshold shift (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. The Journal of the Acoustical Society of America 108:2515.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. The Journal of the Acoustical Society of America 118:10.

Forney, K. A., M. M. Muto, and J. Baker. 1999. U.S. Pacific marine mammal stock assessment: 1999. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFC-282, Southwest Fisheries Science Center; La Jolla, California.

Frankel, A.S. 1994. Acoustic and visual tracking reveals distribution, song variability and social roles of humpback whales in Hawai'ian waters. Unpublished doctoral dissertation, University of Hawai'i. University Microfilms, Inc.

Frankel, A.S. and C.W. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, *Megaptera novaeangliae,* in Hawai'i. Canadian Journal of Zoology 76:521-535.

Frankel, A.S., and C.W. Clark. 2000. Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. Journal of the Acoustical Society of America 108(4).

Frankel, A.S., J. Mobley, L. Herman. 1995. Estimation of auditory response thresholds in humpback whales using biologically meaningful sounds. Pages 55-70. In: R.A. Kastelein, J.A. Thomas, P.E. Nachtigall (editors) Sensory Systems of Aquatic Mammals. De Spil Publication, Woerden, Netherlands.

Frid, A. 2003. Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110:387-399.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6:1 - 11.

Fristrup, K.M., L.T. Hatch, and C.W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. Journal of the Acoustical Society of America 113(6): 3411-3424

Fritts, T.H. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. FWS/OBS-82/65. Report prepared for the U.S. Department of the Interior, Fish and Wildlife Service; Washington, D.C.

Gagnon, C. J. and C. W. Clark. 1993. The use of U.S. Navy IUSS passive sonar to monitor the movement of blue whales. Abstracts of the 10th Biennial Conference on the Biology of Marine Mammals, Galveston, Texas. November 1993.

Gambell, R. 1976. World whale stocks. Mammal Review 6 (1): 41-53.

Gambell, R. 1985. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). Pages: 171-192. In: *Handbook of marine mammals. Volume 3: The sirenians and baleen whales.* Edited by S.H. Ridgeway and R.J. Harrison. Academic Press; London, United Kingdom.

Gambell, R. 1985. Sei whale *Balaenoptera borealis* (Lesson, 1828). Pages 193-240. In: S.H. Ridgway and R. Harrison (editors). Handbook of marine mammals. Vol. 3: The sirenians and baleen whales. Adacemic Press; London, United Kingdom.

Garrison, L., S.L. Swartz, A. Martinez, C. Burks and J. Stamates. 2003. A marine mammal assessment survey of the southeast U.S. continental shelf: February - April 2002. NOAA Technical Memorandum NMFS-SEFSC-492. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center; Miami, Florida.

Gauthier, J and R. Sears. 1999. Behavioral response of four species of balaenopterid whales to biopsy sampling. Marine Mammal Science. 15(1): 85-101.

Gill, J. A., and W. J. Sutherland. 2000. Predicting the consequences of human disturbance from behavioral decisions, Pages 51 - 64 *in* L. M. Gosling, and W. J. Sutherland, eds. Behavior and conservation. Cambridge, United Kingdom, Cambridge University Press.

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. Why behavioral responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.

Gisiner, R. C. 1998. Workshop on the effects of anthropogenic noise in the marine environment. U.S. Navy, Office of Naval Research, Marine Mammal Research Program, Washington, D.C.

Goddard, P.C. and D.J. Rugh. 1998. A group of right whales seen in the Bering Sea in July 1996. Marine Mammal Science 14(2):344-349.

Goold, J.C. and S.E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98: 1279-1291.

Goold, J.C., H. Whitehead and R.J. Reid. 2002. North Atlantic sperm whale, *Physeter macrocephalus*, strandings on the coastlines of the British Iles and eastern Canada. The Canadian field-naturalist 116(3): 18.

Gordon, J.C.D. 1987. Behavior and ecology of sperm whales off Sri Lanka. Ph.D. dissertation, University of Cambridge, Cambridge, England.

Gore, M.A., E. Ahmad, Q.M. Ali, R.M. Culloch, S. Hameed, S.A. Hasnain, B. Hussain, S. Kiani, N. Shaik, P.J. Siddiqui and R.F. Ormond. 2007. Sperm whale, *Physeter macrocephalus*, stranding on the Pakistani coast. Journal of the Marine Biological Association of the United Kingdom 87(1): 2.

Gosho, M.E., D.W. Rice, and J.M. Breiwick. 1984. Sperm whale interactions with longline vessels in Alaska waters during 1997. Unpublished report available Alaska Fisheries Science Center; Seattle, Washington.

Gotelli, N. J. 2001, A primer of ecology. Sunderland, Massachusetts, Sinauer Associates, Inc.

Government Printing Office. 1987. Endangered fish and wildlife; approaching humpback whales in Hawai'ian waters. Federal Register 52 (225, 23 Nov.):44912-44915.

Hain, J.H.W., M.J. Ratnaswamy, R.D. Kenney, and H.E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42: 653-669.

Harris, C. M., editor. 1998. Handbook of acoustical measurements and noise control. Acoustical Society of America, Woodbury, New York.

Herman, L. M., C. S. Baker, P. H. Forestell and R. C. Antinoja. 1980. Right whale *Balaena glacialis* - sightings near Hawai'i: a clue to the wintering grounds? 2:271-275.

Hildebrand, J. A. 2004. Impacts of anthropogenic sound on cetaceans. Unpublished paper submitted to the International Whaling Commission Scientific Committee SC/56/E13. International Whaling Commission, Cambridge, United Kingdom.

Hildebrand, J. A. 2005. Annex K: Report of the standing working group on environmental concerns. Appendix 3. Introduction to acoustics. Journal of Cetacean Research and Management 7:284 - 286.

Hill, P.S. and D.P. DeMaster. 1999. Pacific Marine Mammal Stock Assessments, 1999. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-110. Alaska Fisheries Science Center; Auke Bay, Alaska.

Hohn, A. A., D. S. Rotstein, C. A. Harms, and B. L. Southall. 2006. Report on marine mammal unusual mortality event UME0501Sp Multispecies mass stranding of pilot whales (*Globicephala macrorhynchus*), minke whale (*Balaenoptera acutiorostrata*), and dwarf sperm whales (*Kogia sima*) in North Carolina on 15 - 16 January 2005. NOAA Technical Memorandum NMFS-SEFSC-537. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

Holberton, R. L., B. Helmuth, and J. C. Wingfield. 1996. The corticosterone stress response in gentoo and king penguins during the non-fasting period. The Condor 98:4.

Holt, M.M., V. Veirs and S. Veirs. 2007. Noise effects on the call amplitude of southern resident killer whales (*Orcinus orca*) Poster presented at the International conference on the effects of noise on aquatic life, 13 - 17 August 2007. Nyborg, Denmark.

Hood, L. C., P. D. Boersma, and J. C. Wingfield. 1998. The adrenocortical response to stress in incubating magellanic penguins (*Spheniscus magellanicus*). The Auk 115:9.

Horwood, J. 1987. The sei whale: population biology, ecology and management. Croom Helm; Beckenham, Kent, United Kingdom.

Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden and D. Ziaos (editors). 2001. Contribution of working group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom.

International Whaling Commission (IWC). 1980. Report of the sub-committee on protected species and aboriginal whaling. Reports of the International Whaling Commission 30:103-111.

International Whaling Commission (IWC). 2005. Annex K. Report of the standing working group on environmental concerns. Journal of Cetacean Research and Management 7 (Supplement):267 - 281.

International Whaling Commission [IWC]. 1998. Report of the workshop on the comprehensive assessment of right whales: a worldwide comparison. International Whaling Commission special workshop held 19-25 March 1998, in Cape Town, South Africa. SC/50/REP 4.

Jahoda, M., C. L. Lafortuna, N. Biassoni, C. Almirante, A. Azzelino, S. Panigada, M. Zanardelli *et al*. 2003. Mediterranean fin whale's (*Balaenoptera physalus*) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science 19:15.

