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

Agencies:	National Marine Fisheries Service, with the U.S. Navy as Action Agency and Applicant for a Federal Authorization
Activities Considered:	The U.S. Navy's proposed use of the Surveillance Towed Array Sensor System Low Frequency Active Sonar for the period August 16, 2011, through August 15, 2012. NMFS' 2011 Letter of Authorization for the U.S. Navy to "take" marine mammals incidental to its employment of the Surveillance Towed Array Sensor System Low Frequency Active Sonar for the period August 16, 2011, through August 15, 2012.
Consultation Conducted by:	Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service

Approved by: _____ Date: AUG 12 2011

This document constitutes the National Marine Fisheries Service's (NMFS) Biological Opinion (Opinion) on NMFS' proposed issuance of four letters of authorization to the U.S. Navy for the employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar and the Navy's use of SURTASS LFA sonar. This Opinion is related to NMFS' May 30, 2002, and August 15, 2007, Biological Opinions on the U.S. Navy's proposed use of SURTASS LFA Sonar and NMFS' proposal to issue regulations to authorize the Navy to take marine mammals incidental to its employment of SURTASS LFA sonar: NMFS' May 2002 and August 2007. Biological Opinions considered the potential global effects of SURTASS LFA sonar on threatened and endangered species while this Opinion considers the effects of SURTASS LFA sonar within a specific region of the North Pacific Ocean. This Opinion has been prepared in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

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1 INTRODUCTION

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

For the actions described in this document, the action agencies are (1) the United States Navy (U.S. Navy), which proposes to operate the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar onboard the vessels USNS VICTORIOUS (T-AGOS 19)), USNS ABLE (T-AGOS 20), USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23)in the North Pacific Ocean during 20 training missions: sixteen collective missions in the Northwest Pacific Ocean and four collective missions in the Hawai'i Range Complex, and (2) NMFS' Office of Protected Resources – Permits, Conservation, and Education Division (Permits Division), which proposes to issue four Letter of Authorizations (LOAs) pursuant to Federal regulations under the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 *et seq.*) that would authorize the U.S. Navy to "take" marine mammals incidental to those SURTASS LFA sonar activities. The consulting agency for these proposals is NMFS' Office of Protected Resources - Endangered Species Division.

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

1.1 Background

NMFS issued a Biological Opinion on 13 August 2007 that assessed the effects of SURTASS LFA as a global program that would occur over a 5-year period from 2007 to 2012 whereas this Opinion assesses the effects of SURTASS LFA within specific regions of the Pacific Ocean over a single 12-month period from mid-August 2011 to mid-August 2012. This Opinion relies on the August 2007 Opinion for most of its detailed analyses, but summarizes relevant information from that opinion. Readers interested in more information on specific issues should refer to that Biological Opinion.

This Opinion is based on information provided in the various documents the U.S. Navy has prepared to comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*), including the Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar (Navy 2001a; Navy 2001b), the Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS

LFA) Sonar (Navy 2007d), a February 1999 report on Marine Vertebrates and Low Frequency Sound: Technical Report for LFA EIS prepared by the Marine Mammal and Seabird Ecology Group of the University of California, Santa Cruz, Institute of Marine Sciences (Croll et al. 1999b); a Biological Assessment for the Employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar (Navy 2006a); unclassified annual monitoring reports the U.S. Navy's submitted to comply with the reporting requirements of the Incidental Take Statements contained in previous Biological Opinions on MMPA LOAs for the employment of the SURTASS LFA sonar system (Navy 2008a; Navy 2009; Navy 2010), and various documents NMFS' Permits Division prepared in support of proposed and final regulatory amendments that would authorize the U.S. Navy to take marine mammals incidental to the employment of SURTASS LFA; and other published and unpublished scientific and technical information.

1.2 Consultation History

In August 2007, the National Marine Fisheries Service's Endangered Species Division issued a comprehensive Biological Opinion on the NMFS Permits Division's proposal to promulgate regulations that would authorize the U.S. Navy to "take" marine mammals over a five-year period incidental to its employment of the SURTASS LFA sonar. In August 2007, August 2008, August 2009, and August 2010 NMFS' Endangered Species Division issued Biological Opinions on annual LOAs for the SURTASS LFA sonar system.

On 31 March 2011, the U.S. Navy submitted its 2011 application for LOAs to "take" marine mammals incidental to the operations of the SURTASS LFA sonar onboard the USNS VICTORIOUS (T-AGOS 19), USNS ABLE (T-AGOS 20), USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23) between 16 August 2011 and 15 August 2012.

On 6 June 2011, NMFS' Permits, Conservation, and Education Division provided NMFS' Endangered Species Division with a copy of the four draft LOAs it intended to issue to the U.S. Navy for the SURTASS LFA sonar missions that would occur between 16 August 2011 and 15 August 2012. As proposed, each of the four SURTASS LFA sonar platforms would receive a separate LOA.

On, 19 July 2011, NMFS' Endangered Species Division provided a copy of its draft Biological Opinion to the U.S. Navy and NMFS' Permits Division. Their comments on the draft Opinion were received on 21 July 2011 and 25 Jule 20911, respectively. Those comments have been incorporated, in their entirety, in this version of the Opinion.

2 DESCRIPTION OF THE PROPOSED ACTION

This Opinion considers the Navy's proposed use of SURTASS LFA sonar and NMFS' Permits Division proposal to issue four LOAs to the U.S. Navy to "take" (by harassment) marine mammals incidental to the operation of the SURTASS LFA sonar onboard the vessels USNS VICTORIOUS (T-AGOS 19)USNS ABLE (T-AGOS 20), USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23) in the Northwest Pacific Ocean during 20 training missions: sixteen collective missions in the Northwest Pacific Ocean and four collective missions in the Hawai'i Range Complex. One LOA would apply to each of vessel employing the sonar. The LOAs would be valid from August 16, 2011, through August 15, 2012.

2.1 Active System Component

The active component of the SURTASS LFA sonar system consists of up to 18 low-frequency acoustic-transmitting source elements (called projectors) that are suspended from a cable beneath a ship. The projectors transform electrical energy to mechanical energy by setting up vibrations, or pressure disturbances, with the water to produce the active sound (which is called a "pulse" or a "ping"). The USNS ABLE and USNS VICTORIOUS use a compact LFA system (CLFA) which consists of smaller, lighter-weight projectors than the LFA system used on the USNS IMPECCABLE and USNS EFFECTIVE. The SURTASS LFA's transmitted beam is omnidirectional (full 360 degrees) in the horizontal. The nominal water depth of the center of the array is 400 ft (122 m), with a narrow vertical beamwidth that can be steered above or below the horizontal. Signals transmitted by SURTASS LFA sonar sources have frequencies between 100 and 500 Hertz (Hz), inclusive. The source level of an individual projector in the SURTASS LFA sonar array is about 215 decibels (dB), and the sound field of the array can never have a sound pressure level higher than that of an individual projector. The shallowest water depth that a SURTASS LFA vessel would operate is 100 meters (m) (328.1 ft).

The typical SURTASS LFA sonar signal is not a constant tone, but is a transmission of various signal types that vary in frequency and duration (including continuous wave and frequency-modulated signals). The Navy refers to a complete sequence of sound transmissions as a "ping" which can range from between 6 and 100 seconds, with no more than 10 seconds at any single frequency. The time between pings will typically range from 6 to 15 min (min). The Navy can control the average duty cycle (the ratio of sound "on" time to total time) for the system but the duty cycle cannot be greater than 20 percent; the Navy anticipates a typical duty cycle between 7.5 and 10 percent.

2.2 Passive System Component

The passive or listening component of the SURTASS system uses hydrophones to detect echoes of the active signal returning from submerged objects, such as submarines. The hydrophones are mounted on a horizontal array that is towed behind the ship. The SURTASS LFA sonar ship maintains a minimum speed of 3.0 knots (5.6 km/hr; 3.4 mi/hr) in order to keep the array properly deployed. The return signals, which are usually below background or ambient noise levels, are then processed and evaluated to identify and classify potential underwater threats.

The SURTASS Twin-line (TL-29A) passive horizontal line array is about 305 meters long (1,000 feet), has an operational depth from 152 m (500 ft) to 457 m (1,500 ft); and detects frequencies from 0 to 500 Hz.

2.3 System Deployment

The following summarizes the proposed operations of the SURTASS LFA sonar system between 16 August 2011 and 15 August 2012. For a detailed description of the SURTASS LFA sonar system, its typical operations, and mitigative measures that will be associated with the system's operations, readers should refer to NMFS' 12 August 2007 biological opinion. The proposed LOAs will be valid only for activities associated with the operation of the SURTASS LFA sonar onboard the vessels USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE, and USNS VICTORIOUS which will operate the SURTASS LFA sonar system in portions of the Archipelagic Deep Basins Province, North Pacific Tropical Gyre (West) Province, North Pacific Tropical Gyre (East) Province, and Western Pacific Warm Pool Province in the Pacific Trade Wind Biome; the Kuroshio Current Province and Northern Pacific Transition Zone Province in the Pacific Westerly Winds Biome; the North Pacific Epicontinental Sea Province in

the Pacific Polar Biome; and the China Sea Coastal Province in the North Pacific Coastal Biome (50 CFR 216.180(a)) (Longhurst 1998).

The proposed authorizations for the four ocean surveillance vessels are valid for an estimated combined total of 16 active sonar missions in the Northwest Pacific and four active sonar missions in the Hawai'i operating area. The signals transmitted by the SURTASS LFA sources is limited to between 100 and 500 Hz with a source level for each of the 18 projectors no more than 215 dB (re: 1 micro Pascal (µPa) at 1 meter (m)) and a maximum duty cycle of 20 percent.

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

Based on the Navy's Final Supplemental EIS, the Navy proposes to use an active and passice acoustic monitoring program, visual monitoring, and geographic restrictions to avoid potential, adverse effects of SURTASS LFA sonar on marine animals. In its rulemaking under the MMPA, NMFS has also required the Navy to implement additional mitigation measures.

2.4 Monitoring

To avoid potential injuries to marine mammals (and possibly sea turtles), the Navy proposes to detect animals within an area they call the "LFA mitigation zone" (the area within the 180-dB isopleth of the SURTASS LFA sonar source sound field) before and during low frequency transmissions. NMFS has also added an additional 1-kilometer (km) buffer zone beyond the LFA mitigation zone.

Monitoring will (a) commence at least 30 min before the first SURTASS LFA sonar transmission; (b) continue between pings; and (c) continue for at least 15 min after completion of a SURTASS LFA sonar transmission exercise or, if marine mammals are showing abnormal behavior patterns, for a period of time until those behavior patterns return to normal or until conditions prevent continued observations.

The Navy proposes to use three monitoring techniques: (1) visual monitoring for marine mammals and sea turtles from the SURTASS LFA sonar vessel during daylight hours; (2) use of the passive (low frequency) SURTASS array to listen for sounds generated by marine mammals as an indicator of their presence; and (3) use of high frequency active sonar (High Frequency Marine Mammal Monitoring [HF/M3] sonar) to detect, locate, and track marine mammals (and possibly sea turtles) that might be affected by low frequency transmissions near the SURTASS LFA sonar vessel and the sound field produced by the SURTASS LFA sonar source array.

2.4.1 Visual Monitoring

Visual monitoring will include daytime observations from the SURTASS LFA sonar vessel for potentially affected species. This monitoring will begin 30 min before sunrise, for ongoing transmissions, or 30 min before SURTASS LFA sonar is deployed and continue until 30 min after sunset or until SURTASS LFA sonar array is recovered. The

Navy will hire one or more qualified marine mammal biologist, highly experienced in marine mammal observation techniques, to train observers conducting visual monitoring. If a marine mammal is detected within the 180-dB LFA mitigation zone or the 1 km (0.54 nautical mile (nm) buffer zone extending beyond the LFA mitigation zone, SURTASS LFA sonar transmissions will be immediately suspended. Transmissions will not resume less than 15 min after:

- All marine mammals have left the area of the LFA mitigation and buffer zones; and
- There is no further detection of any marine mammal within the LFA mitigation and buffer zones as determined by the visual and/or passive or active acoustic monitoring.

2.4.2 Passive Acoustic Monitoring

Passive acoustic monitoring for low frequency sounds generated by marine mammals will be conducted when SURTASS is deployed. The following actions will be taken:

- If sounds are detected and estimated to be from a marine mammal, the technician will notify the Officer in Charge who will alert the HF/M3 sonar operator and visual observers;
- If a sound produced by a marine mammal is detected, the technician will attempt to locate the sound source using localization software; and
- If it is determined that the animal will pass within the LFA mitigation zone or 1-km buffer zone (prior to or during transmissions), then the Officer in Charge will order the delay/suspension of transmissions when the animal is predicted to enter either of these zones.

2.4.3 High Frequency Active Acoustic Monitoring

The Navy will conduct high frequency active acoustic monitoring (by using an enhanced, commercial-type high frequency sonar) to detect, locate, and track marine mammals (and possibly sea turtles) that could pass close enough to the SURTASS LFA sonar transmit array to exceed the 180-dB mitigation criterion. This Navy-developed HF/M3 sonar operates with a similar power level, signal type, and frequency as high frequency “fish finder” type sonars used worldwide by both commercial and recreational fishermen.

The HF/M3 source will be ramped-up slowly to operating levels over a period of no less than 5 min:

- No later than 30 min before the first SURTASS LFA sonar transmission;
- Prior to any SURTASS LFA sonar calibrations or tests that are not part of regular SURTASS LFA sonar transmissions; and
- Anytime after the HF/M3 source has been powered down for a period of time greater than 2 min.
- The HF/M3 source will not increase its sound pressure level once a marine mammal is detected; ramp-up may proceed once marine mammals are no longer detected.

2.5 HF/M3 Sonar, LFA Mitigation Zone, and Sound Propagation

The extent of the LFA mitigation zone (i.e., within the 180-dB sound field) is estimated by onboard acoustic modeling and environmental data collected in situ. Factored into this calculation are SURTASS LFA sonar source physical parameters of tow speed, depth, vertical steering, signal waveform/wavetrain selection, and peak transmit source level.

The HF/M3 sonar is located near the top of the SURTASS LFA sonar vertical line array. The HF/M3 sonar computer terminal for data acquisition/processing/display is located in the SURTASS Operations Center. The HF/M3 sonar uses frequencies from 30 to 40 kilohertz (kHz) with a variable bandwidth (1.5 to 6 kHz nominal); a 3-4 percent (nominal) duty cycle; a source level of 220 dB re 1 μPa_{rms} (1 micropascal) at 1 m; a five-minute ramp-up period; and a maximum, nominal detection range of 2-2.5 km (1.08-1.35 nm).

The HF/M3 sonar will operate continuously while the SURTASS LFA sonar is deployed. A remote display from the personal computer (PC) control station will be situated at the Watch Supervisor console, which will be manned 24 hours a day during all SURTASS LFA sonar operations at sea.

When a marine animal is detected by the HF/M3 sonar, it automatically triggers an alert to the Watch Supervisor, who will notify the Officer in Charge. The Officer in Charge will then order the immediate delay/suspension of SURTASS LFA sonar transmissions until the animal is determined to have moved beyond the mitigation zone. All contacts will be recorded and provided to NMFS as part of the long-term monitoring program associated with the proposed action.

Analysis and testing of the HF/M3 sonar operating capabilities indicate that this system substantially increases the probability of detecting marine mammals within the LFA mitigation zone. It also provides an excellent monitoring capability (particularly for medium to large marine mammals) beyond the LFA mitigation zone, out to 2 to 2.5 km (1.08 to 1.35 nm). Testing of the HF/M3 sonar, as documented in the SURTASS LFA Sonar Final EIS Subchapter 2.3.2.2 (Navy 2007d), has demonstrated a probability of single-ping detection above 95 percent within the LFA mitigation zone for most marine mammals (Navy, 2001a).