Jansen, G. 1998. Chapter 25. Physiological effects of noise. Pages 25.21 - 25.19 in C. M. Harris, editor. Handbook of acoustical measurements and noise control. Acoustical Society of America, Woodbury, New York.

Jaquet, N. 1996. How spatial and temporal scales influence understanding of sperm whale distribution. Mammal Review 26:51.

Jaquet, N., and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. Marine ecology progress series 135:10.

Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler. 2005. Sounding the depths II: The rising toll of sonar, shipping and industrial ocean noise on marine life. Natural Resources Defense Council, New York, New York.

Jefferson, T.A. and A.J. Schiro. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. Mammal Review 27(1): 27-50.

Jepson, P. D., M. Arbelo, R. Deaville, I. A. P. Patterson, P. Castro, J. R. Baker, E. Degollada *et al*. 2003. Gas-bubble lesions in stranded cetaceans. Nature 425:575-576.

Jepson, P. D., R. Deaville, I. A. P. Patterson, A. M. Pocknell, H. M. Ross, J. R. Baker, F. E. Howie, R. J. Reid, A. Colloff, and A. A. Cunningham. 2005. Acute and chronic gas bubble lesions in cetaceans stranded in the United Kingdom. Veterinary Pathology 42:291-305.

Jessop, T. S., A. D. Tucker, C. J. Limpus, and J. M. Whittier. 2003. Interactions between ecology, demography, capture stress, and profiles of corticosterone and glucose in a free-living population of Australian freshwater crocodiles. General and Comparative Endocrinology 132:10.

Johnson, P.A. and B.W. Johnson. 1980. Hawai'ian monk seal observations on French Frigate Shoals, 1980. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-50. National Marine Fisheries Service, Southwest Fisheries Science Center; La Jolla California.

Jones, D. M., and D. E. Broadbent. 1998. Chapter 24. Human peformance and noise. Pages 24.21 - 24.24 in C. M. Harris, editor. Handbook of acoustical measurements and noise control. Acoustical Society of America, Woodbury, New York.

Kastak, D., R.J. Schusterman, B.L. Southall, and C. Reichmuth. 2000. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. Journal of the Acoustical Society of America 106(2):1142-1148.

Kasuya, T. 1991. Density dependent growth in North Pacific sperm whales. Marine Mammal Science 7(3):230-257.

Kawakami, T. 1980. A review of sperm whale food. Scientific Report of the Whales Research Institute Tokyo 32:199-218.

Kawamura, A. 1982. Food habits and prey distributions of three rorqual species in the North Pacific Ocean. Scientific Reports of the Whales Research Institute, Tokyo 34:59-91.

Ketten, D. R. 2005. Annex K: Report of the standing working group on environmental concerns. Appendix 4. Marine mammal auditory systems: a summary of audiometric and anatomical data and implications for underwater acoustic impacts. Journal of Cetacean Research and Management 7:286 - 289.

Ketten, D.R. 1994. Functional analyses of whale ears: adaptations for underwater hearing. IEEE Proceedings on Underwater Acoustics 1: 264-270.

Ketten, D.R. 1997. Structure and function in whale ears. Bioacoustics 8: 103-135.

Ketten, D.R. 1998. Marine mammal auditory systems: a summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-256.

Klima, E.F., G.R. Gitschlag, and M.L. Renaud. 1988. Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. Marine Fisheries Review 50(3) 33-42.

Klinowska, M. 1985. Cetacean live stranding sites relate to geomagnetic topography. Aquatic Mammals 1: 27 - 32.

Klinowska, M. 1986. Cetacean live stranding dates relate to geomagnetic disturbances. Aquatic Mammals 11(3): 109 - 119.

Korte, S. M., J. M. Koolhaas, J. C. Wingfield, and B. S. McEwen. 2005. The Darwinian concept of stress: benefits of allostasis and costs of allostatic load and the trade-offs in health and disease. Neuroscience and Biobehavioral Reviews 29:3 - 38.

Krausman, P. R., L. K. Harris, C. L. Blasch, K. K. G. Koenen, and J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs:1-41.

Kuczaj, S., R. Paulos, J. Ramos, R. Thames, G. Rayborn, G. Ioup and J. Newcomb. 2003. Anthropogenic noise and sperm whale sound production. Las Palmas de Gran Canaria, Canary Islands, Spain.

Lafferty, K. D., and R. D. Holt. 2003. How should environmental stress affect the population dynamics of disease? Ecology Letters 6:654-664.

Lagueux, C.J. 1998. Marine turtle fishery of Caribbean Nicaragua: human use patterns and harvest trends. Doctoral Dissertation, University of Florida; Gainesville, Florida.

Lambertsen, R. H. B. A. Kohn, J. P. Sundberg, and C. D. Buergelt. 1987. Genital papillomatosis in sperm whale bulls. Journal of Wildlife Diseases. 23(3):361-367.

Lambertsen, R.H. 1986. Disease of the common fin whale (*Balaenoptera physalus*): Crassicaudiosis of the urinary system. Journal of Mammalogy 67(2): 353-366.

Landis, C.J. 1965. Research: A new high pressure research animal? Undersea Technology 6:21.

Landis, W. G., G.B. Matthews, R.A. Matthews, A. Sergeant. 1994. Application of multivariate techniques to endpoint determination, selection and evaluation in ecological risk assessment. Environmental Toxicology and Chemistry 13: 1917.

Latishev, V.M. 2007. Scientific report from factory ships "Vladivostok" and "Dalniy Vostok" in 1967. Pages: 16-17. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent arctic waters: a guide to their identification. NOAA Technical Report National Marine Fisheries Service Circular 444.

Lenhardt, M.L. 1994. Auditory behavior of the loggerhead sea turtle (*Caretta caretta*). Page 89. In: K.A. Bjorndahl, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (compilers), Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-351.

Lettevall, E., C. Richter, N. Jaquet, E. Slooten, S. Dawson, H. Whitehead, J. Christal and P.M. Howard. 2002. Social structure and residency in aggregations of male sperm whales. Canadian Journal of Zoology 80(7): 8.

Levenson, C. 1974. Source level and bistatic target strength of the sperm whale (*Physeter catodon*) measured from an oceanographic aircraft. Journal of the Acoustical Society of America 55: 1100-1103.

Lipton, J., H. Galbraith, J. Burger, D. Wartenberg. 1993. A paradigm for ecological risk assessment. Environmental Management 17: 1-5.

Ljungblad DK, Clark CW, Shimada H (in press) Sounds attributed to pygmy blue whales (*Balaenoptera musculus brevicauda*) recorded south of the Madagascar Plateau in December 1996 as compared to sounds attributed to "true" blue whales (*Balaenoptera musculus*) recorded off Antarctica in January 1997.

Lombard, E. 1911. Le signe de l'el\'{e}vation de la voix. Annales Maladies Oreille, Larynx, Nez, Pharynx 37:101-119.

Lockyer, C. 1978. The history and behavior of a solitary wild, but sociable bottlenose dolphin (*Tursiops truncatus*) on the west coast of England and Wales. Journal of Natural History 12:513-528.

Lockyer, C. 1981. Growth and energy budgets of large baleen whales from the Southern Hemisphere. Mammals in the Seas. Vol. 3. Food and Agricultural Organization Fisheries Series 5: 379-487.

Lockyer, C. 1984. Review of baleen whale (Mysticeti) reproduction and implications for management. Reports of the International Whaling Commission, Special Issue 6: 27-50.

Loughlin, T.R., D.J. Rugh, and C.H. Fiscus. 1984. Northern sea lion distribution and abundance: 1956-80. Journal of Wildlife Management 48: 729-740.

Lowell, R.B. J.M. Culp, and M.G. Dube. 2000. A weight of evidence approach to northern river risk assessment: integrating the effects of multiple stressors. Environmental Toxicology and Chemistry 19: 1182-1190.