When the SURTASS LFA sonar is deployed, all marine mammal and sea turtle sightings/ detections would be recorded and provided to NMFS as part of the Long Term Monitoring Program associated with the proposed action.

2.6 Geographic Restrictions

The SURTASS LFA sonar system would be operated in a manner that would not cause sonar sound fields to exceed 180 dB re 1 μPa_{rms} within "coastal exclusion zones" or within 1 km of designated offshore areas that are designated as biologically important for marine mammals (see Table 1). For any annual LOA, NMFS' regulations establish a minimum coastal exclusion zone of 12 nm of any coastline, including offshore islands, or designated offshore areas that are biologically important for marine mammals outside the 12 nm coastal exclusion zone during seasons specified for a particular area (see Table 1). When in the vicinity of known recreational and commercial dive sites, SURTASS LFA sonar will be operated to ensure that the sound field at these sites would not exceed 145 dB re 1 μPa_{rms}.

Table 1 identifies the offshore areas NMFS has designated as having biological importance for marine mammals (by season as appropriate). All of these areas will be outside of the Navy's proposed SURTASS LFA sonar operations.

Table 1. Offshore areas of biological importance to marine mammals.

Name of Area	Location of Area	Months of Importance
(1) 200-m isobath North American East Coast	From 28°N. to 50° N., west of 40° W.	Year-round
(2) Costa Rica Dome	Centered at 9° N. and 88° W.	Year-round
(3) Antarctic Convergence Zone	30° E. to 80° E.: 45° S. 80° E. to 150° E.: 55° S. 150° E. to 50° W.: 60° S. 50° W. to 30° E.: 50° S.	October through March
(4) Hawaiian Island Humpback Whale NMS- Penguin Bank	Centered at 21° N. and 157° 30'W	November 1 through May 1
(5) Cordell Bank NMS	Boundaries IAW 15 CFR 922.110	Year-round
(6) Gulf of the Farallones NMS	Boundaries IAW 15 CFR 922.80	Year-round
(7) Monterey Bay NMS	Boundaries IAW 15 CFR 922.130	Year-round
(8) Olympic Coast NMS	Within 23 nm of coast from 47 07'N to 48 30'N latitude	December, January, March, and May
(9) Flower Garden Banks NMS	Boundaries IAW 15 CFR 922.120	Year-round
(10) The Gully	44° 13'N., 59° 06'W. to 43° 47'N.; 58° 35' W. to 43° 35' N.; 58° 35' W. to 43° 35' N.; 59° 08' W. to 44° 06'N.; 59° 20' W.	Year-round

From August 16, 2011 to August 15, 2012, the U.S. Navy proposes to limit their use of SURTASS LFA sonar for testing, training, and military operations to the Northwestern Pacific Ocean and the Hawaii Operating Area in accordance with the the U.S. District Court for the Northern District of California, San Francisco Division, Stipulated Settlement Agreement Order (signed 12 August 2008).

2.7 Action Area

The proposed action would occur in portions of the North Pacific Ocean (which encompasses most of the Pacific Ocean north of 0º Latitude). In particular, the proposed action would occur in portions of the following oceanographic provinces provinces as defined by Longhurst (Longhurst 1998): Archipelagic Deep Basins Province, North Pacific Tropical Gyre (West) Province, North Pacific Tropical Gyre (East) Province, and Western Pacific Warm Pool Province in the Pacific Trade Wind Biome; the Kuroshio Current Province and Northern Pacific Transition Zone Province in the Pacific Westerly Winds Biome; the North Pacific Epicontinental Sea Province in the Pacific Polar Biome; and the China Sea Coastal Province in the North Pacific Coastal Biome subject to the restrictions described in the preceding section.

3 APPROACH TO THE ASSESSMENT

NMFS uses a series of steps to identify and analyze those aspects of proposed actions that are likely to have direct and indirect effects on the physical, chemical, and biotic environment of an action area (the term "potential stressors" is used for these aspects of an action). In the first step, the spatial extent of any potential stressors is identified, including the degree to which 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 the 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 such co-occurrence is likely, then the nature of that co-occurrence is estimated (these represent our exposure analyses). In this step of the analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action's effects and the populations or subpopulations those individuals represent.

Once we identify which listed resources (endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, in the third step of our analyses we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our response analyses) (see Section 5). 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) (see Section 5).

3.1 Potential Stressors

NMFS has identified several aspects of the proposed SURTASS LFA sonar system that represent potential hazards to threatened or endangered species or critical habitat that has been designated for them: (1) the ships and ship traffic associated with the proposed exercise; (2) the low-frequency active component of the sonar system; and (3) the high-frequency active component of the monitoring system. We analyze the potential risks associated with sonars that are likely to be employed during sonar exercises and training missions by treating the acoustic energy produced by those sonars as a potential stressor or pollutant introduced into the ocean environment.

This analysis evaluates the available evidence to determine the likelihood of listed species or critical habitat being exposed to sound pressure levels associated with low-frequency active sonar, which includes estimating the intensity, duration, and frequency of exposure. Our analysis assumed that low-frequency sonar poses no risk to listed species or critical habitat if they are not exposed to sound pressure levels from the SURTASS LFA sonar system (we recognize that the sonar could have indirect, adverse effects on listed species or critical habitat by disrupting marine food chains, a species' predators, or a species' competitors; however, we did not identify situations where this concern might apply to species under NMFS' jurisdiction). Our analyses also assumed that the potential consequences of exposure to low-frequency active sonar on individual animals would be a function of the intensity (measured in both sound pressure level in decibels and frequency), duration, and frequency of the animal's exposure to the low-frequency transmissions.

3.2 Exposure

Exposure analyses are designed to identify the listed resources that are likely to co-occur with these potential effects in space and time and the nature of that co-occurrence. This exposure analyses was 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 (or other sub-divisions of "populations," including demes, runs, or races) those individuals represent.

NMFS generally relies on an action agency's estimates of the number of marine mammals that might be "taken" (as that term is defined for the purposes of the MMPA). In a small number of consultations, however, NMFS has conducted separate analyses to estimate the number of endangered or threatened marine animals that might be exposed to stressors produced by a proposed action to assess the effect of assumptions in an action agency's model on model estimates. For example, NMFS used a model based on components of Hollings' disc equation (1959) (Navy 2008b) to independently estimate the number of marine mammals that might be exposed to Navy training activities in a few recent consultations that satisfied the following conditions; first, the sole or primary stressor was hull-mounted mid-frequency active sonar; and second, data were available on the density of endangered or threatened animals in an action area, the ship's speed, the radial distance at which different received levels would be detected from a source given sound speed profiles, and the duration of specific training exercises.

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

In this Opinion, we relied on the Navy's and NMFS Permits Division exposure estimates of the number of ESA-listed species that might interact with sound fields associated with SURTASS LFA sonar systems because the primary stressor is not hull-mounted mid-frequency sonar. For our exposure analyses, NMFS relied solely on the results of acoustic models the U.S. Navy used to prepare its NEPA compliance documents and to the request from NMFS' Permits Division. The Navy's model, which is called the Acoustic Integration Model or AIM, estimates the number of marine mammals that might be exposed to low-frequency sound produced by the SURTASS LFA sonar system by simulating characteristics of marine animals (e.g., species distribution, density, diving profiles, and general movement); SURTASS LFA sonar transmissions (e.g., sonar operating parameters); and the predicted sound field produced by an LFA transmission. Although many components of the models the Navy used for its exposure analyses are classified, NMFS reviewed unclassified technical documents on the Navy's models and concluded that the Navy's exposure models would provide a reasonable approximation of the number of animals that might be exposed to the sonar during an exercise.

The Acoustic Integration Model simulates acoustic exposure during a hypothetical SURTASS LFA sonar operation. The AIM is composed of three separate elements. The first element calculates the projected three-dimensional sound field from a hypothetical SURTASS LFA sonar source. The sound source can be moving or stationary. The resultant data field is a four-dimensional presentation (position, time) of sound pressure level (SPL). The second element

models the animals' distribution in space and diving behavior. This element assigns the animals to a start point and simulates their movement according to their expected behavior pattern. Programmable features in this element of the model include: (1) number of animals per unit area; (2) size of area in square nm; (3) individual animal start points, courses, propensity to change course, and speeds. The programmable features in the diving behavior are: (1) the depth of four zones within the water column (surface, transition, average diving, and maximum diving zones); (2) percent of time the animal spends in each zone (total among all four equals 100 percent).

The last element of AIM calculates sound exposures. For each sonar transmission, or ping, the predicted location of each animal is used to select the appropriate received level from the modeled sound field. A histogram of received levels for each ping is computed for each animal, as well as summary statistics for each site. This process is repeated for each species in a region, to estimate the number of animals that might be exposed to SURTASS LFA sonar operations. Despite some assumptions that might overestimate the number of animals exposed and other assumptions that might under estimate the number of animals exposed, NMFS concluded that the Navy's exposure models would provide a reasonable approximation of the number of animals that might be exposed to the sonar during an exercise.

3.3 Response Analysis

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

3.4 Risk Analysis for Endangered and Threatened Species

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the

continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations.

Our risk analyses begin by identifying the probable risks the proposed actions are likely to pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those risks to individuals to identify consequences to the populations that include those individuals. 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 current or expected future reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to stressors produced by an action would reasonably be expected to reduce the individual's current or expected future reproductive success by increasing the individual's likelihood of dying prematurely, having reduced longevity, increasing the age at which individuals become reproductively mature, reducing the age at which individuals stop reproducing, reducing the number of live births individuals produce during any reproductive bout, decreasing the number of times an individual is likely to reproduce over its reproductive lifespan (in animals that reproduce multiple times), or causing an individual's progeny to experience any of these phenomena (Brommer et al. 1998; Coulson et al. 2006; Kotiaho et al. 2005; McGraw and Caswell 1996; Oli and Dobson 2003; Saether et al. 2005; Sterns 1992).

When individual, listed plants or animals are expected to experience reductions in their current or expected future reproductive success, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Sterns 1992). 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. On the other hand, when listed plants or animals exposed to an Action's effects are *not* expected 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 (for example, see Anderson 2000; Mills and Beatty 1979; Sterns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

If we conclude that listed plants or animals are likely to experience reductions in their current or expected future reproductive success, our assessment tries to determine if those 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. The primary advantage of this approach is that it considers the consequences of the response of endangered and threatened species in terms of fitness costs, which allows us to assess how particular behavioral decisions are likely to influence individual reproductive success (Bejder et al. 2009). Individual-level effects can then be translated into changes in demographic parameters of populations, thus allowing for an assessment of the biological significance of particular human disturbances.

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 is 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 of the population(s) those individuals represent. Here "significant" also means "clinically or biotically significant" rather than statistically significant.

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

3.5 Risk Analysis 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. 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 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 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 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.

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 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, the 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 asks 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, the limited value is our point of reference for our assessment.

3.6 Evidence Available for the Consultation

In 2002, NMFS' Endangered Species Division completed its first Biological Opinion on the U.S. Navy's proposed employment of the SURTASS LFA sonar system and NMFS' Permits Division's proposal to authorize the "take" of marine mammals pursuant to the Navy's employment of that sonar system. From 2002 to 2010, inclusive, NMFS completed biological opinions on each annual LOA the NMFS Permits Division issued to the U.S. Navy for annual SURTASS LFA missions. This Opinion builds on these earlier Biological Opinions NMFS has prepared on the employment of the SURTASS LFA sonar system and uses the evidence we collected, analyzed, and synthesized for those earlier opinions as its foundation. For this Opinion, then, we first identified new lines of evidence that had become available since we completed the earlier opinions on the potential effects of the SURTASS LFA sonar system on endangered species, threatened species, and critical habitat that has been designated for them.

In addition, we conducted electronic literature searches using the *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. 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*, *Marine Mammal Science*), sea turtles (*Copeia*, *Herpetologia*, *Journal of Herpetology*), ecology (*Ambio*, *Bioscience*, *Journal of Animal Ecology*, *Journal of Applied Ecology*, *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*, *Ethology*). We manually searched issues of the *Journal of Cetacean Research and Management* and *Reports of the International Whaling Commission* (IWC).

To supplement our searches, we examined the literature that was cited in documents and any articles we collected through our electronic searches. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

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).

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

Over the past few years, several organizations have argued that several of our previous biological opinions on the Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them. In each instance, we have had to explain how section 7 consultations and biological opinions consider "cumulative impacts" (in the NEPA sense of the term). We reiterate that explanation in this sub-section.

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) (CEQ 1997).

By regulation, the Services assess the effects of a proposed action by adding its direct and indirect effects to the *impacts* of the activities we identify in an *Environmental Baseline* (50 CFR §402.02). Although our regulations use the term "adding" the effects of actions to an environmental baseline, we do not assume that the effects of actions are all additive; our assessments consider synergistic effects, multiplicative effects, and antagonistic effects of stressors on endangered species, threatened species, and any critical habitat that has been designated for those species.

In practice we address "cumulative impacts" by focusing on individual organisms, which integrate the environments they occupy or interact with indirectly over the course of their lives. In our assessments, we think in terms of the biotic or ecological "costs" of exposing endangered and threatened individuals to a single stressor, a sequence of single stressors, or a suite of stressors (or "stress regime"). At the level of individual organisms, these "costs" consist of incremental reductions in the current or expected future reproductive success of the individuals that result from exposing those individuals to one or more stressors. The "costs" of those exposures might be immediately significant for an organism's reproductive success (for example, when an individual dies or loses one of its young) or the "costs" might become significant only over time. The costs of synergistic interactions between two stressors or a sequence of stressors would be expected to be higher than the "costs" incurred without the synergism; the "costs" of antagonistic interactions would be expected to be lower than the "costs" incurred without the antagonism.

We begin our assessments by either qualitatively or quantitatively accumulate the biotic "costs" of exposing endangered or threatened individuals to the threats we identify in the *Status of the Species* and *Environmental Baseline* sections of our biological opinions. Then we estimate the probable additional "costs" associated with the proposed action on those individuals and ask whether or to what degree those "costs" would be expected to translate into reductions in the current and expected future reproductive success of those individuals. If we would expect those "costs" to reduce the current and expected future reproductive success of individuals or an endangered or threatened species, we would assess the consequences of those reductions on the population or populations those individuals represent and the species those populations comprise.

3.8 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 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). Humans perceive a 10 dB increase in noise as a doubling of sound level, or a 10 dB decrease in noise as a halving of sound level. 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: $1\mu Pa_{rms}$) 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. Thus a sound that is 160 dB loud underwater would have the same effective intensity as a sound that is 97 dB loud in air.

Sound frequency is measured in cycles per second, or 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. 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. However, their sensitivity at lower frequencies below 1000 Hz is quite poor. On the other hand, the hearing sensitivity of most fish is best at frequencies between 100 Hz and 1000 Hz. Thus, fish might be expected to suffer more harmful effects from loud, low frequency noise than 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 LFA 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 about 1,500 m/s (5,000 ft/s) and 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.

4 STATUS OF LISTED RESOURCES

This section identifies the ESA-listed species and critical habitat that occur within the Action Area that may be affected by the Navy’s use of SURTASS LFS sonar. It then summarizes the biology and ecology of those species and what is known about their life histories in the Action Area. The species occurring within the action area that may be affected by the Proposed Action are listed in Table 2, along with their ESA listing status.