Lowry, L., D.W. Laist and E. Taylor. 2007. Endangered, threatened, and depleted marine mammals in U.S. waters. A review of species classification systems and listed species. Report prepared for the Marine Mammal Commission; Bethesda, Maryland.

MacArthur, R.A., R.H. Johnson and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: A physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57(10):2010-2021.

Mackintosh, N.A. 1942. The southern stocks of whalebone whales. Discovery Reports 22:197-300.

Mackintosh, N.A. 1965. The stocks of whales. Fishing News (Books) Ltd., London.

Mackintosh, N.A. and J.F.G. Wheeler. 1929. Southern blue and fin whales. Discovery Reports 1: 257-540.

MacLeod, C. D., and A. D'Amico. 2006. A review of beaked whale behavior and ecology in relation to assessing and mitigating impacts of anthropogenic noise. Journal of Cetacean Research and Management **7**:211 - 221.

MacLeod, C. D., G. J. Pierce, and M. B. Santos. 2004. Geographic and temporal variations in strandings of beaked whales (Ziphiidae) on the coasts of the UK and the Republic of Ireland from 1800-2002. Journal of Cetacean Research and Management **6**:79 - 86.

Madsen, P.T. and B. Mohl. 2000. Sperm whales (*Physeter catodon* L 1758) do not react to sounds from detonators. The Journal of the Acoustical Society of America 107: 668-671.

Magalhaes, S., R. Prieto, M. A. Silva, J. Goncalves, M. Afonso-Dias, and R. S. Santos. 2002. Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. Aquatic Mammals 28:267-274.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior: Final Report for the Period of 7 June 1982 - 31 July 1983. Prepared for U.S. Department of the Interior Minerals Management Service, Alaska OCS Office by Bolt Beranek and Newman Inc. Cambridge: Bolt Beranek and Newman Inc., 1983.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J. E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 586. Rep. from Bolt, Beranek, & Newman, Inc. Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, Alaska.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. Report No. 5851, Unpublished report prepared by Bolt, Beranek and Newman Inc., Cambridge, USA, for U.S. Minerals Management Service, Alaska OCS Office, Anchorage, Alaska.

Marcoux, M., L. Rendell and H. Whitehead. 2007. Indications of fitness differences among vocal clans of sperm whales. Behavioral Ecology and Sociobiology 61(7): 1093-1098.

Marshall, G. J. 1998. Crittercam: an animal-borne imaging and data logging system. Marine Technology Science Journal. 32(1):11-17.

Masaki, Y. 1976. Biological studies on the North Pacific sei whale. Bulletin of the Far Seas Fisheries Research Laboratory (Shimizu) 14:1-104.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Reports of the International Whaling Commission Special Issue No. 1: 71-79.

Masaki, Y. 1980. On the pregnancy rate of the North Pacific sperm whales. Reports of the International Whaling Commission Special Issue 2: 43-48.

Mate, B., K.M. Stafford and D.K. Ljungblad. 1994. A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. Journal of the Acoustic Society of America 96: 3268-3269.

Maury, M.F. 1852. Whale chart of the world, (The wind and current charts), Series F, Washington, D.C.

Maury, M.F. 1853. A chart showing the favorite reports of the sperm and right whales by M.F. Maury, L.L.D. Lieutenant, U.S. Navy. Constructed from Maury's whale chart of the world by Robert H. Wayman, Lieutenant, U.S. Navy by Authority of the Commo. Bureau of Ordinance and Hydrography; Washington, D.C.

Maybaum, H.L. 1989. Effects of 3.3 kHz sonar system on humpback whales *Megaptera novaeangliae*, in Hawai'ian waters. Eos.71(2):92.

Maybaum, H.L. 1993. Responses of humpback whales to sonar sounds. The Journal of the Acoustical Society of America 94(3):1848-1849.

Mayo, C.A., and M. K. Marx. 1990. Surface foraging behavior of the North Atlantic right whale (*Eubalaena glacialis*) and associated zooplankton characteristics. Canadian Journal of Zoology 68: 2214-2220.

McArdle, B.H. 1990. When are rare species not there? Oikos 57:276-277.

McCall Howard, M.P. 1999. Sperm whales *Physeter macrocephalus* in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying. Unpublished Thesis prepared for a Batchelor of Science Degree. Dalhousie University, Halifax, Nova Scotia.

McCarthy, J.J., O. Canziani, N.A. Leary, D.J. Dokken and K.S. White (editors). 2001. Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom

McCarty, L. S., and M. Power. 1997. Environmental risk assessment within a decision-making framework. Environmental Toxicology and Chemistry 16:122.

McCauley, R. D., and D. H. Cato. 2001. The underwater noise of vessels in the Hervey Bay (Queensland) whale watch fleet and its impact on humpback whales. Journal of the Acoustical Society of America 109:2455.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Report R99-15. Centre for Marine Science and Technology, Curtin University of Technology, Western Australia.

McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. Journal of the Acoustical Society of America 98:712-721.

McDonald, M.A. and Fox, C.G. 1999. Passive acoustic methods applied to fin whale population density estimation. Journal of the Acoustical Society of America 105(5): 2643-2651

McEwen, B. S., and J. C. Wingfield. 2003. The concept of allostasis in biology and biomedicine. Hormones and Behavior 43:2 - 15.

McEwen, B. S., and T. Seeman. 2000. Overview - protective and damaging effects of mediators of stress: elaborating and testing the concepts of allostasis and allostatic load. Annals of the New York Academy of Sciences 896:18.

Meredith, G.N. and R.R. Campbell. 1988. Status of the fin whale, *Balaenoptera physalus*, in Canada. Canadian Field-Naturalist 102: 351-368.

Mikhalven, Y.A. 1997. Humpback whales *Megaptera novaeangliae* in the Arabian Sea. Marine Ecology Progress Series 149:13-21.

Miller, P.J.O., N. Biassoni, A. Samuels and P.L. Tyack. 2000. Whales songs lengthen in response to sonar. Nature 405, 903

Mills, J.H. and J.A. Going. 1982. Review of environmental factors affecting hearing. Environmental Health Perspective 44:119-127.

Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fitness. Philosophy of Science 46:263-286.

Mizroch, S.A., D.W. Rice, and J.M. Breiwick. 1984. The blue whale, *Balaenoptera musculus*. Marine Fisheries Review 46(4):15-19.

Mizroch, S.A., D.W. Rice, and J.M. Breiwick. 1984b. The fin whale, *Balaenoptera physalu*s. Marine Fisheries Review 46(4):20-24.

Mizue, K. 1951. Food of whales (in the adjacent waters of Japan). Scientific Reports of the Whales Research Institute 5:81-90.

Moberg, G. P. 1985. Biological response to stress: key to assessment of animal well-being? Pages 27 - 49 in G. P. Moberg, editor. Animal stress. American Physiological Society, Bethesda, Maryland.

Moberg, G. P. 2000. Biological response to stress: implications for animal welfare. Pages 1 - 21 in G. P. Moberg, and J. A. Mench, editors. The biology of animal stress. Basic principles and implications for animal welfare. Oxford University Press, Oxford, United Kingdom.

Mobley, J. R., L. M. Herman, A. S. Frankel. 1988. Responses of wintering Humpback whales (*Megaptera novaeangliae*) to playback of recordings of winter and summer vocalizations and of synthetic sounds. Behavioral Ecology and Sociobiology 23: 211-223

Mobley, J. R., M. Smultea, T. Norris, and D. Weller. 1996. Fin whale sighting north of Kauai, Hawai'i. Pacific Science 50: 230-233.

Mobley, J. R., R. A. Grotefendt, P. H. Forestell, and A. S. Frankel. 1999a. Results of Aerial surveys of marine mammals in the major Hawai'ian Islands (1993-1998): Report to the Acoustic Thermometry of Ocean Climate Marine Mammal Research Program. Cornell University Bioacoustics Research Program, Ithaca, New York.

Mohl, B. 2001. Sound transmission in the nose of the sperm whale *Physeter catodon.* A post mortem study. Journal of Comparative Physiology A Sensory Neural and Behavioral Physiology 187:335-340.

Mohl, B., M. Wahlberg, P. T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. The Journal of the Acoustical Society of America 114:12.

Mohl, B., M. Wahlberg, P. T. Madsen, L. A. Miller, and A. Surlykke. 2000. Sperm whale clicks: Directionality and source level revisited. Journal of the Acoustical Society of America 107:638.

Mohl, *et al*. 2000. Sperm whale clicks: Directionality and source level revisted. Journal of the Acoustical Society of America 107 (1), January 2000, pp. 638 -645.

Moore, J.C. 1953. Distribution of marine mammals in Florida waters. American Midland Naturalist 49(1): 117-158.

Moore, K. E., W. A. Watkins, and P. L. Tyack. 1993. Pattern similarity in shared codas from sperm whales (*Physeter catodon*). Marine Mammal Science 9:1-9.

Morton, A.B. and H.K. Symonds. 2002. Displacement of *Orcinus orca* (L ) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science 59(1): 71-80.

Mullin, K.D. and G.L. Fulling. 2007. Abundance of cetaceans in the southern U.S. North Altantic Ocean during summer 1998. Fisheries Bulletin 101:603-613.

Mullins, J., H. Whitehead, and L.S. Weilgart. 1988. Behavior and vocalizations of two single sperm whales, Physeter macrocephalus off Nova Scotia. Canadian Journal of Fisheries and Aquatic Sciences 45(10):1736-1743.

Myrberg, A.A., Jr. 1978. Ocean noise and behavior of marine animals: Relationships and implications. Pages 169-208. In: J.L. Fletcher and R.G. Busnel (eds.) Effects of Noise on Wildlife. Academic Press; New York, New York.

Nachtigall, P. E., A. Y. Supin, J. Pawloski, and W. W. L. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using evoked auditory potentials. Marine Mammal Science 20:15.

Nachtigall, P. E., J. L. Pawloski, and W. W. L. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). The Journal of the Acoustical Society of America 113:5.

Nachtigall, P. E., M. M. L. Yuen, T. A. Mooney, and K. A. Taylor. 2005. Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. The Journal of Experimental Biology 208:4181.

Nasu, K. 1974. Movement of baleen whales in relation to hydrographic conditions in the northern part of the North Pacific Ocean and the Bering Sea. Pages 345-361 *in* D.W. Hood and E.J. Kelley (eds.), Oceanography of the Bering Sea. Institute of Marine Science, University of Alaska; Fairbanks, Alaska.

National Marine Fisheries Service (NMFS). 1992. Environmental assessment of the effects of biopsy darting and associated approaches on humpback whales (*Megaptera novaeangliae*) and right whales (*Eubalaena glacialis*) in the North Atlantic. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service [NMFS]. 1994. An assessment of whale watching in the United States. Prepared for the International Whaling Commission by U.S. Department of Commerce, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service [NMFS]. 1997. Biological opinion on U.S. Navy activities off the southeastern United States along the Atlantic coast. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office; St. Petersburg, Florida.

National Marine Fisheries Service [NMFS]. 1998a. Recovery plan for the blue whale (*Balaenoptera musculus*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service [NMFS]. 1998b. Recovery plan for the fin whale *Balaenoptera physalus*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service [NMFS]. 2001. Final biological opinion on the U.S. Navy's North Pacific Acoustic Laboratory Sound Source. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service [NMFS]. 2002. Biological opinion on shrimp trawling in the southeastern United States, under the sea turtle conservation regulations and as managed by the Fishery Management Plans for Shrimp in the south Atlantic and Gulf of Mexico. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office; St. Petersburg, Florida.

National Marine Fisheries Service [NMFS]. 2002. Biological opinion on the U.S. Navy's Surveillance Towed Array Sensor System Low Frequency Active Sonar (SURTASS LFA). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Endangered Species Division, Silver Spring, Maryland.

National Marine Fisheries Service. 2007. Biological opinion on the U.S. Navy's proposed 2007 USS Truman 07-1 Combined Carrier Strike Group Composite Training Unit/Joint Task Force exercise. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service [NMFS]. 1997. Biological opinion on U.S. Navy activities off the southeastern United States along the Atlantic coast. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office; St. Petersburg, Florida.

National Marine Fisheries Service [NMFS]. 2007. Biological opinion on the U.S. Navy's proposed 2007 USS Truman 07-1 Combined Carrier Strike Group Composite Training Unit/Joint Task Force exercise. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

National Marine Fisheries Service and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1998a. Recovery plan for U.S. Pacific population of the east Pacific green turtle (*Chelonia mydas*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Pacific Region; Silver Spring, Maryland.

National Marine Fisheries Service and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1998b. Recovery plan for U.S. Pacific population of the hawksbill turtle (*Eretmochelys imbricata*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Pacific Region; Silver Spring, Maryland.

National Marine Fisheries Service and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1998c. Recovery plan for U.S. Pacific population of the leatherback turtle (*Dermochelys coriacea*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Pacific Region; Silver Spring, Maryland.

National Marine Fisheries Service and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1998d. Recovery plan for U.S. Pacific population of the loggerhead turtle (*Caretta caretta*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Pacific Region; Silver Spring, Maryland.

National Marine Fisheries Service and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1998e. Recovery plan for U.S. Pacific population of the olive ridley turtle (*Lepidochelys olivacea*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Pacific Region; Silver Spring, Maryland.

National Research Council [NRC]. 1994. Low-frequency sound and marine mammals, current knowledge and research needs. National Academy Press; Washington, D.C.

National Research Council [NRC]. 1996. Marine mammals and low frequency sound: Progress since 1994 - an interim report. National Academy Press; Washington, D.C.

National Research Council [NRC]. 2000. Marine mammals and low frequency sound: Progress since 1994. National Academy Press; Washington, D.C.

National Research Council [NRC]. 2003. Ocean noise and marine mammals. National Academy Press; Washington, D.C.

National Research Council 2005. Marine mammal populations and ocean noise : determining when noise causes biologically significant effects. National Academies Press, Washington, D.C.

Nemoto T. 1964. School of baleen whales in the feeding areas. Scientific Reports of the Whales Research Institute 18: 89-110.

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. Scientific Reports of the Whales Research Institute 12:33-89.

Nemoto, T. 1970. Feeding pattern of baleen whales in the oceans. Pages 241-252 *in* Steele, J.H. (ed.), Marine Food Chains. University of California Press, Berkeley, California.

Nemoto, T. 1978. Humpback whales observed within the continental shelf waters of the Bering Sea. Scientific Reports of the Whales Research Institute, Tokyo 39:245-247.

Nemoto, T., and A. Kawamura. 1977. Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. Reports of the International Whaling Commission, Special Issue 1:80-87.

Newman, M. C., D. R. Ownby, L. C. A. Mezin, D. C. Powell, T. R. L. Christensen, S. B. Lerberg, and B. A. Anderson. 2000. Applying species-sensitivity distributions in ecological risk assessment: assumptions of distribution type and sufficient numbers of species. Environmental Toxicology and Chemistry 19:508.

Nishiwaki, M. 1952. On the age determination of Mystacoceti, chiefly blue and fin whales. Scientific Reports of the Whales Research Institute 7: 87-119.

Nishiwaki, M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. Pages 171-191 *in* Norris, K.S., (ed.), Whales, Dolphins and Porpoises. University of California Press, Berkeley.

Nitta, E.T. 1991. The marine mammal stranding network for Hawaii, an overview. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.