Table 2. Species listed under the Federal Endangered Species Act (ESA) under NMFS' jurisdiction that may occur and critical habitat in the Action Area for the SURTASS LFA sonar.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E - 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus*)	E - 35 FR 18319	-- --	71 FR 38385
Western North Pacific Gray Whale (*Eschrichtius robustus*)	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*)	E - 35 FR 18319	-- --	55 FR 29646
North Pacific Right Whale (*Eubalaena japonica*)	E - 73 FR 12024	73 FR 19000	-- --
Sei Whale (*Balaenoptera borealis*)	E - 35 FR 18319	-- --	-- --
Sperm Whale (*Physeter macrocephalus*)	E - 35 FR 18619	-- --	75 FR 81584
Marine Mammals - Pinnipeds			
Steller Sea Lion (*Eumetopias jubatus*)	T - 55 FR 49204	58 FR 45269	73 FR 11872
Hawaiian Monk Seal (*Monachus schauinslandi*)	E – 41 FR 51611	53 FR 18988	72 FR 46966
Sea Turtles			
Green Sea Turtle (*Chelonia mydas*)	E - 43 FR 32800	63 FR 46693	63 FR 28359
Hawksbill Sea Turtle (*Eretmochelys imbricate*)	E – 35 FR 8491	63 FR 46693	63 FR 28359
Loggerhead Sea Turtle (*Caretta caretta*)	Prop. E - 75 FR 12598	Prop. 75 FR 12598	63 FR 28359
Olive Ridley Sea Turtle (*Lepidochelys olivacea*)	E - 61 FR 17	-- --	63 FR 28359
Leatherback Sea Turtle (*Dermochelys coriacea*)	E - 61 FR 17	Prop. 75 FR 319	63 FR 28359
Fish			
Pacific Salmon (*Oncorhynchus spp.*)	Multiple ESUs & DPSs [1] 70 FR 37160 71 FR 834 72 FR 26722	70 FR 52630	72 FR 2493 72 FR 29121 74 FR 25706

[1] *Evolutionarily Significant Units (ESUs) and Distinct Population Segments (DPSs).*

4.1 Species and Critical Habitat 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 various proposed activities. The first criterion was exposure or some reasonable expectation of a co-occurrence between one or more potential stressors associated with the 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 the 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 and critical habitat listed in Table 2 at the beginning of this section; this subsection summarizes the results of those evaluations.

4.1.1 Pacific Salmon

None of the proposed SURTASS LFA sonar missions would occur north of 40° North latitude, which encompasses the ocean distribution of threatened or endangered species of Pacific salmon and steelhead (*Oncorhynchus spp*.). Therefore, the species of Pacific salmon and steelhead that occur in these waters are not likely to be exposed to LFA sonar transmissions and, as a result, are not likely to be adversely affected by the sonar. Consequently, species of Pacific salmon and steelhead will not be considered further in this Opinion.

4.1.2 Steller Sea Lions

The endangered western population of Steller sea lions (*Eumetopias jubatus*) also occurs north of 40° north latitude and therefore, is not expected to be exposed to or adversely affected by SURTASS LFA sonar transmissions. The threatened eastern population of Steller sea lions occurs from the Prince William Sound east and south along the Pacific coast of Canada and the Pacific Northwest States and, similarly, would not be exposed to and therefore will not be or adversely affected by SURTASS LFA sonar transmissions. Consequently, neither species of Steller sea lions will be considered further in this Opinion.

4.1.3 North Pacific Right Whale Critical Habitat

Critical habitat for the North Pacific Right Whale has been designated in the Gulf of Alaska and the Southeastern Bering Sea north of 40° north latitude. None of the proposed SURTASS LFA sonar missions would occur north of 40° North latitude. Therefore, the proposed issuance of the letters of authorization for Navy's employment of SURTASS LFA sonar is not likely to adversely affect North Pacific Right Whale critical habitat and is not likely to result in the destruction or adverse modification of that critical habitat. Therefore, critical habitat will not be considered further in this Opinion.

4.1.4 Hawaiian Monk Seal Critical Habitat

Critical habitat that has been designated for Hawaiian monk seals occurs in the action area. In May 1988, NMFS designated critical habitat for the Hawaiian monk seal out from shore to 20 fathoms in 10 areas of the northwestern Hawaiian Islands. Critical habitat for monk seals includes all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms around the following: Kure Atoll, Midway Islands, except Sand Island and its harbor, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island (50 CFR 226.201).

None of the proposed missions are scheduled to occur in critical habitat of the Hawaiian monk seal (i.e., ocean waters out to 20 fathoms depth). In addition, the proposed missions are not likely to adversely affect prey species of the Hawaiian monk seals. As a result, the proposed missions are not likely to adversely affect the conservation value of the critical habitat that has been designated for Hawaiian monk seals.

4.1.5 Sea Turtle Species Critical Habitat

The critical habitats for the green, hawksbill, and leatherback sea turtles are located within geographically restricted areas of SURTASS LFA sonar sound field of no greater than 180 dB within 12 nm (22 km) of any coast. Because of these geographical restrictions, the proposed issuance of the LOAs for Navy's employment of SURTASS LFA sonar is not likely to adversely affect critical habitat that has been designated for listed species and is not likely to result in

the destruction or adverse modification of that critical habitat. Therefore, critical habitat will not be considered further in this Opinion.

4.2 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. The threats posed by the direct and indirect effects of global climate change are, or will be, common to all of the species we discuss in this Opinion. Because of this commonality, we present this narrative here rather than in each of the species-specific narratives that follow.

The 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 2001; IPCC 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.

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 percent since the 1950s.

Table 3. 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 Antarctic Peninsula, which is the northern extension of the Antarctic continent, contains the richest areas of krill in the Southern Ocean. The extent of sea ice cover around this Peninsula has the highest degree of variability relative to other areas within the distribution of krill. Relatively small changes in climate conditions are likely to exert a strong influence on the seasonal pack-ice zone in the Peninsula area, which is likely to affect densities of krill in this region. Because krill are important prey for baleen whales or form a critical component of the food chains on which baleen whales depend, increasing the variability of krill densities or causing those densities to decline dramatically is likely to have adverse effect on populations of baleen whales in the Southern Ocean.

Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators that depend on krill for prey — Antarctic fur seals (*Arctocephalus gazella*), gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*), and black-browed albatrosses (*Thalassarche melanophrys*) — at South Georgia Island and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50 percent in the 1990s, although incidental mortalities in longline fisheries probably contributed to the decline of the albatross. These authors concluded, however, that these declines result, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older age classes, which lowers the number of predators this prey

species can sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s.

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

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (for example, see Payne et al. 1990; Payne 1986); 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 which influences the abundance of marine mammal prey such as zooplankton and fish. In the 1970s and 1980s, the North Atlantic Oscillation Index has been positive and sea surface temperatures increased. These 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. 2003a). In the late 1980s and 1990s, the North Atlantic Oscillation Index was mainly positive but exhibited two substantial, multi-year reversals to negative values. This was followed by two major, multi-year declines in copepod prey abundance (Drinkwater et al. 2003; Pershing et al. 2010). Calving rates for North Atlantic right whales followed the declining trend in copepod abundance, although there was a time lag between the two (Greene et al. 2003b).

Although the North Atlantic Oscillation Index has been positive for the past 25 years, atmospheric models suggest that increases in ocean temperature associated with climate change forecasts may produce more severe fluctuations in the North Atlantic Oscillation. Such fluctuations would be expected to cause dramatic shifts in the reproductive rate of critically endangered North Atlantic right whales (Drinkwater et al. 2003; Greene et al. 2003b) 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 ocean currents, the future climates that are forecast place sea turtles at substantially greater risk of extinction than they already face.

4.3 Species Considered Further in this Biological Opinion

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 SURTASS LFA sonar activities the U.S. Navy proposes to conduct. In each narrative, we present a general species description and a summary of information on the distribution and population structure of each species to provide 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 LFA sonar.

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 1998b), fin whales (NMFS 2010a), fin and sei whale (NMFS 1998a), humpback whale (NMFS 1991), right whale (NMFS 2004), sperm whale (NMFS 2010b), a status report on large whales prepared by Perry et al. (1999a) and the status review and recovery plan for the leatherback sea turtle (NMFS and USFWS 1998a; NMFS and USFWS 2007). 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. (1999b), NRC (2000; 2003; 2005), and Richardson and Wursig (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this Opinion.

4.3.1 Blue Whale

The blue whale, *Balaenoptera musculus* (Linnæus 1758), is a cosmopolitan species of baleen whale. It is the largest animal ever known to have lived on Earth: adults in the Antarctic have reached a maximum body length of about 33 m and can weigh more than 150,000 kilograms (kg). The largest blue whales reported from the North Pacific are a female that measured 26.8 m (88 ft) taken at Port Hobron, Alaska in 1932 (Reeves et al. 1985) and a 27.1 m (89 ft) female taken by Japanese pelagic whaling operations in 1959 (NMFS 1998b).

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

Distribution

Blue whales are found along the coastal shelves of North America and South America (Clarke 1980; Donovan 1984; Rice 1998). In the western North Atlantic Ocean, blue whales are found from the Arctic to at least the mid-latitude waters of the North Atlantic (CETAP 1982; Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Blue whales have been observed frequently off eastern Canada, particularly in waters off Newfoundland, Canada during the winter. In the summer month, they have been observed in Davis Strait (Mansfield 1985), the Gulf of St. Lawrence (from the north shore of the St. Lawrence River estuary to the Strait of Belle Isle), and off eastern Nova Scotia (Sears 1987a). In the eastern North Atlantic Ocean, blue whales have been observed off the Azores Islands, although Reiner et al. (1996) do not consider them common in that area.

In 1992, the Navy conducted an extensive acoustic survey of the North Atlantic Ocean 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, Canada 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 nm 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 Hawaiian Islands and off Midway Island in the western edge of the Hawaiian Archipelago (Barlow 2006; Northrop et al. 1971; Thompson and Friedl 1982), although blue whales are rarely sighted in Hawaiian waters and have not been reported to strand in the Hawaiian Islands.

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 (Acevedo and Smultea 1995; 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.

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. Blue whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska. Nishiwaki (1966) reported that blue whales occur in the Aleutian Islands and in the Gulf of Alaska. An array of hydrophones, deployed in October 1999, detected two blue whale call types in the Gulf of Alaska (Stafford 2003). Fifteen blue whale sightings off British Columbia and in the Gulf of Alaska have been made since 1997 (Calambokidis et al. 2009). Three of these photographically verified sightings were in the northern Gulf of Alaska within 71 nm of each other and were less than 100 nm offshore (Calambokidis et al. 2009).

Blue whales appear to migrate to waters offshore of Washington, Oregon, and northern California to forage. Thus far, blue whales are associated with deeper, pelagic waters in the action area; they have not been reported to occur proximate to the coast or in Puget Sound itself. Although a resident population of blue whales might occur off the coast of Vancouver Island throughout the year (Burtenshaw et al. 2004), most blue whales that occur in the action area for this consultation appear to migrate between summer, foraging areas and winter rearing areas along the Pacific Coast of the United States. That seasonal migration brings them to waters off the Keyport Range Complex (with some individuals continuing north to the Gulf of Alaska) during the warm, summer season with a southward migration to waters off California, south to Central America, during the winter season (Calambokidis et al. 2009; Gregr et al. 2000; Mate et al. 1998).

Population Structure

For this and all subsequent species, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Futuymda (1986) and Wells and Richmond (1995) and is more restrictive than those uses of 'population' that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see review by Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as 'population decline,' 'population collapse,' 'population extinction,' and 'population recovery' apply to the restrictive definition of 'population' but do not explicitly apply to alternative

definitions. As a result, we do not treat the different whale "stocks" recognized by the International Whaling Commission or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those "stock" distinctions in these narratives.

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

In addition to these subspecies, the IWC's Scientific Committee has formally recognized one blue whale population in the North Pacific (Donovan 1991), although there is increasing evidence that there may be more than one blue whale population in the Pacific Ocean Gilpatrick et al. (1997), Barlow et al. (1995), Mizroch et al. (1984), Ohsumi and Wada (1972). For example, studies of the blue whales that winter off Baja California and in the Gulf of California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick et al. 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (Barlow et al. 1997; Calambokidis et al. 1990; Sears 1987b). A population of blue whales that has distinct vocalizations inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America (Gregr et al. 2000; Mate et al. 1998; Stafford 2003). We assume that this population is the one affected by the activities considered in this Opinion.

Natural Threats

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

Anthropogenic Threats

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

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 194, 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the

late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

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

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

Although commercial fisheries using large gill nets or other large set gears poses some entanglement risk to marine mammals, there is little direct evidence of blue whale mortality from fishing gears. Therefore it is difficult to estimate the numbers of blue whales killed or injured by gear entanglements. The offshore drift gillnet fishery is the only fishery that is likely to take blue whales from this stock, but no fishery mortalities or serious injuries have been observed. In addition, the injury or mortality of large whales due to interactions or entanglements in fisheries may go unobserved because large whales swim away with a portion of the net or gear. Fishermen have reported that large whales tend to swim through their nets without becoming entangled and cause little damage to nets (Carretta et al. 2008).

Status and Trends

Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Blue whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for blue whales.

It is difficult to assess the current status of blue whales because (1) there is no general agreement on the size of the blue whale 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). These estimates, however, are more than 20 years old.

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

The size of the blue whale population in the North Atlantic is also uncertain. The population has been estimated to number from a few hundred individuals (Allen 1970; Mitchell 1974) to 1,000 to 2,000 individuals (Sigurjónsson 1995). Gambell (1976) estimated there were between 1,100 and 1,500 blue whales in the North Atlantic before whaling began and Braham (1991) estimated there were between 100 and 555 blue whales in the North Atlantic during the late 1980s and early 1990s. Sears et al. (1987) identified over 300 individual blue whales in the Gulf of St. Lawrence, which provides a minimum estimate for their population in the North Atlantic. Sigurjónsson and Gunnlaugson (1990) concluded that the blue whale population had been increasing since the late 1950s and argued that the blue whale population had increased at an annual rate of about 5 percent between 1979 and 1988, although the level of confidence we can place in these estimates is low.

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

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

Diving and Social Behavior

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

2001). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

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

Vocalization and Hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see McDonald et al. 1995). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. Reported source levels are 180-188 dB re 1µPa, but may reach 195 dB re 1µPa_{rms} (Aburto et al. 1997; Clark and Gagnon 2004; Ketten 1998; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 µPa_{rms} -1 m in the 17-30 Hz range and pygmy blue whale calls at 175± 1 dB re 1 µPa_{rms} -1 m in the 17-50 Hz range.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Edds-Walton 1997; Payne and Webb. 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Edds-Walton 1997; Payne and Webb. 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

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

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995).

Critical Habitat

Critical habitat has not been designated for blue whales.

4.3.2 Fin Whale

The fin whale, *Balaenoptera physalus* (Linnæus 1758), is a well-defined, cosmopolitan species of baleen whale (Gambell 1985a). Fin whales are the second-largest whale species by length. Fin whales are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. The streamlined appearance can change during feeding when the pleated throat and chest area becomes distended by the influx of prey and seawater, giving the animal a tadpole-like appearance. The basic body color of the fin whale is dark gray dorsally and white ventrally, but the pigmentation pattern is complex. The lower jaw is gray or black on the left side and creamy white on the right side. This asymmetrical coloration extends to the baleen plates as well, and is reversed on the tongue. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990). Fin whales live 70-80 years (Kjeld 1982).

Distribution

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

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

Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast seaward to the continental shelf (about the 1,000-fathom contour). In this region, they tend to occur north of Cape Hatteras where they accounted for about 46 percent of the large whales observed in surveys conducted between 1978 and 1982. During the summer months, fin whales in this region tend to congregate in feeding areas between 41°20'N and 51°00'N, from shore seaward to the 1,000-fathom contour. 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.

In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985a). The overall distribution may be based on prey availability. 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* 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 IWC 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 whale populations.

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

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

Mizroch et al. (1984) identified five fin whale "feeding aggregations" in the Pacific Ocean: (1) an eastern group that move along the Aleutians, (2) a western group that move along the Aleutians (Berzin and Rovnin 1966; Nasu 1974); (3) an East China Sea group; (4) a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (Rice 1974); and (5) 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.

Fin whales also appear to migrate to waters offshore of Washington, Oregon, and northern California to forage. Most fin whales that occur in the action area for this consultation appear to migrate between summer, foraging areas and winter rearing areas along the Pacific Coast of the United States, although Moore et al. (1998) recorded fin whale vocalizations in waters off Washington and Oregon throughout the year, with concentrations between

September and February, which demonstrates that fin whales are likely to occur in the action area throughout the year.

Natural Threats

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04 to 0.06 for northeast Atlantic fin whales. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1983). Adult fin whales engage in flight responses (up to 40 km/h) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Killer whale or shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999a).

Anthropogenic Threats

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

Fin whales experience significant injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Douglas et al. 2008; Lien 1994; Perkins and Beamish 1979; Waring et al. 2007). Between 1969 and 1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). In 1999, one fin whale was reported killed in the Gulf of Alaska pollock trawl fishery and one was killed the same year in the offshore drift gillnet fishery (Angliss and Outlaw 2005; Carretta and Chivers. 2004). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004.

Jensen and Silber's (2004) review of the NMFS' ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawai'i. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005; Nelson et al. 2007). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008). Similarly, 2.4 percent of living fin whales from the Mediterranean show ship strike injury and 16 percent of stranded individuals were killed by vessel collision (Panigada et al. 2006). There are also numerous reports of ship strikes off the Atlantic coasts of France and England (Jensen and Silber 2004).

Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship

strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to be capable of reducing ship strike mortality by 27 percent in the Bay of Fundy region.

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

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

Status and Trends

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Although fin whale population structure remains unclear, various abundance estimates are available. Pre-exploitation fin whale abundance is estimated at 464,000 individuals worldwide; the estimate for 1991 was roughly 25 percent of this (Braham 1991). Historically, worldwide populations were severely depleted by commercial whaling, with more than 700,000 whales harvested in the twentieth century (Cherfas 1989).

The status and trend of fin whale populations is largely unknown. Over 26,000 fin whales were harvested between 1914-1975 (Braham 1991 as cited in Perry et al. 1999a). NMFS estimates roughly 3,000 individuals occur off California, Oregon, and Washington based on ship surveys in summer/autumn of 1996, 2001, and 2005, of which estimates of 283 and 380 have been made for Oregon and Washington alone (Barlow 2003; Barlow and Taylor 2001; Forney 2007). Barlow (2003) noted densities of up to 0.0012 individuals/km^2 off Oregon and Washington and up to 0.004 individuals/km^2 off California.

Fin whales were extensively hunted in coastal waters of Alaska as they congregated at feeding areas in the spring and summer (Mizroch et al. 2009). There has been little effort in the Gulf of Alaska since the cessation of whaling activities to assess abundance of large whale stocks. Fin whale calls have been recorded year-round in the Gulf of Alaska, but are most prevalent from August-February (Moore et al. 1998; Moore et al. 2006).

Regardless of which of these estimates, if any, have the closest correspondence to the actual size and trend of the fin whale population, all of these estimates suggest that the global population of fin whales consists of tens of thousands of individuals and that the North Atlantic population consists of at least 2,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience

phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

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

Diving and Social Behavior

The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives, each of 13-20 s duration, followed by a deep dive of 1.5-15 min (Gambell 1985a; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2-6 min (Hain et al. 1992; Watkins 1981b). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll et al. 2001). However, Lafortuna et al. (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known (Panigada et al. 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75 percent of sightings during the Cetacean and Turtle Assessment Program (Hain et al. 1992).

Individuals or groups of less than five individuals represented about 90 percent of the observations. Barlow (2003) reported mean group sizes of 1.1–4.0 during surveys off California, Oregon, and Washington.

Vocalization and Hearing

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981a; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995) reported the most common sound as a 1 s vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. Au (2000) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a). Source levels for fin whale vocalizations are 140-200 dB re 1μPa_{rms}-m (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987).

Although their function is still in doubt, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997; Payne and Webb. 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999).

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

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995).

Critical Habitat

Critical habitat has not been designated for fin whales.

4.3.3 Western North Pacific Gray Whale

Gray whales are mysticetes, or baleen whales. Gray whales are the only species in the family Eschrichtiidae. These large whales can grow to about 50 ft (15 m) long, and weigh approximately 80,000 pounds (lb) (35,000 kg). Females are slightly larger than males. They have a mottled gray body, with small eyes located just above the corners of the mouth. Their "pectoral fins" (flippers) are broad, paddle-shaped, and pointed at the tips. Lacking a dorsal fin, they instead have a "dorsal hump" located about two-thirds of the way back on the body, and a series of 8-14 small bumps, known as "knuckles," between the dorsal hump and the tail flukes. The tail flukes are more than 15 ft (3 m) wide, have S-shaped trailing edges, and a deep median notch.

Gray whales become sexually mature between 6-12 years, at an average of 8 years old. After 12-13 months of gestation, females give birth to a single calf. Newborn calves are approximately 14-16 ft (4.5-5 m) long, and weigh about 2,000 lb (920 kg). Calves are born dark gray and lighten as they age to brownish-gray or light gray. All gray whales are mottled with lighter patches, and have barnacles and whale lice on their bodies, with higher concentrations found on the head and tail. The average and maximum life span of gray whales is unknown, although one female was estimated at 75-80 years old after death (Jones and Swartz 2002).

Distribution

The western North Pacific population of gray whales is distributed between the west central Sea of Okhotsk (from summer to fall) and the South China Sea (winter). Gray whales are the most coastal of the baleen whales and the western Pacific population is no exception: whales in this population generally forage in shallow, nearshore waters throughout the year except when crossing open-water passages.

Most feeding occurs on their northern feeding grounds, although Nerini (Nerini 1984) reported evidence of extensive feeding during migration. Feeding areas off northeastern Sakhalin Island, Russia appear to be important for this species during the summer (Johnson et al. 2007). Their migratory route from these feeding grounds to winter rearing areas include regions off the eastern shore of Sakhalin Island in the Okhotsk Sea, along the eastern shore of mainland Russia near the La Perouse and Tatarskiy Straits, and off the eastern shore of the Korean peninsula (Brownell and Chun 1977). Data derived from whaling records suggest that gray whale numbers off Korea peaked in two pulses, one between December and January (probably during the southward migration) and the other between March and April (during the northward migration) (Andrews 1914; Kato and Kasuya. 2002). In addition, gray whales have been occasionally sighted off the Pacific coast of southern Japan between 1959-1997 (Omura 1984).

Winter calving and mating areas for this population remain unknown. However, some investigators have suggested that the western population of gray whales calves off the southern end of the Korean Peninsula (Andrews 1914), although the analyses that led to this conclusion are being debated (Rice and Wolman 1971). Historical records indicate that the western population of gray whales occurred as far south as the Yellow Sea, East China Sea, and South China Sea (Weller et al. 2002), so calving may occur in these areas. In addition, Omura (1974) suggested that an alternative or additional calving and mating area was in the Seto Inland Sea off southern Japan, although this suggestion has not been supported by empirical observation.

Population Structure

Western Pacific gray whales appear to exist as a single population that occurs from the Sea of of Okhotsk (from summer to fall) and the South China Sea (winter). Gray whales are frequently observed traveling alone or in small, unstable groups, although large aggregations may be seen on feeding and breeding grounds. Similar to other baleen whales, long-term bonds between individuals are rare.

Threats to the Species

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 (based on studies of northeast Atlantic fin whales). 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. 1999a). Killer whale or shark attacks may injure or kill very young or sick whales (Perry et al. 1999a).

There is limited information on the human activities that threaten gray whales; however, the decline in the western Pacific gray whale population can be largely attributed to modern commercial whaling off Russia, Korea, and Japan between the 1890s and 1960s. This population has been legally protected under the International Convention for the Regulation of Whaling since 1946. The Republic of Korea and China, however, did not join the IWC until 1978 and 1980, respectively. Prior to their membership, at least 67 gray whales were killed between 1948 and 1966 off the Republic of Korea, and the absence of catch reports from 1967 to 1980 does not necessarily indicate the absence of gray whale harvests by either of these countries during that fourteen year period (Brownell and Chun 1977). The Democratic People's Republic of Korea, recognized for its long-term involvement in coastal and pelagic whaling operations, is not currently a member of the IWC and nothing is known about this country's whaling activities over the past fifty years.

Current threats to the western gray whale population include continued mortality from an undetermined level of hunting (Brownell et al. 1999a; Brownell et al. 1999b), and incidental catches in the extensive coastal net fisheries off southern China (Weller et al. 2002). The substantial nearshore industrialization and shipping congestion throughout the migratory corridor(s) of this population also represent potential threats by increasing the likelihood of exposure to chemical pollution and ship strikes. Present and planned large-scale offshore gas and oil development in the South China Sea, and within 20 km of the only known feeding ground for western gray whales off northeast Sakhalin Island in the Okhotsk Sea, is of particular concern (Weller et al. 2002; Weller et al. 1999). Activities related to oil and gas exploration, including high-intensity geophysical seismic surveying, drilling operations, increased ship and air traffic, and oil spills, all pose potential threats to gray whales. Disturbance from underwater industrial noise may displace whales from critical feeding, migratory, and breeding habitat (Bryant et al. 1984;

Richardson et al. 1995). Physical habitat damage from drilling and dredging operations, combined with possible impacts of oil and chemical spills on benthic prey communities also warrants concern.

Despite international agreements that prohibit harvests of these whales, at least one western gray whale was illegally killed off Hokkaido, Japan, in 1996 (Baker et al. 2002; Brownell et al. 1999a; Brownell et al. 1999b). Baker et al. (2002) report the sale of meat from seven gray whales, whose genetics apparently match the published sequence from Washington State, in Japan in 1999. Based on the results of their investigations, Baker et al. (2002) suggested that illegal hunting along the coast of Japan could be one of the factors inhibiting the recovery of this critically endangered population.

Status

The North Atlantic population of gray whales became extinct as a result of whaling activity during the early 1900s. In the North Pacific, the IWC started to manage commercial whaling for gray whales in 1969 and fully protected gray whales commercial whaling in 1976. North Pacific gray whales were listed as endangered under the ESA in 1973. The eastern Pacific population of the gray whale was removed from the list of threatened and endangered species in 1994 (59 FR 31094). However, the western Pacific population of gray whales remains protected as an endangered species under the ESA. Critical habitat has not been designated for the western Pacific population of gray whales.

Gray whales are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Gray whales were listed as critically endangered by IUCN in 2000 (IUCN 2010).

The western Pacific population of gray whales was thought to be extinct as recently as 1972 (Bowen 1974), but is known to survive today as a small remnant population (Brownell and Chun 1977; Weller et al. 2002). Aerial and ship-based sighting records in the Okhotsk Sea between 1979 and 1989 indicated that gray whales aggregated predominantly along the shallow-water shelf of northeastern Sakhalin Island, Russia, and were most common off the southern portion of Piltun Lagoon (Weller et al. 2002).

Photo-identification data on western gray whales, collected by the two research teams operating off Sakhalin Island from 1994-2008 and 2002-2008 respectively, provided an estimated population size in 2009 (excluding calves) of 131 animals (90 percent Bayesian confidence interval 120-140), of which 33 (CI 29-38) are estimated to be reproductively mature females (Cooke 2010). The estimated annual survival rate is 0.69 (CI 0.58-0.78) for calves and 0.985 (CI 0.977-0.991) for non-calves. The estimated age at sexual maturity is 9.0 years (7.7-11.2) (Cooke 2010). The population is projected to continue to increase with high probability (>99 percent) if there are no additional anthropogenic mortalities. It remains unclear whether the population estimates represent the entire western gray whale population or only a part which visits Sakhalin Island.

Diving and Social Behavior

Gray whales are not deep divers. While foraging, they will generally remain in waters less than 80 m in depth. Their average dive times are between 4 and 5 min.

Vocalizations and Hearing

Gray whales produce and probably hear low frequency sounds (Croll et al. 1999b). Experimental playback studies have shown that gray whales avoid novel, low frequency sound sources, including sounds produced by SURTASS LFA, when received levels are about 160 dB (Croll et al. 1999b). There are no data on the hearing range of gray whales.

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

Critical Habitat

Critical habitat has not been designated for gray whales.

4.3.4 Humpback Whale

Humpback whales (*Megaptera novaeangliae*) are distinguished from other whales in the same Family (Balaenopteridae) by extraordinarily long flippers (up to 5 m or about 1/3 total body length), a more robust body, fewer throat grooves (14-35), more variable dorsal fin, and utilization of very long (up to 30 min.), complex, repetitive vocalizations (songs) (Payne and McVay 1971) during courtship. Their grayish-black baleen plates, approximately 270-440 on each side of the jaw, are intermediate in length (6570 centimeters (cm)) to those of other baleen whales. Humpbacks in different geographical areas vary somewhat in body length, but maximum recorded size is 18m (Winn and Reichley 1985).

The whales are generally dark on the back, but the flippers, sides and ventral surface of the body and flukes may have substantial areas of natural white pigmentation plus acquired scars (white or black). Researchers distinguish individual humpbacks by the apparently unique black and white patterns on the underside of the flukes as well as other individually variable features (Glockner and Venus 1983; Katona and Whitehead 1981; Kaufman and Osmond 1987).

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 breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic 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 1991). These whales migrate to Hawai'i, southern Japan, the Mariana Islands, and Mexico during the winter.

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. Based on genetic and photo-identification studies, the NMFS currently recognizes four stocks, likely corresponding to populations, of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific (Hill and DeMaster 1998). However, gene flow between them may exist. Humpback whales summer in coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawai′i, southern Japan, the Mariana Islands, and Mexico during winter. However, more northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in the waters around Hawai′i while the eastern North Pacific population (also called the California-Oregon-Washington-Mexico stock) winters along Central America and Mexico. However, Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure.

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. Based on the data collected during that study, Calambokidis et al. (2008) estimated the rates of exchange among humpback whales in different areas in the Hawaiian Islands that are presented in Table 4.

Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai′i and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawai′i may have emigrated from Mexican wintering areas. A "population" of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in the Mariana Islands, at Guam, Rota, and Saipan from January-March (Darling and Cerchio 1993; Eldredge 1991; Eldredge 2003; Rice 1998). During 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 2008; Calambokidis 1997; Calambokidis et al. 2001).

Table 4. Rates of exchange among humpback whales in sub-areas in the Hawaiian Islands based on data presented in Calambokidis et al. (2008). [1]

Sub-Area	Kaua'i	Oahu	Penguin Bank[2]	Moloka'i	Maui	Hawai'i
Kaua'i	**203 (0.0793)**	1 (0.0049)	0 (0.0000)	4 (0.0197)	29 (0.1429)	2 (0.0099)
O'ahu		**89 (0.0348)**	0 (0.0000)	5 (0.0562)	20 (0.2247)	9 (0.1011)
Penguin Bank			**34 (0.0133)**	3 (0.0882)	4 (0.1176)	3 (0.0882)
Moloka'i				**201 (0.0785)**	61 (0.3035)	12 (0.0597)
Maui					**1526 (0.596)**	99 (0.0649)
Hawai'i						**507 (0.1980)**

1 *Numbers along the diagonal are the total number of individuals that were identified in a sub-area (highlighted in bold), number in the sub-diagonals are the number of individuals from one sub-area that were identified in other areas. Numbers in parentheses are percentages.*

2 *Penguin Bank is located off the southwest tip of the island of Molokai and is an important shallow, marine habitat that is part of the Hawaiian Islands Humpback Whale National Marine Sanctuary*.