Norrgard, J. 1995. Determination of stock composition and natal origin of a juvenile loggerhead turtle population (*Caretta caretta*) in Chesapeake Bay using mitochondrial DNA analysis. Thesis prepared in partial fulfillment of a Master's Degree in Arts. College of William and Mary; Williamsburg, Virginia

Norris, T.F. 1994. Effects of boat noise on the acoustic behavior of humpback whales. The Journal of the Acoustical Society of America 96(1):3251.

Norton, S. B., D. J. Rodier, J. H. Gentile, W. H. Van Der Schalie, and W. P. Wood. 1992. The framework for ecological risk assessment at the EPA. Environmental Toxicology and Chemistry 11:1663.

Notarbartolo-di-Sciara, G., M. Zanardelli, M. Jahoda, S. Panigada, and S. Airoldi. 2003. The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea. Mammal Review 33:105-150.

Nowacek, D., M. P. Johnson and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London. Series B. Biological Sciences 271: 227-231.

O'Hara, J. and J.R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia 1990:564-567.

O'Hara, T.M., M.M. Krahn, D. Boyd, P.R. Becker, and L.M. Philo. 1999. Organochlorine contaminant levels in Eskimo harvested bowhead whales of arctic Alaska. Journal of Wildlife Diseases 35(4): 741-52.

O'Shea, T.J. and R.L.J. Brownell. 1994. Organochlorine and metal contaminants in baleen whales: A review and evaluation of conservation implications. Science of the Total Environment 154 (2-3): 179-200.

Ohsumi, S. 1980. Catches of sperm whales by modern whaling in the North Pacific. Reports of the International Whaling Commission Special Issue 2: 11-18.

Ohsumi, S. 1980. Criticism of Japanese fishing effort for sperm whales in the North Pacific. Reports of the International Whaling Commission Special Issue 2: 19-30.

Ohsumi, S. 1980. Population assessment of the sperm whale in the North Pacific. Reports of the International Whaling Commission Special Issue 2: 31-42.

Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Reports of the International Whaling Commission 24:114-126.

Palumbi, S.R. and J. Roman. 2006. The history of whales read from DNA. Pages: 102-115. In: *Whales, whaling, and ocean ecosystems*. Edited by J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L. Brownell Jr. University of California Press; Berkeley and Los Angeles, California.

Parks, S.E. and C.W. Clark. 2007. Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. Journal of the Acoustic Society of America 122(6): 3725-3731.

Parrish, F. A., M.P. Craig, K. Abernathy, G.J. Marshall and B.M. Buhleier. Hawai'ian monk seals (*Monachus Shauinslandi*) foraging in deepwater coral beds, another endangered species using old growth "Trees?" (May 23, 2000) (unpublished manuscript, on file with the NMFS).

Patricelli, G.L. and J.L. Blickley. 2006. Avian communication in urban noise: causes and consequences of vocal adjustment. The Auk 123(3):639-649.

Patterson, B. and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. In: Tavolga, W.N. (ed.) Marine bioacoustics.

Payne, R. and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Annals of the New York Academy of Sciences 188:0110-141.

Parry, M., O. Canziani, J. Palutikof and P.J. van der Linden (editors). 2007. Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: history and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61: 1-74.

Piantadosi, C. A., and E. D. Thalmann. 2004. Pathology: Whales, sonar and decompression sickness. Nature 428:n.

Piatt, J. F. and D. A. Methven. 1992. Threshold foraging behavior of baleen whales. Marine Ecology Progress Series 84:205-210.

Piatt, J. F., D. A. Methven, A. E. Burger, R. L. McLagan, V. Mercer and E. Creelman. 1989. Baleen whales and their prey in a coastal environment. Canadian Journal of Zoology 67:1523-1530.

Polmar, N. 2001. The Naval Institute guide to the ships and aircraft of the U.S. fleet. Naval Institute Press; Annapolis, Maryland.

Posner, M.I. 1994. Attention: the mechanism of consciousness. Proceedings of the National Academy of Science of the United States of America 91:7398-7403.

Potter, J.R. 2004. A possible mechanism for acoustic triggering of decompression sickness symptoms in deep-diving marine mammals. Underwater Technology April 2004: 20-23.

Prevalichin, V.I. 2007. Scientific report for "Dalniy Vostok" and "Vladivostok" for the 1973 season. Pages: 20-22. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175.* Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Pryor, K. 1990. Non-acoustic communication in small cetaceans: glance, touch, position, gesture, and bubbles. In: J.A. Thomas and R.A. Kastelein (eds.), Sensory Abilities in Cetaceans - Laboratory and Field Evidence. p.537-544. NATO ASI Series, Plenum Press, New York.

Rankin-Baransky, K.C. 1997. Origin of loggerhead turtles (*Caretta caretta*) in the western North Atlantic as determined by mt DNA analysis. Thesis prepared in partial fulfillment of a Master's Degree in Science. Drexel University; Philadelphia, Pennsylvania

Ray, G. C., E. Mitchell, D. Wartzok, V. Koxicki, and R. Maiefski. 1978. Radio tracking of a fin whale (*Balaenoptera physalus*). Science 202: 521-524.

Reeves, R. R. 1992. Whale responses to anthropogenic sounds: a literature review. New Zealand Department of Conservation, Wellington, New Zealand.

Reeves, R.R. and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. The Canadian Field-Naturalist 111(2): 293-307.

Reeves, R.R., B.D. Smith, E.A. Crespo, G. Notarbartolo di Sciara. 2002. Dolphins, whales and porpoises. 2002 – 2010 Conservation action plan for the world's cetaceans. The World Conservation Union, Cetacean Specialist Group. IUCN; Gland, Switzerland and Cambridge, United Kingdom.

Relyea, R. A. 2003. Predator cues and pesticides: A double dose of danger for amphibians. Ecological Applications 13:7.

Relyea, R. A. 2005. The lethal impacts of roundup and predatory stress on six species of North American tadpoles. Archives of Environmental Contamination and Toxicology 48:7.

Relyea, R. A., and N. Mills. 2001. Predator-induced stress makes the pesticide carbaryl more deadly to gray treefrog tadpoles (*Hyla versicolor*). Proceedings of the National Academy of Sciences of the United States of America 98:6.

Rendell, L. and H. Whitehead. 2004. Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. Animal Behavior 67(5): 10.

Rendell, L. and H. Whitehead. 2005. Coda playbacks to sperm whales in Chilean waters. Marine Mammal Science 21(2): 10.

Rendell, L., H. Whitehead and A. Coakes. 2005. Do breeding male sperm whales show preferences among vocal clans of females? Marine Mammal Science 21(2): 6.

Reneerkens, J., R. I. G. Morrison, M. Ramenofsky, T. Piersma, and J. C. Wingfield. 2002. Baseline and stress-induced levels of corticosterone during different life cycle substages in a shorebird on the high arctic breeding grounds. Physiological and Biochemical Zoology 75:200-208.

Rice, D.W. 1974. Whales and whale research in the eastern North Pacific . Pages 170-195 *in* Schevill, W.E. (ed.), The Whale Problem: A Status Report. Harvard University Press, Cambridge, Massachusetts.

Rice, D.W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Reports of the International Whaling Commission, Special Issue No. 1:92-97.

Rice, D.W. 1986. Sperm whales. Pages 94-101 *in* D. Haley (ed.), Marine Mammals of the Eastern North pacific and Arctic Waters, 2nd ed. Pacific Search Press, Seattle, Washington.

Rice, D.W. 1989. Sperm whale, *Physeter macrocephalus* (Linneaus, 1758). In: *Handbook of marine mammals. Volume 4. River dolphins and the larger toothed whales.* Edited by S.H. Ridgeway and R.J. Harrison. Academic Press, Inc.; New York, New York.

Richard, K.R., M.C. Dillon, H. Whitehead and J.M. Wright. 1996. Patterns of kinship in groups of free-living sperm whales (*Physeter macrocephalus*) revealed by multiple molecular genetic analyses. Proceedings of the National Academy of Science of the United States of America 93(16): 8792-8795.