Separate feeding groups of humpback whales are thought to inhabit western U.S. and Canadian waters, with the boundary between them located roughly at the U.S./Canadian border. The southern feeding ground ranges between 32°-48°N, with limited interchange with areas north of Washington State (Calambokidis et al. 2004; Calambokidis et al. 1996). Humpback whales feed along the coasts of Oregon and Washington from May-November, with peak numbers reported May-September, when they are the most commonly reported large cetacean in the region (Calambokidis and Chandler. 2000; Calambokidis et al. 2004; Dohl 1983; Green et al. 1992). Off Washington State, humpback whales concentrate between Juan de Fuca Canyon and the outer edge of the shelf break in a region called "the Prairie," near Barkley and Nitnat canyons, in the Blanco upwelling zone, and near Swiftsure Bank (Calambokidis et al. 2004). Humpback whales also tend to congregate near Heceta Bank off the coast of Oregon (Green et al. 1992). Additional data suggest that further subdivisions in feeding groups may exist, with up to six feeding groups present between Kamchatka and southern California (Witteveen et al. 2009).

Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005). Although humpback whales were common in inland Washington State waters in the early 1900s, severe hunting throughout the eastern North Pacific has diminished their numbers and few recent inshore sightings have been made (Calambokidis et al. 1990; Scheffer and Slipp 1948).

Historically, humpback whales occurred in Puget Sound. Since the 1970s, however, humpback whales have become rare within Puget Sound, although at least five humpback whales have been observed in Puget Sound since 1976 (Calambokidis et al. 1990; Calambokidis et al. 2004; Osborne et al. 1988). Because of their contemporary rarity in Puget Sound, we assume that humpback whales would not be exposed to Navy training activities within the Sound itself, but would be exposed in waters offshore of Washington.

Although humpback whales no longer appear to occur in Puget Sound, they have consistently been more common than any other large cetacean observed off the coast of Washington State for more than a decade (Calambokidis et al. 2009; Calambokidis et al. 2004; Forney 2007). Humpback whales occur in those waters seasonally from May through November, becoming fairly common beginning in July, and reaching peak densities from August to September and declines substantially from September onward (Calambokidis 1997; Calambokidis and Chandler. 2000; Calambokidis et al. 2001; Calambokidis et al. 1997; Green et al. 1992). During that time interval, humpback whales have been reported in coastal waters, on the continental shelf, and the continental slope, with concentrations occurring in steep slope water near Grays, Astoria, and Nitinat canyons (Forney 2007; Green et al. 1992).

Several authors have reported that humpback whales do not occur off the coasts of Washington and Oregon in the winter (Green et al. 1992). However, Shelden et al. (Shelden et al. 2000) reported observations of humpback whales north and south of Juan de Fuca canyon (off northern Washington) in late December. These authors also reported that humpback whales were common in Georgia Strait during the winter in the early 1900s and they suggested that, as their population increases, humpback whales might be re-occupying areas they had previously abandoned after their populations were decimated by whalers; these authors also allowed that humpback whales might remain in waters off Washington when their prey is abundant late in the year.

Natural Threats

Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999a). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period.

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 whales and was ultimately responsible for listing several species as endangered.

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 were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). 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, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. NMFS estimates that between 2002 and 2006, there were incidental serious injuries to 0.2 humpback whales annually in the Bering Sea/Aleutian Islands sablefish longline fishery. This estimation is not considered reliable. Observers have not been assigned to a number of fisheries known to interact with the Central and Western North Pacific stocks of humpback whale. In addition, the Canadian observation program is also limited and uncertain (Angliss and Allen 2009).

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997). Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9 percent.

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher PCB levels have been observed in Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

Status and Trends

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA.

In the North Pacific the pre-exploitation population size may have been as many as 15,000 humpback whales, and current estimates are 6,000-8,000 whales (Calambokidis et al. 2009; Rice 1978). It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999a). Population estimates have risen over time from 1,407-2,100 in the 1980s to 6,010 in 1997 (Baker 1985; Baker and Herman. 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). Based on surveys between 2004 and 2006, Calambokidis et al. (2008) estimated that the number of humpback whales in the North Pacific consisted of about 18,300 whales, not counting calves. Because estimates vary by

methodology, they are not directly comparable and it is not clear which of these estimates is more accurate or if the change from 1,407 to 18,300 is the result of a real increase or an artifact of model assumptions. Tentative estimates of the eastern North Pacific stock suggest an increase of 6-7 percent annually, but fluctuations have included negative growth in the recent past (Angliss and Outlaw 2005).

Diving

Maximum diving depths are approximately 170 m, with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1-5.1 min in the north Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

Social Behavior

During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best 1995).

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin (*Mallotus villosus*), herring (*Clupea* spp.*)* and mackerel (*Scomber scombrus*). Like other large mysticetes, they are a “lunge feeder” taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with open mouths through the middle. Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific (southeast Alaska), most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (Dolphin 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al. 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (Au et al. 2006; Au et al. 2000; Frazer and Mercado III 2000; Richardson et al. 1995; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also

produced in breeding areas (Richardson et al. 1995; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m; (Au et al. 2000; Erbe 2002a; Payne 1985; Richardson et al. 1995; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995).

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

Critical Habitat

Critical habitat has not been designated for humpback whales.

4.3.5 North Pacific Right Whale

The northern right whale, *Eubalaena japonica* (Lacépède 1818), is a large baleen whale. Adults are generally between 45 and 55 ft in length and can weigh up to 70 tons. Females are larger than males. The distinguishing features of right whales include a stocky body, generally black coloration (although some individuals have white patches on their undersides), lack of a dorsal fin, large head (about 1/4 of the body length), strongly bowed margin of the lower lip, and callosities on the head region. Two rows of long (up to about eight feet in length), dark baleen plates hang from the upper jaw, with about 225 plates on each side. The tail is broad, deeply notched, and all black with smooth trailing edge. Many basic life history parameters of North Pacific right whales are unknown.

While no reproductive data are known for the North Pacific, studies of North Atlantic right whales suggest calving intervals of two to seven years and growth rates that are likely dependent on feeding success (Best et al. 2001; Burnell 2001; Cooke et al. 2001; Kenney 2002; Knowlton et al. 1994). It is presumed that right whales calve during mid-winter (Clapham et al. 2004). Western North Pacific sightings have been recorded along Japan, the Yellow Sea, and Sea of Japan (Best et al. 2001), areas that are speculated to be important breeding and calving areas. A lifespan of up to 70 years can be expected based upon North Atlantic right whale data.

Distribution

Very little is known of the distribution of right whales in the North Pacific and very few of these animals have been seen in the past 20 years. Historical whaling records indicate that right whales ranged across the North Pacific north of 30° N latitude and occasionally as far south as 20° N, with a bimodal distribution longitudinally favoring the eastern and western North Pacific and occurring infrequently in the central North Pacific (Gregr and Coyle 2009; Josephson et al. 2008; Maury 1853; Scarff 1986; Townsend 1935). North Pacific right whales summered in the North Pacific and southern Bering Sea from April or May to September, with a peak in sightings in coastal waters of Alaska in June and July (Klumov 2001; Maury 1853; Omura et al. 1969; Townsend 1935). North Pacific right whale summer range extended north of the Bering Strait (Omura et al. 1969). However, they were particularly abundant in the Gulf of Alaska from 145° to 151°W, and apparently concentrated in the Gulf of Alaska, especially south of Kodiak Islands and in the eastern Aleutian Islands and southern Bering Sea waters (Berzin and Rovnin 1966; Braham and Rice 1984).

Current information on the seasonal distribution of right whales is spotty. In the eastern North Pacific, this includes sightings over the middle shelf of the Bering Sea, Bristol Bay, Aleutian and Pribilof Islands (Goddard and Rugh

1998; Hill and DeMaster 1998; Perryman et al. 1999; Wade et al. 2006; Waite et al. 2003). More southerly records indicate occurrence along Hawai′i, California, Washington, and British Columbia (Herman et al. 1980; Scarff 1986). However, records from Mexico and California may suggest historical wintering grounds in offshore southern North Pacific latitudes (Brownell Jr. et al. 2001; Gregr and Coyle 2009).

Population Structure

All North Pacific right whales constitute a single population.

Natural Threats

Right whales have been subjects of killer whale attacks and, because of their robust size and slow swimming speed, tend to fight killer whales when confronted (Ford and Reeves 2008). Similarly, mortality or debilitation from disease and red tide events are not known, but have the potential to be significant problems in the recovery of right whales because of their small population size.

Anthropogenic Threats

Whaling for North Pacific right whales was discontinued in 1966 with the IWC whaling moratorium. However, North Pacific right whales remain at considerable risk of extinction. These include but are not limited to the following: (1) life history characteristics such as slow growth rate, long calving intervals, and longevity; (2) distorted age structure of the population and reduced reproductive success; (3) strong depensatory or Allee effects; (4) habitat specificity or site fidelity; and (5) habitat sensitivity. However, the proximity of the other known right whale habitats to shipping lanes (e.g., Unimak Pass, Alaska) suggests that collisions with vessels may also represent a threat to North Pacific right whales (Elvin and Taggart 2008).

Climate change may have a dramatic effect on survival of North Pacific right whales. Right whale life history characteristics make them very slow to adapt to rapid changes in their habitat (see Reynolds et al. 2002). They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate. 2003). Zooplankton abundance and density in the Bering Sea has been shown to be highly variable, affected by climate, weather, and ocean processes and in particular ice extent (Baier and Napp 2003; Napp and G. L. Hunt 2001). The largest concentrations of copepods occurred in years with the greatest southern extent of sea ice (Baier and Napp 2003). It is possible that changes in ice extent, density and persistence may alter the dynamics of the Bering Sea shelf zooplankton community and in turn affect the foraging behavior and success of right whales. No data are available for the western North Pacific.

Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989. No other incidental takes of right whales are known to have occurred in the North Pacific. Based on the available records, the estimated annual mortality rate incidental to U.S. commercial fisheries approaches zero whales per year from this stock. Therefore, the annual human-caused mortality level is considered to be insignificant and approaching a zero mortality and serious injury rate (Angliss and Outlaw 2008).

Status and Trends

The North Pacific right whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. The early listing included both the North Atlantic and the North Pacific populations, although subsequent genetic studies conducted by Rosenbaum (2000) resulted in strong evidence that

the North Atlantic and North Pacific right whales are separate species. Following a comprehensive status review, NMFS concluded that Northern right whales are indeed two separate species. In March 2008, NMFS published a final rule listing North Pacific and North Atlantic right whales as separate species (73 FR 12024).

Very little is known about right whales in the eastern North Pacific, which were severely depleted by commercial whaling in the 1800s (Brownell Jr. et al. 2001). At least 11,500 individuals were taken by American whalers in the early- to mid-19th century, but harvesting continued into the 20th century (Best 1987). Illegal Soviet whaling took 372 individuals between 1963 and 1967 (Brownell Jr. et al. 2001). In the last several decades there have been markedly fewer sightings due to a drastic reduction in number, caused by illegal Soviet whaling in the 1960s (Doroshenko 2000). Previous estimates of the size of the right whale population in the Pacific Ocean range from a low of 100-200 (Braham and Rice 1984) to a high of 220-500 (Berzin 1978). The current population size of right whales in the North Pacific is likely fewer than 1,000 animals (NMFS 2006b).

Abundance estimates and other vital rate indices in both the eastern and western North Pacific are not well established. Where such estimates exist, they have very wide confidence limits. In 2010, the population of North Pacific right whales that summer in the southeastern Bering Sea was approximately 30 animals (Wade et al. 2011). More specifically, mark-recapture photographic studies suggested a population of 31 whales (95% confidence level = 23-54); and genotyping study suggested a population of 28 whales (95% confidence level = 24-42). The estimated population contains eight females (95% confidence level = 7–18) and 20 males (95% confidence level = 17–37) (Wade et al. 2011).

Previous estimates of the size of the right whale population in the Pacific Ocean range from a low of 100-200 to a high of 220-500 (Berzin 1978; Braham and Rice 1984). Although Hill and DeMaster (1998) argued that it is not possible to reliably estimate the population size or trends of right whales in the North Pacific, Reeves and Kenney (2003) concluded that North Pacific right whales in the eastern Pacific Ocean exist as a small population of individuals while the western population of right whales probably consists of several hundred animals, although Clapham et al. (2005) placed this population at likely under 100 individuals. Brownell et al. (2001) reviewed sighting records and also estimated that the abundance of right whales in the western North Pacific was likely in the low hundreds.

Scientists participating in a recent study utilizing acoustic detection and satellite tracking identified 17 right whales (10 males and 7 females) in the Bearing Sea, which is almost threefold the number seen in any previous year in the last four decades (Wade et al. 2006). These sightings increased the number of individual North Pacific right whales identified in the genetic catalog for the eastern Bering Sea to 23. Amidst the uncertainty of the eastern North Pacific right whale's future, the discovery of females with calves provides hope that this endangered population may still possess the capacity to recover (Wade et al. 2006). Available age composition of the North Pacific right whale population indicates that most individuals are adults (Kenney 2002). Length measurements for two whales observed off California suggest at least one of these whales was not yet sexually mature and two calves have been observed in the Bering Sea (Carretta et al. 1994; Wade et al. 2006). However, to date, there is no evidence of reproductive success (i.e., young reared to independence) in the eastern North Pacific. No data are available for the western North Pacific.

Acoustic monitoring for right whales was carried out via autonomous hydrophones in 2000-2001 near Kodiak Island, and right whale calls were recorded in August and early September (Mellinger et al. 2004; Moore et al. 2006).

Diving

Very little is known about North Pacific right whale diving abilities. Dives of 5 to 15 min or even longer have been reported for North Atlantic right whales. Observations of North Atlantic right whales found that the average depth dive was strongly correlated with both the average depth of peak copepod abundance and the average depth of the bottom mixed layer's upper surface. North Atlantic right whale feeding dives are characterized by a rapid descent from the surface to a particular depth between 262 and 574 ft (80 and 175 m), remarkable fidelity to that depth for 5 to 14 min, and then rapid ascent back to the surface. Right whale dive patterns in the Great South Channel region east of Cape Cod are closely correlated with the horizontal and vertical distributions and movements of dense patches of their zooplankton prey (Winn et al. 1995). Longer surface intervals have been observed for reproductively active females and their calves (Navy 2006b).

Social Behavior

Historical concentrations of sightings in the Bering Sea together with some recent sightings indicate that this region, together with the Gulf of Alaska, may represent an important summer habitat for eastern North Pacific right whales (Brownell Jr. et al. 2001; Clapham et al. 2004; Goddard and Rugh 1998; Scarff 1986; Shelden et al. 2005). Few sighting data are available from the eastern North Pacific, with a single sighting of 17 individuals in the southeast Bering Sea being by far the greatest known occurrence (Wade et al. 2006). Some further sightings have occurred in the northern Gulf of Alaska (Wade et al. 2006). Recent eastern sightings tend to occur over the continental shelf, although acoustic monitoring has identified whales over abyssal waters (Mellinger et al. 2004). It has been suggested that North Pacific right whales have shifted their preferred habitat as a result of reduced population numbers, with oceanic habitat taking on a far smaller component compared to shelf and slope waters (Shelden et al. 2005).

Historical sighting and catch records provide the only information on possible migration patterns for North Pacific right whales (Omura 1958; Omura et al. 1969; Scarff 1986). During summer, whales have been found in the Gulf of Alaska, along both coasts of the Kamchatka Peninsula, the Kuril Islands, the Aleutian Islands, the southeastern Bering Sea, and in the Okhotsk Sea. Fall and spring distribution was the most widely dispersed, with whales occurring in mid-ocean waters and extending from the Sea of Japan to the eastern Bering Sea. In winter, right whales have been found in the Ryukyu Islands (south of Kyushu, Japan), the Bonin Islands, the Yellow Sea, and the Sea of Japan. Whalers never reported winter calving areas in the North Pacific and where calving occurs remains unknown (Clapham et al. 2004; Gregr and Coyle 2009; Scarff 1986). North Pacific right whales probably migrate north from lower latitudes in spring and may occur throughout the North Pacific from May through August north of 40º N from marginal seas to the Gulf of Alaska and Bering Sea, although absence from the central North Pacific has been argued due to inconsistencies in whaling records (Clapham et al. 2004; Josephson et al. 2008). This follows generalized patterns of migration from high-latitude feeding grounds in summer to more temperate, possibly offshore waters, during winter (Braham and Rice 1984; Clapham et al. 2004; Scarff 1986).

Vocalizations and Hearing

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

4.3.6 Sei Whale

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

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

The Sei is regarded as the fastest swimmer among the great whales, reaching bursts of speed in excess of 20 knots. When a sei whale begins a dive it usually submerges by sinking quietly below the surface, often remaining only a few meters deep, leaving a series of swirls or tracks as it move its flukes. When at the water's surface, sei whales can be sighted by a columnar or bushy blow that is about 10-13 feet (3-4 m) in height. The dorsal fin usually appears at the same time as the blowhole, when the animal surfaces to breathe. This species usually does not arch its back or raise its flukes when diving.

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

Distribution

The sei whale occurs in all oceans of the world except the Arctic. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999a). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999a). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

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

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 (Gambell 1985b; Masaki 1977).

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 not well defined, but presumed to be discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

North Pacific. Some mark-recapture, catch distribution, and morphological research indicate more than one population may exist – one between 155°-175° W, and another east of 155° W (Masaki 1976; Masaki 1977). Sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska and south to California to the east and Japan and Korea to the west (Leatherwood et al. 1982; Nasu 1974). Sightings have also occurred in Hawaiian waters (Smultea et al. 2010). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Whaling data suggest that sei whales do not venture north of about 55°N (Gregr et al. 2000). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July-September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea. Harwood (1987) evaluated Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea. Harwood (1987) reported that 75-85 percent of the North Pacific population resides east of 180°. During winter, sei whales are found from 20°-23° N (Gambell 1985b; Masaki 1977). Considering the many British Columbia whaling catches in the early to mid 1900s, sei whales have clearly utilized this area in the past (Gregr et al. 2000; Pike and Macaskie 1969).

Sei whales appear to prefer to forage in regions of steep bathymetric relief, such as continental shelf breaks, canyons, or basins situated between banks and ledges (Best and Lockyer. 2002; Gregr and Trites. 2001; Kenney and Winn. 1987), where local hydrographic features appear to help concentrate zooplankton, especially copepods. In their foraging areas, sei whales appear to associate with oceanic frontal systems (Horwood 1987). In the north Pacific, sei whales are found feeding particularly along the cold eastern currents (Perry et al. 1999a).

In the early to mid-1900s, sei whales were hunted off the coast of British Columbia (Gregr et al. 2000; Pike and Macaskie 1969). Masaki (1977) presented sightings data on sei whales in the North Pacific from the mid-1960s to the early 1970s. Over that time interval sei whales did not appear to occur in waters of Washington State and southern British Columbia in May or June, their densities increased in those waters in July and August (1.9 - 2.4 and 0.7 - 0.9 whales per 100 miles of distance for July and August, respectively), then declined again in September.

More recently, sei whales have become known for an irruptive migratory habit in which they appear in an area then disappear for time periods that can extend to decades. Based on a sei whale that stranded near Port Angeles and the sei whales observed by Forney and her co-workers (Forney 2007), we know that these whales still occur in waters off Washington, Oregon, and northern California.

Natural Threats

The foraging areas of right and sei whales in the western North Atlantic Ocean overlap and both whales feed preferentially on copepods (Mitchell 1975).

Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

Anthropogenic Threats

Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas.

Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales. Data on entanglement and entrapment in non-U.S. waters are not reported systematically. Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980s. Some of these may have been fin whales instead of sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation may not mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997). The offshore drift gillnet fishery is the only fishery that is likely to take sei whales from this stock, but no fishery mortalities or serious injuries to sei whales have been observed. Sei whales, like other large whales, may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast between 1975 and 1996, two showed evidence of collisions (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada's Maritime Provinces (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in death. One sei whale was killed in a collision with a vessel off the coast of Washington in 2003 (Waring et al. 2009). New rules for seasonal (June through December) slowing of vessel traffic in the Bay of Fundy to 10 knots and changing

shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to reduce sei whale ship strike mortality by 17 percent.

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

Status and Trends

The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973.

Ohsumi and Fukuda (1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973. From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Harwood and Hembree. 1987; Perry et al. 1999a). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911-1955. 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. 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 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). There have been no direct estimates of sei whale populations for the eastern Pacific Ocean (or the entire Pacific). Between 1991 and 2001, during aerial surveys, there were two confirmed sightings of sei whales along the U.S. Pacific coast.

Sei whales are known to occur in the Gulf of Alaska and as far north as the Bering Sea in the north Pacific. However, their distribution is poorly understood. The only stock estimate for U.S. waters is for the eastern north Pacific stock offshore California, Oregon and Washington (Carretta et al. 2009); abundance in Alaskan waters is unknown and they have not been sighted during recent surveys (Rone et al. 2010; Waite et al. 2003).

Diving

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 min (Gambell 1985b). 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 m. 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 1985b).

Social Behavior

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2007). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Mizroch et al. 1984; Rice 1977). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95 percent of their diets (Calkins 1986). The dominant food for sei whales off California during June-August is northern anchovy, while in September-October whales feed primarily on krill (Rice 1977). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollack, capelin, and Atka mackerel (Nemoto and Kawamura 1977). In the

Southern Ocean, analysis of stomach contents indicates sei whales consume Calanus spp. and small-sized euphasiids with prey composition showing latitudinal trends (Kawamura 1974). Evidence indicates that sei whales in the Southern Hemisphere reduce direct interspecific competition with blue and fin whales by consuming a wider variety of prey and by arriving later to feeding grounds (Kirkwood 1992). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Little is known about the actual social system of these animals. Groups of 2-5 individuals are typically observed, but sometimes thousands may gather if food is abundant. However, these large aggregations may not be dependent on food supply alone, as they often occur during times of migration. Norwegian workers call the times of great sei whale abundance "invasion years." During mating season, males and females may form a social unit, but strong data on this issue are lacking.

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 s duration and tonal and upsweep calls in the 200-600 Hz range of 1-3 s durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin et al. 2009). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 msec) FM sweeps between 1.5-3.5 kHz (Richardson et al. 1995).

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

Critical Habitat

Critical habitat has not been designated for sei whales.

4.3.7 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Adult females may grow to lengths of 36 ft (11 m) and weigh 15 tons (13,607 kg). Adult males, however, reach about 52 ft (16 m) and may weigh as much as 45 tons (40,823 kg).

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

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

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

Distribution

Sperm whales are distributed in all of the world's oceans, from equatorial to polar waters, and are highly migratory. Mature males range between 70º N in the North Atlantic and 70º S in the Southern Ocean (Perry et al. 1999a; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50º N or S (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring 1993) where adult males join them to breed.

Population Structure

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

Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin in summer, and occur south of 40° N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974). Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl 1983; Forney et al. 1995; Shallenberger 1981). They are seen in every season except winter (December-February) in Washington and Oregon (Green et al. 1992). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993).

Sperm whales are seasonal migrants to waters off the coast of Washington and Oregon where their densities are highest during spring and summer; they do not appear to occur in these waters during the winter. Sperm whales also tend to occur in the deeper water at the western edge of the action area. In surveys of waters off Oregon and Washington conducted by Green et al. (1992), no sperm whales were encountered in waters less than 200 m deep, 12 percent of the sperm whales were encountered in waters 200 to 2000 m deep (the continental slope), and the remaining 88 percent of the sperm whales were encountered in waters greater than 2,000 m deep. In surveys conducted by Forney and her co-workers (Forney 2007), sperm whales were reported from the Olympic Coast Slope transects (west of the Olympic Coast National Marine Sanctuary), but not from surveys conducted over the National Marine Sanctuary or the area immediately west of Cape Flattery.

Natural Threats

Sperm whales are known to be occasionally predated upon by killer whales (Jefferson et al. 1991; Pitman et al. 2001) by pilot whales (Arnbom et al. 1987; Palacios and Mate. 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate.

1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic Threats

Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959-1983). However, other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). However, all of these estimates are likely underestimates due to illegal killings and inaccurate reporting by Soviet whaling fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

In U.S. waters in the Pacific, sperm whales have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of nine sperm whales per year from 1991-1995 (Barlow et al. 1997).

Interactions between sperm whales and longline fisheries in the Gulf of Alaska have been reported since 1995 and are increasing in frequency (Hill and DeMaster 1998; Hill et al. 1999; Rice 1989). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the Gulf of Alaska from the sablefish longline fishery (Angliss and Outlaw 2008). Sperm whales have also been observed in Gulf of Alaska feeding off longline gear (for sablefish and halibut) at 38 of the surveyed stations (Angliss and Outlaw 2008). Recent findings suggest sperm whales in Alaska may have learned that fishing vessel propeller cavitations (as gear is retrieved) are an indicator that longline gear with fish is present as a predation opportunity (Thode et al. 2007).

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and HCHs in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 µg Cr/g tissue, with the mean (8.8 µg Cr/g tissue) resembling levels found in human lung

tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals did not appear to accumulate chromium at higher levels.

Status and Trends

Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is unknown, several studies and estimates of abundance are available. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead and Mesnick 2003).

There are approximately 76,803 sperm whales in the eastern tropical Pacific, eastern North Pacific, Hawai′i, and western North Pacific (Whitehead 2002a). Minimum estimates in the eastern North Pacific are 1,719 individuals and 5,531 in the Hawaiian Islands (Carretta et al. 2007). The tropical Pacific is home to approximately 26,053 sperm whales and the western North Pacific has approximately 29,674 (Whitehead 2002a). There was a dramatic decline in the number of females around the Galapagos Islands during 1985-1999 versus 1978-1992 levels, likely due to migration to nearshore waters of South and Central America (Whitehead and Mesnick 2003).

Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947-1987. Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). In 2000, the Japanese Whaling Association announced plans to kill 10 sperm whales in the Pacific Ocean for research. Although consequences of these deaths are unclear, the paucity of population data, uncertainly regarding recovery from whaling, and re-establishment of active programs for whale harvesting pose risks for the recovery and survival of this species. Sperm whales are also hunted for subsistence purposes by whalers from Lamalera, Indonesia, where a traditional whaling industry has been reported to kill up to 56 sperm whales per year.

Diving

Sperm whales are probably the deepest and longest diving mammalian species, with dives to 3 km down and durations in excess of 2 hours (Clarke 1976; Watkins 1985; Watkins et al. 1993). However, dives are generally shorter (25- 45 min) and shallower (400-1,000 m). Dives are separated by 8-11 min rests at the surface (Gordon 1987; Watwood et al. 2006) (Jochens et al. 2006; Papastavrou et al. 1989). Sperm whales typically travel ~3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Clarke 1986; Whitehead 2002b). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of

sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

Social Behavior

Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead 2008). However, no sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred miles are common, (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. However, general transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Gaskin (1973) proposed a northward population shift of sperm whales off New Zealand in the austral autumn based on reduction of available food species and probable temperature tolerances of calves.

Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins and Schevill 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet 1996; Jaquet and Whitehead 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000; Davis et al. 2002). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet and Whitehead 1996; Waring et al. 1993). Sperm whales over George's Bank were associated with surface temperatures of 23.2-24.9°C (Waring et al. 2004).

Local information is inconsistent regarding sperm whale tendencies. Gregr and Trites (2001) reported that female sperm whales off British Columbia were relatively unaffected by the surrounding oceanography. However, Tynan et al. (2005) reported increased sperm whales densities with strong turbulence associated topographic features along the continental slope near Heceta Bank. Two noteworthy strandings in the region include an infamous incident (well publicized by the media) of attempts to dispose of a decomposed sperm whale carcass on an Oregon beach by using explosives. In addition, a mass stranding of 47 individuals in Oregon occurred during June 1979 (Norman et al. 2004; Rice et al. 1986).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals) versus the Pacific (25-30 individuals) (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (200-236 dB re 1μPa_{rms}), although lower source level energy has been suggested at around 171 dB re 1 μPa_{rms} (Goold and Jones 1995; Madsen et al. 2003; Weilgart and Whitehead 1997; Weilgart et al. 1993). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Goold and Jones 1995; NMFS 2006a; Weilgart et al. 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972). These long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intra-group interactions (Weilgart et al. 1993). They may also aid in intra-specific communication. Another class of sound, "squeals", are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5-60 kHz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b).

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

Critical Habitat

Critical habitat has not been designated for sperm whales.

4.3.8 Hawaiian Monk Seal

The Hawaiian monk seal is one of the rarest marine mammals in the world. Part of the "true seal" family (Phocidae), they are one of only two remaining monk seal species. The other is the Mediterranean monk seal, and a third monk seal species, the Caribbean monk seal, is extinct. The Hawaiian monk seal has a silvery-grey colored back with lighter creamy coloration on their underside; newborns are black. Additional light patches and red and green tinged coloration from attached algae are common. The back of the animals may become darker with age, especially in males.

Distribution

The Hawaiian monk seal is found primarily on the Leeward Chain of the Hawaiian Islands, especially Nihoa, Necker, French Frigate Shoals, Pearl and Hermes Reef, Kure Atoll, Laysan, and Lisianski. Sightings on the main Hawaiian Islands have become more common in the past 15 years and a birth was recorded on Kauai and Oahu in 1988 and 1991 respectively (Kenyon 1981) (Kenyon 1981, Riedmann 1990). Midway was an important breeding rookery, but is no longer used (Reeves et al. 1992). Hawaiian monk seals breed primarily at Laysan Island, Lisianski Island, and Pearl and Hermes Reefs (Tomich 1986). Monk seals are increasingly sighted in the main Hawaiian Islands. Monk seals have been reported on at least three occasions at Johnston Island over the past 30 years (not counting nine adult males that were translocated there from Laysan Island in 1984).

The distribution, destinations, routes, food sources, and causes of monk seal movements when they are not traveling between islands are not well known (Johnson 1979), but recent tagging studies have shown individuals sometimes travel between the breeding populations in the northwest Hawaiian Islands.

Population Structure

Hawaiian monk seals appear to exist as a single population that occurs in the Northwest Hawaiian Islands and Main Hawaiian Islands. However, groups of individuals that occupy specific islands or atolls in the Hawaiian Archipelago are treated as sub-populations for the purposes of research and management activity.

Pearl and Hermes Reef, the Midway Islands, and Kure Atoll form the three westernmost sub-populations of Hawaiian monk seals. There is a higher degree of migration among these sub-populations than among the sub-populations that occupy Laysan, Lisianski and French Frigate Shoals, which are more isolated. As a result, population growth in the westernmost sub-populations can be influenced more by immigration than by intrinsic growth. Several recent cohorts (groups of individuals born in the same year) at all three sites indicate that survival of juveniles has declined.

Threats to the Species

Hawaiian monk seals appear to be threatened by the spread of infectious diseases, including leptospirosis, toxoplasmosis, and West Nile virus, although domestic animals and humans may be vectors for these diseases (which would make them anthropogenic rather than natural threats). The absence of antibodies to these diseases in monk seals would make them extremely vulnerable to potential infection.