Richardson W.J., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press; San Diego, California.

Richardson, W. J., C. R National Marine Fisheries Service [NMFS]. 1998b. Recovery plan for the fin whale *Balaenoptera physalus*. Prepared by R.R. Reeves, G.K. Silber, and P. Michael Payne for the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources; Silver Spring, Maryland.. Greene, Jr., C. I. Malme and D. H. Thompson. 1991. Effects of noise on marine mammals. OCS Study MMS-90-0093; LGL Rep. TA834-1. Unpublished report prepared by LGL Ecological Research Associates, Inc. for U.S. Minerals Management Service, Atlantic OCS Reg., Herndon, Virginia. NTIS PB91-168914.

Richardson, W.J., C.R. Greene, Jr., W.R. Koski and M.A. Smultea. 1991a. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska -- 1990 phase. OCS Study MMS 91-0037; LGL Rep. TA848-5. Unpublished Report prepared by LGL Ltd., for U.S. Minerals Management Service, Herndon, Virginia. NTIS PB92-170430.

Richter, C., S. Dawson and E. Slooten. 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. Marine Mammal Science 22(1): 18.

Richter, C., S.M. Dawson and E. Slooten. 2003. Sperm whale watching off Kaikoura, New Zealand: effects of current activities on surfacing and vocalization patterns. Science for Conservation 219. New Zealand Department of Conservation; Wellington, New Zealand.

Rivers, J.A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Marine Mammal Science 13(2):10.

Romano, T.A., M.J. Keogh, C. Kelly, P. Feng, L. Berk, C.E. Schlundt, D.A. Carder and J.J. Finneran. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Science 61: 1124-1134.

Romero, A., K.T. Hayford and J. Romero. 2002. The marine mammals of Grenada, W.I., and their conservation status. Mammalia 66(4): 479-494.

Romero, L. M. 2004. Physiological stress in ecology: lessons from biomedical research. Trends in Ecology and Evolution 19:249-255.

Romero, L. M., and M. Wikelski. 2001. Corticosterone levels predict survival probabilities of Galapagos marine iguanas during El Nino events. Proceedings of the National Academy of Sciences of the United States of America 98:5.

Romero, L. M., and M. Wikelski. 2002. Exposure to tourism reduces stress-induced corticosterone levels in Galapagos marine iguanas. Biological conservation 108:371-374.

Salden, D.R. 1988. Humpback whale encounter rates offshore at Maui, Hawaii. The Journal of Wildlife Management 52(2): 301-304.

Sapolsky, R. M., L. M. Romero, and A. U. Munck. 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocrine Reviews 21:55 – 89.

Schmidly, D.J. 1981. Marine mammals of the southeastern United States coast and the Gulf of Mexico. Biological Services Program FWS.OBS-80/41. U.S. Department of the Interior, Bureau of Land Management and U.S. Fish and Wildlife Service; Slidell, Louisiana.

Scott, T.M. and S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science 13(2): 4.

Sears, C.J. 1994. Preliminary genetic analysis of the population structure of Georgia loggerhead sea turtles. NOAA Technical Memorandum NMFS-SEFSC-351. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center; Miami, Florida.

Sears, C.J., B.W. Bowen, R.W. Chapman, S.B. Galloway, S.R. Hopkins-Murphy and C.M. Woodley. 1995. Demographic composition of the feeding population of juvenile loggerhead sea turtles (*Caretta caretta*) off Charleston, South Carolina: evidence from mitochondrial DNA markers. Marine Biology 123:869-874.

Sergeant, D. E. 1977. Stocks of fin whales, *Balaenoptera physalus*, in the North Atlantic Ocean. Reports of the International Whaling Commission 27: 460-473.

Shane, S.H., R.S. Wells, and B. Wursig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: A review. Marine Mammal Science 2(1):34-63.

Sharpe F.A., L.M. Dill. 1997. The behavior of Pacific herring schools in response to artificial humpback whale bubbles. Canadian Journal of Zoology 75: 725-730

Sigurjonsson, J. and T. Gunnlaugsson. 1990. Recent trends in abundance of blue whales (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*) off west and southwest Iceland with a note on occurrence of other cetacean species. Report of the International Whaling Commission 40: 557-551.

Sih, A., A. M. Bell, and J. L. Kerby. 2004. Two stressors are far deadlier than one. Trends in Ecology and Evolution 19:274-276.

Silber, G. K. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawai'ian humpback whale (*Megaptera novaeangliae*). Canadian Journal of Zoology 64:2075-2080.

Slabbekoorn, H. and M. Peet. 2003. Birds sing at a higher pitch in urban noise: Great Tits hit the high notes to ensure that their mating calls are heard above the city's din. Nature 424:267.

Sleptsov, M.M. 1955. Biology of whales and the whaling fishery in Far Eastern seas. >Pishch. Prom.', Moscow [In Russian] (Translated with comments and conclusions only by Fisheries Research Board of Canada Translation Series 118, 6 pp.)

Slijper E. 1962. Whales. Basic Books; New York, New York.

Smith, S.C. and H. Whitehead. 1993. Variations in the feeding success and behavior of Galapagos sperm whales (Physeter macrocephalus) as they relate to oceanographic conditions. Canadian Journal of Zoology 71(10): 1991-1996.

Smith, S.C. and H. Whitehead. 2000. The diet of Galapagos sperm whales *Physeter macrocephalus* as indicated by fecal sample analysis. Marine Mammal Science 16(2): 11.

Smultea, M.A. 1989. Habitat utilization patterns of humpback whales off West Hawai'i. Unpublished report prepared for the Marine Mammal Commission, Contract No. T6223925-9. Bethesda, Maryland.

Sonobuoy Tech Systems. No date. AN/SSQ-63E DICASS sonobuoy. Brochure of specifications. Columbia City, Indiana and Deleon Springs, Florida.

Southall, B.L. 2007. Mid-frequency active sonar - marine mammal behavioral response functions. Scientific peer-review process - December 2007. Memorandum to Mr. James Lecky, Director, Office of Protected Resources. U.S. Department of Commerce, National Oceanic and Atmospheric Administrration, National Marine Fisheries Service; Silver Spring, Maryland.

Southall, B. L., R. Braun, F. M. D. Gulland, A. D. Heard, R. W. Baird, S. M. Wilkin, and T. K. Rowles. 2006. Hawai'ian melon-headed whale (*Peponacephala electra*) mass stranding event of July 3 - 4, 2004. NOAA Technical Memorandum NMFS-OPR-31. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.

Southall, B. L., R. J. Schusterman, and D. Kastak. 2000. Masking in three pinnipeds: Underwater, low-frequency critical ratios. Journal of the Acoustical Society of America 108:1322.

Spaulding, G.C. 1964. Comparative feeding habits of the fur seal, sea lion, and harbour seal on the British Columbia coast. Fisheries Research Board of Canada, Bulletin No. 146.

Spero, D. 1981. Vocalizations and associated behavior of northern right whales *Eubalaena glacialis*. Abstracts of the Fourth Biennial Conference on the Biology of Marine Mammals, San Francisco, USA, December 1981.

St. Aubin, D.J. and J.R. Geraci. 1988. Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whales *Delphinapterus leucas*. Physiological Zoology 61(2): 170-175.

Stark, J. D., J. E. Banks, and R. Vargas. 2004. How risky is risk assessment: The role that life history strategies play in susceptibility of species to stress. Proceedings of the National Academy of Sciences of the United States of America 101:732-736.

Stearns, S. C. 1992. The evolution of life histories. New York, New York, Oxford University Press.

Stone, C.J. 1997. Cetacean observations during seismic surveys in 1996. Joint Nature Conservation Committee, Rep. 228, Aberdeen, Scotland.

Stone, C.J. 1998. Cetacean observations during seismic surveys in 1997. Joint Nature Conservation Committee Rep. 278, Aberdeen, Scotland..

Stone, C.J. 2000. Cetacean observations during seismic surveys in 1998. Joint Nature Conservancy, Aberdeen, Scotland.

Stone, C.J. 2001. Marine mammal observations during seismic surveys in 1999. JNCC Report 316. Joint Nature Conservation Committee Rep. 316, Aberdeen, Scotland.

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters, 1998-2000 JNCC Report No. 323.

Sun, J.W.C. and P.M. Narins. 2005. Anthropogenic sounds differentially affect amphibian call rate. Biological Conservation 121:419-427.

Swift, R. 1998. The effects of array noise on cetacean distribution and behavior. Department of Oceanography. University of Southampton; Southampton, United Kingdom

Taylor, B., J. Barlow, R. Pitman, L. Ballance, T. Klinger, D. DeMaster, J. Hildebrand, J. Urban, D. Palacios, and J Mead. 2004. A call for research to assess risk of acoustic impact on beaked whale populations. Unpublised paper submitted to the International Whaling Commission, Scientific Committee SC/56/E36. Cambridge, United Kingdom.

Thomas, J. A., R. A. Kastelein and F. T. Awbrey. 1990. Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. Zoo Biology 9(5): 393-402.

Thompson P.O., L.T. Findley, O. Vidal, W.C. Cummings. 1996. Underwater sounds of blue whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. Marine Mammal Science 288-293.

Thompson P.O., W.C. Cummings, S.J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. Journal of the Acoustical Society of America 80: 735-740.

Thompson T. J., H. E. Winn, and P. J. Perkins. 1979. Mysticete sounds. Pages 403-431. In: H.E. Winn and B.L. Olla (editors). Behavior of Marine Animals. Vol. 3. Cetaceans. Plenum Press; New York, New York.

Thompson, P.O. and W.A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawai'i. Cetology 45: 1-19.

Thompson, P.O., L.T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, Balaenoptera physalus, in the Gulf of California, Mexico. Journal of the Acoustical Society of America 92: 3051-3057.

Thomson, C.A. and J.R. Geraci. 1986. Cortisol, aldosterone, and leucocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. Canadian Journal of Fisheries and Aquatic Sciences 43(5): 1010-1016

Tillman, M.F. 1977. Estimates of population size for the North Pacific sei whale. Reports of the International Whaling Commission Special Issue No. 1:98-106.

Todd S., P. Stevick, J. Lien, F. Marques, D. Ketten. 1996. Behavioral effects of exposure to underwater explosions in humpback whales *Megaptera novaeangliae*. Canadian Journal of Zoology 74: 1661-1672.

Tomich, P.Q. 1986. Mammals in Hawai'i. A synopsis and notational bibliography. Second edition. Bishop Museum Press; Honolulu, Hawai'i.

Tomilin, A. G. 1957. Cetacea. In: Heptner, V. G. (ed.). Mammals of the USSR and adjacent countries. Vol. 9. Israel Program for Scientific Translations, Jerusalem, 1967.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica (N.Y.) 19:1-50.

Trimper, P. G., N. M. Standen, L. M. Lye, D. Lemon, T. E. Chubbs, and G. W. Humphries. 1998. Effects of low-level jet aircraft noise on the behavior of nesting osprey. The Journal of Applied Ecology 35:9.

Turl, C.W. 1980. Literature review on: I. Underwater noise from offshore oil operations and II. Underwater hearing and sound productions of marine mammals. Naval Ocean Systems Center Report, San Diego, California.

Tyack P. and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. Behavior 83: 132-154.

Tyack, P.L. 2000. Functional aspects of cetacean communication. Pages 270-307. In: J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead (eds.) Cetacean societies: field studies of dolphins and whales. The University of Chicago Press; Chicago, Illinois.

Tyack, P.L. and C.W. Clark. 1997. Long range acoustic propagation of whale vocalizations. In: M. Taborsky and B. Taborsky. (editors) Advances in Ethology, 32. pp 28. Contributions to the XXV International Ethological Conference: Vienna, Austria.

U.S. Department of the Navy [Navy]. 2006. Final comprehensive overseas environmental assessment for major Atlantic fleet training exercises. Department of the Navy, Chief of Naval Operations; Washington, D.C.

U.S. Department of the Navy [Navy]. 2007a. Draft supplement to the final comprehensive overseas environmental assessment for major Atlantic fleet training exercises. 2008 exercises. Department of the Navy, Chief of Naval Operations; Washington, D.C.

U.S. Department of the Navy [Navy]. 2007b. Draft Environmental Impact Statement and Overseas Environmental Impact Statement (EIS/OEIS): Ship Shock Trial on the Mesa Verde (LPD 19). Department of the Navy, Chief of Naval Operations; Washington, D.C.

U.S. Department of the Navy [Navy]. 2008. Final Atlantic Fleet Active Sonar Training Environmental Impact Statement and Overseas Environmental Impact Statement U.S. Department of the Navy, Fleet Forces Command, Norfolk, Virginia.

U.S. Environmental Protection Agency [EPA]. 1998. Guidelines for ecological risk assessment. Federal Register 63(93); 26846-26924.

van Rij, N.G. 2007. Implicit and explicit capture of attention: what it takes to be noticed. A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Psychology. University of Canterbury; Canterbury, United Kingdom

Vladimirov, V.L. 2007. Scientific report for "Dalniy Vostok" and "Slava" for the 1969 season. Page 19. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

Vladimirov, V.L. 2007. Scientific report from the factory ships "Slava" and "Dalniy Vostok" for the 1968 season. Page 18. In: *Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. NOAA Technical Memorandum NMFS-AFSC-175*. Edited by Y.V. Ivashchenko, P.J. Clapham and R.L. Brownell Jr. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center; Seattle, Washington.

von Ziegesar, O. 1984. A survey of the humpback whales in southeastern Prince William Sound, Alaska: 1980, 1981, and 1983. Report to the Sate of Alaska, Alaska Council on Science and Technology.

Wada, S. 1980. Japanese whaling and whale sighting in the North Pacific 1978 season. Reports of the International Whaling Commission 30:415-424.

Wade, P.R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the Eastern Tropical Pacific. Reports of the International Whaling Commission 43:477-493.

Walsh, M. T., R. Y. Ewing, D. K. Odell, and G. D. Bossart. 2001. Mass strandings of cetaceans. Pages 83 - 96 in L. Dierauf, and F. M. D. Gulland, editors. Marine mammal medicine. CRC Press, Boca Raton, Florida.

Watkins W.A., W.E. Schevill. 1972. Sound source location by arrival-times on a non-rigid three-dimensional hydrophone array. Deep-Sea Research 19: 691-706.

Watkins, W. A. 1977. Acoustic behavior of sperm whales. Oceanus. 2:50-58.

Watkins, W. A., K. E. Moore, D. Wartzok, and J. H. Johnson. 1981. Radio tracking of finback *(Balaenoptera physalu*s) and humpback *(Megaptera novaeangliae*) whales in Prince William Sound, Alaska. Deep-Sea Research 28A(6):577-588.

Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). Journal of the Acoustical Society of America 82(6): 1901-1912.

Watkins, W.A. 1980. Acoustics and the behavior of sperm whales. Pages 283-290. In: R.G. Busnel and J.F. Fish (editors). Animal Sonar Systems. Plenum Press; New York, New York.

Watkins, W.A. 1981. Activities and underwater sounds of fin whales. Scientific Reports of the International Whaling Commission 33: 83-117.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science 2(4): 251-262.

Watkins, W.A. and W.E. Schevill. 1975. Sperm whales (*Physter catodon*) react to pingers. Deep-Sea Research 22: 123-129.

Watkins, W.A. and W.E. Schevill. 1977. Spatial distribution of *Physeter catodon* (sperm whales) underwater. Deep-Sea Research 24: 693-699.