Biotoxins such as ciguatera can cause mortality in phocids, but its role in mortality of monk seals was implicated and not confirmed, remaining unclear due to the lack of assays for testing tissues and the lack of epidemiological data on the distribution of toxin in monk seal prey.

The primary cause of adult female mortality affecting the recovery potential in the monk seal population during the 1980s and early 1990s was injury and death of female monk seals caused by "mobbing" attacks initiated by male monk seals. Although NMFS has developed and implemented measures to mitigate the effects of mobbing attacks, they are still considered a serious threat to Hawaiian monk seals. In recent years, low juvenile survival, in part due to food limitation, has been evident at all subpopulations of Hawaiian monk seals in the Northwest Hawaiian Islands.

Monk seals, particularly pups, are also subjected to extensive predation by sharks, which appear to be a particular problem for the monk seals occupying French Frigate Shoals in the Northwest Hawaiian Islands. Sharks are known to injure and kill Hawaiian monk seals, and monk seal remains have been found in the stomachs of tiger sharks and Galapagos sharks.

Several human activities are known to threaten Hawaiian monk seals: commercial and subsistence hunting, intentional harassment, competition with commercial fisheries, entanglement in fishing gear, habitat destruction on breeding beaches, pollution, and unintentional human disturbance (Kenyon 1981; Reeves et al. 1992; Riedman 1990).

Marine debris and derelict fishing gear have been well documented to entangle monk seals, and monk seals have one of the highest documented entanglement rates of any pinniped species. Marine debris and derelict fishing gear continue to affect the Northwest Hawaiian Islands. The number of monk seals found entangled has not changed nor has the rate at which marine debris accumulates in the Northwest Hawaiian Islands declined.

Establishment of a 20-person U.S. Coast Guard long-range navigation station at Kure Atoll in 1960 resulted in a significant disturbance of the seal population on Green Island beaches caused by the residents and their dogs and vehicles (Johnson et al. 1982; Kenyon 1972). After the station was established and occupied, counts of monk seals declined rapidly on Green Island (Gerrodette and Gilmartin 1990; Kenyon 1972). Kenyon (1972) attributed this decline to human disturbance, which caused adult females to abandon prime pupping habitat. Pup survival declined first (Wirtz 1968), followed by a decline in recruitment of breeding females; these two phenomena combined to skew the age structure skewed of monk seals toward older animals (Johnson et al. 1982) and bias the sex ratio of adults toward males (Reddy and Griffth. 1988). The number of monk seals born on this atoll declined steadily from the late 1970s to the mid 1980s; in 1986, only one pup was born on the atoll (Gerrodette and Gilmartin 1990; Reddy 1989).

Recovery Actions

In June 2006, the Papahanaumokuakea Marine National Monument (71 FR 51134, August 29, 2006) was established in the Northwest Hawaiian Islands. The boundary of the Monument includes about 140,000 square miles of emergent and submerged lands and waters of the northwest Hawaiian Islands and regulating activities such as fishing that pose potential risks to the marine habitat of Hawaiian monk seals.

Status

Hawaiian monk seals were listed as endangered under the Endangered Species Act of 1973 on November 23, 1976 (41 FR 51611). A 5-year status review completed in 2007 recommended retaining monk seals as an endangered species (72 FR 46966, August 22, 2007). Critical habitat was originally designated for Hawaiian monk seals on April 30, 1986 (51 FR 16047), and was extended on May 26, 1988 (53 FR 18988; CFR 226.201).

Monk seals are considered one of the most endangered groups of pinnipeds on the planet because all of their populations are either extinct (for example, the Caribbean monk seal) or near exist at numbers that are precariously close to extinction (Mediterranean and Hawaiian monk seals).

Two periods of anthropogenic decline have been reported for Hawaiian monk seals. The first decline occurred in the 1800s when sealers, crews of wrecked vessels, and guano and feather hunters nearly hunted the population to extinction (Dill and Bryan 1912; Kenyon and Rice 1959). Following the collapse of this population, expeditions to the Northwest Hawaiian Islands reported increasing numbers of seals (Bailey 1952). A survey in 1958 suggested that the population had partially recovered from its initial collapse. The population of Hawaiian monk seals was believed to number slightly more than 1,000 seals at the end of this period (Rice 1960).

A second decline occurred from the late 1950s to the mid-1970s. Consistent declines in the monk seal population trends have been recorded since surveys commenced in the late 1950s. Counts of Hawaiian monk seals made since the late 1950s and 1980s at the atolls, islands, and reefs where they haul out on the northwest Hawaiian Islands showed a 50 percent population decline (NMFS 2007b). The total population for the five major breeding locations plus Necker Island for 1987 was estimated to be 1,718 seals including 202 pups of the year (Gilmartin 1988). This compares with 1,488 animals estimated for 1983 (Gerrodette 1985). In 1992 the Hawaiian monk seal population was estimated to be 1580 (standard error = 147) (Ragen 1993). The best estimate of total abundance for 1993 was 1,406 (standard error = 131, assuming a constant coefficient of variation). Thus, between 1958 and 1993, mean beach counts declined by 60 percent. For the years 1985 to 1993 the mean beach counts declined by approximately 5 percent per year. This downward trend is expected to continue, mainly due to poor pup and juvenile survival in recent years. NMFS (NMFS 2007b) estimates the current monk seal population to be between 1,300 and 1,400 individuals. Data collected at five major haulouts recorded a 23 percent decline in the number of births in 1990 from the average annual levels recorded between 1983 and 1989 (NMFS 2007b).

Regardless of which of these estimates, if any, most closely correspond to the actual size and trend of Hawaiian monk seals, the evidence available suggest that these monk seals exist as a “small” population (that is, they 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). For example, Hawaiian monk seals have very low survival of juveniles and sub-adults due to starvation (which is believed to be caused by limitations in the food base), low juvenile survival has lead to low juvenile recruitment into the adult population, and the adult population increasingly consists of ageing females who reproductive success is expected to decline (if it has not already declined) in the foreseeable future. A positive feedback loop between reduced reproductive success of adult females and reduced recruitment into the adult population (which reduces the number of adult females) is the kind of demographic pattern that is likely to increase the monk seal’s decline toward extinction. As a result, we assume that Hawaiian monk seals have elevated extinction probabilities because of exogenous threats caused by anthropogenic

activities (primarily whaling, entanglement, and ship strikes), natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate), and endogenous threats caused by the small size of their population.

Diving and Social Behavior

Several recent studies of the foraging patterns of Hawaiian monk seals near rookeries in the northwestern Hawaiian Islands provide insight into their diving behavior. Dive depths appear to differ slightly between rookeries as well as between age classes and genders. At Pearl and Hermes Reef, most dives were from 8-40 m with a second much smaller node at 100- 120 m (Stewart and Yochem. 2004). At Kure Atoll, most dives were shallower than 40 m, with males tending to dive deeper than females (Stewart and Yochem 2004). At Laysan Island, a similar dive pattern was recorded with most dives shallower than 40 m, but at that location females tended to dive deeper than males (250-350 m) (Stewart 2004). Parrish et al. (Parrish et al. 2002) noted a tendency towards night diving at French Frigate Shoals, with dives to ~80-90 m. Based on these data, the following are rough order estimates of time at depth: 90 percent at 0-40 m; 9 percent at 40-120 m; 1 percent at >120 m.

Vocalizations and Hearing

The information on the hearing capabilities of endangered Hawaiian monk seals is somewhat limited, but they appear to have their most sensitive hearing at 12 to 28 kHz. Below 8 kHz, their hearing is less sensitive than that of other pinnipeds. Their sensitivity to high frequency sound drops off sharply above 30 kHz (Richardson et al. 1995; Thomas et al. 1990). An underwater audiogram for Hawaiian monk seal, based on a single animal whose hearing may have been affected by disease or age, was best at 12 to 28 kHz and 60 to 70 kHz (Thomas et al. 1990). The hearing showed relatively poor hearing sensitivity, as well as a narrow range of best sensitivity and a relatively low upper frequency limit (Thomas et al. 1990).

4.3.9 Green Sea Turtle

Green turtles are the largest of all the hard-shelled sea turtles with a comparatively small head. While hatchlings are just 2 inches (50 mm) long, adults can grow to more than 3 feet (0.91 m) long and weigh 300-350 pounds (136-159 kg). Adult green turtles are unique among sea turtles in that they are herbivorous, feeding primarily on seagrasses and algae. This diet is thought to give them greenish colored fat, from which they take their name. A green turtle's carapace (top shell) is smooth and can be shades of black, gray, green, brown, and yellow. Their plastron (bottom shell) is yellowish white.

Scientists estimate green turtles reach sexual maturity anywhere between 20 and 50 years, at which time females begin returning to their natal beaches (i.e., the same beaches where they were born) every 2-4 years to lay eggs. The nesting season varies depending on location. In the southeastern U.S., females generally nest between June and September, while peak nesting occurs in June and July. During the nesting season, females nest at approximately two week intervals, laying an average of five clutches. In Florida, green turtle nests contain an average of 135 eggs, which will incubate for approximately 2 months before hatching.

Distribution

Green turtles are found in the Pacific Ocean, Atlantic Ocean, Indian Ocean, Carribean Sea, and Mediterranean Sea, primarily in tropical or, to a lesser extent, subtropical waters. These regions can be further divided into nesting

aggregations within the eastern, central, and western Pacific Ocean; the western, northern, and eastern Indian Ocean; Mediterranean Sea; and eastern, southern, and western Atlantic Ocean, including the Caribbean 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 most frequently in U.S. coastal waters with temperatures exceeding 18°C.

Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher densities of their food items associated with these oceanic phenomena. For example, in the western Atlantic Ocean, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS 1998b). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS and USFWS 1998b).

Population Structure

The population dynamics of green sea turtles and all of the other sea turtles considered 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-Bissau (Bijagos Archipelago), Iles Eparses - (Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida; NMFS and USFWS 1998c; Seminoff et al. 2002).

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

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green sea 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, green sea turtles forage coastally from San Diego Bay, California in the north to Mejillones, Chile in the South. Based on mtDNA analyses, green sea turtles found on foraging grounds

along Chile's coast originate from the Galapagos nesting beaches, while those green sea turtles 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.

Threats to the Species

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

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 (Brautigam and Eckert 2006); the turtle fishery along the Caribbean coast of Nicaragua, by itself, has captured more than 11,000 green sea turtles each year (Brautigam and Eckert 2006; Lagueux 1998b).

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

Green sea turtles are also captured and killed in commercial fisheries. Gillnets account for the highest number of green sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots,

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

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

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

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

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

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

Status

Green sea 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. 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 sea turtles appear to be stable or increasing in the Atlantic Ocean (e.g. Bujigos Archipelago (Guinea-Bissau), Ascension Island, Tortuguero (Costa Rica), Yucatan Peninsula (Mexico), and Florida), declines of over 50 percent have been documented in the eastern (Bioko Island, Equatorial Guinea) and western Atlantic (Aves Island, Venezuela). Nesting populations in Turkey (Mediterranean Sea) have declined between 42 percent and 88 percent since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50 percent have been documented at Sharma (Republic of Yemen) and Assumption and

Aldabra (Seychelles), while no changes have occurred at Karan Island (Saudi Arabia) or at Ras al Hadd (Oman). The number of females nesting annually in the Indian Ocean has increased at the Comoros Islands, Tromelin and maybe Europa Island (Iles Esparses; Seminoff 2004).

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

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

Diving and Social Behavior

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS 1998c).). The maximum recorded dive depth for an adult green turtle was 110 m (Berkson 1967) (Lutcavage and Lutz 1997), while subadults routinely dive 20 m for 9-23 min, with a maximum recorded dive of 66 min (Brill et al. 1995 in Lutcavage and Lutz 1997).

Vocalizations and Hearing

The information on green sea 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. 1999b).

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

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

4.3.10 Hawksbill Sea Turtle

The hawksbill turtle is small to medium-sized compared to other sea turtle species. Adults weigh 100-150 lbs (45 to 68 kg) on average, but can grow as large as 200 lbs (91 kg). Hatchlings weigh about 0.5 oz (14 g). The carapace (top shell) of an adult ranges from 25 to 35 inches (63 to 90 cm) in length and has a "tortoiseshell" coloring, ranging from dark to golden brown, with streaks of orange, red, and/or black. Male hawksbills mature when they are about 27 inches (69 cm) long. Females mature at about 31 inches (78 cm). The ages at which turtles reach these lengths are unknown.

The hawksbill turtle's head is elongated and tapers to a point, with a beak-like mouth that gives the species its name. The shape of the mouth allows the hawksbill turtle to reach into holes and crevices of coral reefs to find sponges, their primary food source as adults, and other invertebrates. Hawksbill turtles are unique among sea turtles in that they have two pairs of prefrontal scales on the top of the head and each of the flippers usually has two claws.

Female hawksbills return to their natal beaches every 2-3 years to nest at night approximately every 14-16 days during the nesting season. A female hawksbill generally lays 3-5 nests per season, which contain an average of 130 eggs. Hawksbill turtles usually nest high up on the beach under or in the beach/dune vegetation on both calm and turbulent beaches. They commonly nest on pocket beaches, with little or no sand.

The shells of hatchlings are 1-2 inches (about 42 mm) long and are mostly brown and somewhat heart-shaped. The plastron (bottom shell) is clear yellow. The rear edge of the carapace is almost always serrated, except in older adults, and has overlapping "scutes".

Distribution

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

In the continental U.S., hawksbill sea turtles have been reported in every state on the coast of the Gulf of Mexico and along the coast of the Atlantic Ocean from Florida to Massachusetts, except for Connecticut; however, sightings of hawksbill sea turtles north of Florida are rare. The only states where hawksbill sea turtles occur with any regularity are Florida (particularly in the Florida Keys and the reefs off Palm Beach County on Florida’s Atlantic coast, where the warm waters of the Gulf Stream pass close to shore) and Texas. In both of these states, most sightings are of post-hatchlings and juveniles that are believed to have originated from nesting beaches in Mexico.

Hawksbill sea turtles have stranded along almost the entire Atlantic coast of the United States, although most stranding records occur south of Cape Canaveral, Florida, particularly in Palm Beach, Broward and Miami-Dade counties (Florida Sea Turtle Stranding and Salvage database). During their pelagic-stage, hawksbills disperse from the Gulf of Mexico and southern Florida in the Gulfstream Current, which would carry them offshore of Georgia and the Carolinas. As evidence of this, a pelagic-stage hawksbill was captured 37 nm east of Sapelo Island, Georgia in May 1994 (Parker 2005). There are also records of hawksbill sea turtles stranding on the coast of Georgia (Odell et al. 2008), being captured in pound nets off Savannah, and being captured in summer flounder trawls (Epperly et al. 1995), gillnets (Epperly et al. 1995), and power plants off Georgia and the Carolinas. There are also records of hawksbill sea turtles being captured in pound nets off Savannah, and being captured in summer flounder trawls, gillnets, and power plants off Georgia and the Carolinas (Epperly et al. 1995).

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

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

Population Structure

Hawksbill sea turtles, like other sea turtles, are divided into regional groupings that represent major oceans or seas: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. In these regions, the population structure of hawksbill turtles is usually based on the distribution of their nesting aggregations (Table 5).

Table 5. Nesting aggregations of hawksbill sea turtles that have been identified using molecular genetics (after Albreu and LeRoux 2006 and Spotila 2004).