Watkins, W.A. and Wartzok, D. 1985. Sensory biophysics of marine mammals. Marine Mammal Science 1(3): 219-260.

Watkins, W.A., K.E. Moore, and P. Tyack. 1985. Codas shared by Caribbean sperm whales. In: Abstracts of the Sixth Biennial Conference on the Biology of Marine Mammals, November 1985; Vancouver, British Columbia.

Watkins, W.A., K.E. Moore, and P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Watkins, W.A., M.A. Dahr, K.M. Fristrup and T.J. Howald 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Marine Mammal Science 9(1):55-67.

Watkins, W.A., P. Tyack, K.E. Moore, and J.E. Bird. 1987. The 20 Hz signals of finback whales (*Balaenoptera physalus*). Journal of the Acoustical Society of America 82(6): 1901-1912.

Weilgart, L. and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40: 277-285.

Weilgart, L.S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85:1091-1116.

Weilgart, L.S. and H. Whitehead. 1988. Distinctive vocalizations from mature male sperm whales (*Physeter macrocephalus*). Canadian Journal of Zoology 66:1931-1937.

Weinrich, M.T., H. Rosenbaum, C. Scott Baker, A.L. Blackmer and H. Whitehead. 2006. The Influence of maternal lineages on social affiliations among humpback whales (*Megaptera novaeangliae*) on their feeding grounds in the southern Gulf of Maine. Journal of Heredity 97(3): 226-234.

Weinrich, M.T., R.H. Lambertsen, C.R. Belt, M.R. Schilling, H.J. Iken and S.E. Syrjala. 1992. Behavioral reactions of humpback whales *Megaptera novaeangliae* to biopsy procedures. Fisheries Bulletin 90(3): 588-598.

Weinrich, M.T., R.H. Lambertsen, C.S. Baker, M.R. Schilling and C.R. Belt. 1991. Behavioral responses of humpback whales (*Megaptera novaeangliae*) in the southern Gulf of Maine to biopsy sampling. Reports of the International Whaling Commission (Special Issue 13): 91-97.

Wentsel, R. S. 1994. Risk assessment and environmental policy. Environmental Toxicology and Chemistry 13:1381.

Whitehead, H. 1982. Population of humpback whales in the northwest Atlantic. Reports of the International Whaling Commission 32: 345-353.

Whitehead, H. 1987. Updated status of the humpback whale, *Megaptera novaeangliae*, in Canada. Canadian Field-Naturalist 101(2): 284-294.

Whitehead, H. 1993. The behavior of mature male sperm whales on the Galapagos Islands breeding grounds. Canadian Journal of Zoology 71(4): 689-699.

Whitehead, H. 1996. Babysitting, dive synchrony, and indications of alloparental care in sperm whales. Behavioral Ecology and Sociobiology 38: 237-244.

Whitehead, H. 1996. Variation in the feeding success of sperm whales: temporal scale, spatial scale, and relationship to migrations. The Journal of Animal Ecology 65(4): 429-438.

Whitehead, H. 1999. Variation in the visually observable behavior of groups of Galapagos sperm whales. Marine Mammal Science 15(4): 17.

Whitehead, H. 2002. Sperm whale (*Physeter macrocephalus*). Pages 1165 - 1172 in W.F. Perrin, B. Würsig, and J. G. M. Thewissen, editors. Encyclopedia of marine mammals. Academic Press, Inc., San Diego, California.

Whitehead, H. 2003, Sperm whales. Chicago, Illinois, University of Chicago Press.

Whitehead, H. and C. Glass. 1985. Orcas (killer whales) attack humpback whales. Journal of Mammalogy 66(1): 183-185.

Whitehead, H. and F. Nicklin. 1995. Sperm Whales. National geographic 188(5): 18.

Whitehead, H. and L. Rendell. 2004. Movements, habitat use and feeding success of cultural clans of South Pacific sperm whales. Journal of Animal Ecology 73(1): 190-196.

Whitehead, H. and L. Weilgart. 2000. The sperm whale: social females and roving males. Pages: 154-172. In: *Cetacean societies. Field studies of dolphins and whales*. Edited by J. Mann, R.C. Connor, P.L. Tyack and H. Whitehead. University of Chicago Press; Chicago, Illinois.

Whitehead, H. and L. Weilgart. 1991. Patterns of visually observable behavior and vocalizations in groups of female sperm whales. Behavior 118(Parts 3-4): 275-296.

Whitehead, H. and P.L. Hope. 1991. Sperm whalers off the Galapagos Islands and in the western North Pacific, 1830-1850: Ideal free whalers? Ethology and sociobiology 12(2): 147-162.

Whitehead, H. and T. Arnbom. 1987. Social organization of sperm whales off the Galapagos Islands, February-April 1985. Canadian Journal of Zoology 65(4): 913-919.

Whitehead, H., J. Christal and S. Dufault. 1997. Past and distant whaling and the rapid decline of sperm whales off the Galápagos Islands. Conservation Biology 11(6): 1387-1396.

Whitehead, H., J. Gordon, E. A. Mathews and K. R. Richard. 1990. Obtaining skin samples from living sperm whales. Marine Mammal Science 6(4):316-326.

Whitehead, H., L. Rendell and M. Marcoux. 2006. Coda vocalizations recorded in breeding areas are almost entirely produced by mature female sperm whales (*Physeter macrocephalus*). Canadian Journal of Zoology 84: 5.

Whitehead, H., M. Dillon, S. Dufault, L. Weilgart and J. Wright. 1998. Non-geographically based population structure of South Pacific sperm whales: dialects, fluke-markings and genetics. Journal of Animal Ecology 67(2): 253-262.

Whitehead, H., M. Dillon, S. Dufault, L. Weilgart and J. Wright. 1998. Non-geographically based population structure of South Pacific sperm whales: dialects, fluke-markings and genetics. Journal of Animal Ecology 67(2): 10.

Whitehead, H., S. Waters and T. Lyrholm. 1992. Population structure of female and immature sperm whales (*Physeter macrocephalus*) off the Galapagos Islands. Canadian Journal of Fisheries and Aquatic Science 49(1): 78-84.

Wiley, D.N., R.A. Asmutis, T.D. Pitchford and D.P. Gannon. 1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fisheries Bulletin 93: 196-205.

Wilkinson, D. M. 1991. Program review of the Marine Mammal Stranding Network. Unpublished report prepared for the Assistant Administrator for Fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.

Wingfield, J. C., K. M. O'Reilly, and L. B. Astheimer. 1995. Modulation of the adrenocortical responses to acute stress in Arctic birds: A possible ecological basis. American Zoologist 35:10.

Winn, H.E, P.J. Perkins, L. Winn. 1970. Sounds and behavior of the northern bottlenosed whale. Pages 53-59. In: Proceedings of the 7th Annual Conference on the Biology, Sonar and Diving of Mammals. Stanford Research Institute; Menlo Park, California.

Winn, H.E., C.A. Price, and P.W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Reports of the International Whaling Commission Special Issue No. 10:129- 138.

Witzell, W.N. 1999. Distribution and relative abundance of sea turtles caught incidentally by the U.S. pelagic longline fleet in the western North Atlantic Ocean, 1992-1995. Fishery Bulletin 97:200-211.

Wood, W.E. and S.M. Yezerinac. 2006. Song sparrow (*Melospiza melodus*) song varies with urban noise. The Auk 123:650-659.

Yeung, C. 1999. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1998. NOAA Technical Memorandum NMFS-SEFSC-430. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center; Miami, Florida.

Yochem, P. K. and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). In: S.H Ridgway and R. Harrison (editors) Handbook of marine mammals. Volume 3. The sirenians and baleen whales. Academic Press, Inc.; London, United Kingdom.

Young, G.A. 1973. Guide-lines for evaluating the environmental effects of underwater explosion tests. U.S. Department of the Navy, Naval Ordnance Laboratory; Silver Spring, Maryland.