Ocean Basin – Nesting Aggregations	**Estimated Number of Nesting Females**
Atlantic (eastern) – Democratic Republic of Sao Tomé and Principe and Equatorial Guinea (particularly, the Island of Bioko)	**200-400**
Atlantic (western) and Caribbean – Antigua, Barbados, Belize, Brazil, Costa Rica, Cuba, Dominican Republic, Guatemala, Jamaica, Martinique, Mexico, Puerto Rico, Turks and Caicos, U.S. Virgin Islands, and Venezuela	**5,000 – 6,000**
Indian Ocean – Andaman and Nicobar Islands, Australia, British Indian Ocean Territories (Cagos Peninsula and southern Maldives), Seychelles, Burma, East Africa, Egypt, Maldives, Oman, Saudi Arabia, Seychelles, Sudan, and Yemen	**6,000 – 7,000**
Pacific Ocean – Australia (Great Barrier Reef to Arnhem Land), Indonesia, Malaysia, Palau, Papua New Guinea, Phillipines, Solomon Islands, Thailand	**10,000**

Threats to the Species

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

Three human activities are known to threaten hawkbill 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 hawkbill sea turtle populations was overharvests by humans for subsistence and commercial purposes. In the Atlantic, hawksbill sea turtles are still captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Brautigam and Eckert 2006).

For centuries, hawksbill sea turtles have been captured for their shells, which have commercial value, rather than food (the meat of hawksbill sea turtles is considered to have a bad taste and can be toxic to humans) ((NMFS and USFWS 1993; NMFS and USFWS 1998d). Until recently, tens of thousands of hawksbills were captured and killed each year to meet demand for jewelry, ornamentation, and whole stuffed turtles (Milliken and Tokunga 1987 cited in Eckert 1993). In 1988, Japan's imports from Jamaica, Haiti and Cuba represented some 13,383 hawksbills: it is extremely unlikely that this volume could have originated solely from local waters (Greenpeace 1989 cited in Eckert 1993).

Although Japan banned the importation of turtle shell in 1994, domestic harvests of eggs and turtles continue in the United States, its territories, and dependencies, particularly in the Caribbean and Pacific Island territories. Large numbers of nesting and foraging hawksbill sea turtles are captured and killed for trade in Micronesia, the Mexican Pacific coast, southeast Asia and Indonesia ((NMFS and USFWS 1993; NMFS and USFWS 1998d). In addition to the demand for the hawksbill's shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Before the U.S. certified Japan under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles.

The second most important threat to hawksbill sea turtles is the loss of nesting habitat caused by the expansion of resident human populations in coastal areas of the world and increased destruction or modification of coastal ecosystems to support tourism. Hawksbill sea turtles are also captured and killed in commercial fisheries. Along the Atlantic coast of the U.S., NMFS estimated that about 650 hawksbill sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with most of those sea turtles dying as a result of their capture. Each year, about 35 hawksbill sea turtles are captured in Atlantic pelagic longline fisheries. Although most of these turtles are released alive, these fisheries are expected to kill about 50 hawksbill sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

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

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

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

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

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

Status

Hawksbill sea turtles were listed as endangered under the ESA in 1970. Under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, hawksbill sea turtles are identified as “most endangered.”

Hawksbill sea turtles are solitary nesters, which makes it difficult to estimate the size of their populations. There are no global estimates of the number of hawksbill sea turtles, but a minimum of 15,000 to 25,000 females are thought to nest annually in more than 60 geopolitical entities (Groombridge and Luxmoore 1989). Moderate populations appear to persist around the Solomon Islands, northern Australia, Palau, Persian Gule islands, Oman, and parts of the Seychelles. In a more recent review, Groombridge and Luxmoore (1989) list Papua New Guinea, Queensland, and Western Australia as likely to host 500-1,000 nesting females per year, while Indonesia and the Seychelles may support >1,000 nesting females. The largest known nesting colony in the world is located on Milman Island, Queensland, Australia where Loop (1995) tagged 365 hawksbills nesting within an 11 week period. With the exception of Mexico, and possibly Cuba, nearly all Wider Caribbean countries are estimated to receive <100 nesting females per year.

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

Hawksbill sea turtles, like green sea turtles, are thought to be declining globally as a direct consequence of a historical combination of overexploitation and habitat loss. However, like several of the species we have already

discussed, the information available on the status and trend of hawksbill sea turtles do not allow us to make definitive statements about the global extinction risks facing these sea turtles or the risks facing particular populations (nesting aggregations) of these turtles. However, the limited data available suggests that several hawksbill sea turtles populations exist at sizes small enough to be classified as "small" populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) while others are large enough to avoid these problems. Exogenous threats such as overharvests and entanglement in fishing gear only increase their probabilities of becoming extinct in the foreseeable future.

Diving and Social Behavior

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

Vocalizations and Hearing

There is no information on hawksbill sea turtle vocalizations or hearing. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtle: their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol et al. 1999b; 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). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

4.3.11 Loggerhead Sea Turtle

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

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

Hatchlings vary from light to dark brown to dark gray dorsally and lack the reddish-brown coloration of adults and juveniles. Flippers are dark gray to brown above with white to white-gray margins. The coloration of the plastron is

generally yellowish to tan. At emergence, hatchlings average 1.8 in (45 mm) in length and weigh approximately 0.04 lbs (20 g).

Distribution

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

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

Population Structure

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

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

the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas nesting aggregation that occurs in the islands of the Dry Tortugas near Key West, Florida (NMFS 2001).

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

Threats to the Species

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

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 of native species that tolerate human presence (*e.g.*, raccoons, armadillos, and opossums) and which feed on turtle eggs.

When they are in coastal or marine waters, loggerhead turtles are affected by a completely different set of human activities that include discharges of toxic chemicals and other pollutants into the marine ecosystem; underwater explosions; hopper dredging, offshore artificial lighting; entrainment or impingement in power plants; entanglement in marine debris; ingestion of marine debris; boat collisions; poaching, and interactions with commercial fisheries. Of these, interactions with fisheries represent a primary threat because of the 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 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 capture about 2,000 loggerhead sea turtles each year, killing almost 700; the effects of capture-related stress on the current or expected future reproductive success of sea turtles remains unknown.

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

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

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

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

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

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding,

diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death.

Status

Loggerhead sea turtles are currently listed as threatened under the ESA throughout its global range. In 2010 NMFS and FWS published a proposed rule to list several distinct population segments (DPS) of loggerhead sea turtles (75 FR 12598, March 16, 2010). Two DPSs are proposed for the Pacific Ocean, three in the Indian Ocean, and four in the Atlantic Ocean/Mediterranean Sea (See Table 6.).

Table 6. Proposed Loggerhead Sea Turtle Distinct Population Segments.

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

All loggerheads inhabiting the North Pacific Ocean are derived primarily, if not entirely, from Japanese beaches (although low level nesting may occur in areas around the South China Sea). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six "submajor'' beaches (10 – 100 nests per season) were identified. Using information collected from these nine beaches (Kamezaki et al. 2003) found a substantial decline (50–90 percent) in the size of the annual loggerhead nesting population over the last half of the 20th century. Also, nest count data for the last two decades suggests that the North Pacific population is "small" and lacks a robust gene pool when compared to the larger northwest Atlantic and north Indian Ocean loggerhead populations. Small

populations are more susceptible to demographic variability which increases their probability of extinction. Available evidence indicates that due to loss of adult and juvenile mortalities from fishery bycatch and, to a lesser degree the loss of nesting habitat, the North Pacific loggerhead population is declining.

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

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

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

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

In the Southwest Indian Ocean, the highest concentration of nesting occurs on the coast of Tongaland, South Africa, where surveys and management practices were instituted in 1963 (Baldwin et al. 2003). Nesting beach data from this

region from 1965 to 2008 indicates an increasing nesting population between the first decade of surveys, which documented 500–800 nests annually, and the last 8 years, which documented 1,100–1,500 nests annually (Nel 2006). These data represent approximately 50 percent of all nesting within South Africa and are believed to be representative of trends in the region. Loggerhead nesting occurs elsewhere in South Africa and Madagascar, but sampling is not consistent and no trend data are available. This population, although small, is increasing but juvenile mortality from fishery bycatch remains a concern.

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

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

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

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

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

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

In the northeastern Atlantic, the Cape Verde Islands support the only large nesting population of loggerheads in the region (Fretey 2001). Nesting occurs at some level on most of the islands in the archipelago with the largest nesting numbers reported from Boa Vista Island where 833 and 1,917 nests were reported in 2001 and 2002, respectively, and between 1998 and 2002 the local project had tagged 2,856 females (Cruz et al. 2007). More recently, in 2005, about 3,121 females were reported (López-Jurado et al. 2003). Elsewhere in the northeastern Atlantic, loggerhead

nesting is non-existent or occurs at very low levels. Population trends could not be determined for the Cape Verde population because of limited data; however, evidence of directed killing of nesting females suggests that this nesting population is under severe pressure and likely significantly reduced from historic levels. Available evidence indicates that this population is declining due to ongoing mortality of mature females and eggs, low hatchling and emergence success and mortality of juveniles and adults from fishery bycatch.

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

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

Diving and Social Behavior

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). The maximum recorded dive depth for a post-nesting female was 211-233 m, while mean dive depths for both a post-nesting female and a subadult were 9-22 m. Routine dive times for a post-nesting female were between 15 and 30 min, and for a subadult, between 19 and 30 min (Sakamot et al. 1990 cited in Lutcavage and Lutz 1997). Two loggerheads tagged by Hawai'i-based longline observers in the North Pacific and attached with satellite-linked dive recorders were tracked for about 5 months. Analysis of the dive data indicates that most of the dives were very shallow - 70 percent of the dives were no deeper than 5 m. In addition, the loggerheads spent approximately 40 percent of their time in the top meter and nearly all of their time at depths shallower than 100 m. On 5 percent of the days, the turtles dove deeper than 100 m; the deepest daily dive recorded was 178 m (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 m. On only five percent of recorded dive days loggerheads dove to depths greater than 100 m at least once. In the areas that the loggerheads were diving, there was a shallow thermocline at 50 m. 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. (1999b) 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. 1999b). This is similar to the results produced by Ridgway et al. (1969) who studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear). They concluded that the maximum sensitivity of green sea turtles occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz.

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

4.3.12 Olive Ridley Sea Turtle

The olive ridley gets its name from the olive coloration of its heart-shaped top shell (carapace). Adult turtles are relatively small. The size and morphology of the olive ridley varies from region to region, with the largest animals being observed on the Pacific coast of Mexico. There are often only five pairs of costal "scutes" on the carapace, but that number varies. Some individuals have been documented having as many as nine pairs of costal scutes. Each of the four flippers has one or two visible claws. The carapace of eastern Pacific olive ridleys is greater in height than other populations. Western Atlantic olive ridleys usually have a darker coloration than eastern Pacific olive ridleys.

Distribution

Olive ridley turtles occur in the tropical waters of the Pacific and Indian Oceans from Micronesia, Japan, India, and Arabia south to northern Australia and southern Africa. In the Atlantic Ocean, they occur off the western coast of Africa and the coasts of northern Brazil, French Guiana, Surinam, Guyana, and Venezuela in South America, and occasionally in the Caribbean Sea as far north as Puerto Rico. In the eastern Pacific Ocean, olive ridley turtles are found from the Galapagos Islands north to California. While olive ridley turtles have a generally tropical to subtropical range, individual turtles have been reported as far as the Gulf of Alaska (Hodge and Wing 2000).

Olive ridley turtles nest along continental margins and oceanic islands. The largest nesting aggregation in the world occurs in the Indian Ocean along the northeast coast of India where more than 600,000 olive ridley turtles nested in a single week in 1991 (Mrosovsky 1993). The second most important nesting area occurs in the eastern Pacific along the west coast of Mexico and Central America. Olive ridley turtles also nest along the Atlantic coast of South America, western Africa, and the western Pacific (Groombridge 1982; Sternberg and Pritchard 1981).

In the eastern Pacific, olive ridley turtles nest along the Mexico and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. Few turtles nest as far north as southern Baja California, Mexico (Fritts et al. 1982) or as far south as Peru (Brown and Brown 1982). The post-

nesting migration routes of olive ridleys traversed thousands of kilometers of deep oceanic waters, ranging from Mexico to Peru, and more than 3,000 kilometers out into the central Pacific (Plotkin, et al. 1993). Although they are the most abundant north Pacific sea turtle, surprisingly little is known of the oceanic distribution and critical foraging areas of olive ridley turtles.

Most records of olive ridley turtles are from protected, relative shallow marine waters. Deraniyagalia (Deraniyagala 1939) described the habitat of olive ridley turtles as shallow waters between reefs and shore, larger bays, and lagoons. Nevertheless, olive ridley turtles have also been observed in the open ocean. Since, olive ridley turtles throughout the eastern Pacific Ocean depend on rich upwelling areas off South America for food, olive ridley turtles sighted offshore may have been foraging.

Population Structure

Olive ridley sea turtles exist as two separate populations: one that occurs in the western Pacific and Indian Ocean (northern Australia, Malaysia, Thailand, and the State of Orissa in India) and another than occurs along the Pacific coast of the Americas from Mexico to Columbia (Chaloupka et al. 2004).

Threats to the Species

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

In India, uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large scale mortality of adult olive ridley turtles during the last two decades. Since 1993, more than 50,000 olive ridleys have stranded along the coast, at least partially because of near-shore shrimp fishing (Shanker and Mohanty 1999). Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. However, mortality due to shrimp trawling reached a record high of 13,575 ridleys during the 1997-1998 season and none of the approximately 3,000 trawlers operating off the Orissa coast use turtle excluder devices in their nets despite mandatory requirements passed in 1997 (Pandav and Choudhury 1999).

Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (NMFS and USFWS 1998f). However, human-induced mortality caused this population to decline. From the 1960s to the 1970s, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan (NMFS and USFWS 1998f). Although olive ridley meat is palatable, it was not widely sought after; its eggs, however, are considered a delicacy. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo 1982).

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, has improved the situation for the olive ridley. Surveys of important olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Arenas et al. 2000; Marquez-M. et al. 1996). Annual nesting at the principal beach,

Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests. At a smaller olive ridley nesting beach in central Mexico, Playon de Mismalayo, nest and egg protection efforts have resulted in more hatchlings, but the population is still seriously decremented and is threatened with extinction (Silva-Batiz et al. 1996). Nevertheless some authors have suggested that olive ridley turtles in Mexico should be considered recovered (Arenas et al. 2000).

The main threats to turtles in Thailand include egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e. carapace), indirect capture in fishing gear, and loss of nesting beaches through development (Aureggi et al. 1999; Aureggi et al. 2005). During the 1996-97 survey, only six olive ridley nests were recorded, and of these, half were poached, and one was predated by feral dogs. During the 1997-98 survey, only three nests were recorded.

Olive ridley nests in Indonesia are subject to extensive hunting and egg collection. In combination with rapid rural and urban development, these activities have reduced the size of the nesting population in the region as well as their nesting success.

Status

Olive ridley turtle populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened. The International Union for Conservation of Nature and Natural Resources has classified the Kemp's ridley turtle as "endangered" (IUCN Red List, 2000).

Where population densities are high enough, nesting takes place in synchronized aggregations known as arribadas. The largest known arribadas in the eastern Pacific are off the coast of Costa Rica (~475,000 - 650,000 females estimated nesting annually) and in southern Mexico (~800,000 nests per year at La Escobilla, in Oaxaca, Mexico (Millá án, 2000)). In Costa Rica, 25,000 to 50,000 olive ridleys nest at Playa Nancite and 450,000 to 600,000 turtles nest at Playa Ostional each year (NMFS and USFWS 1998d). In an 11-year review of the nesting at Playa Ostional, (Ballestero, et al., 2000) report that the data on numbers of nests deposited is too limited for a statistically valid determination of a trend; although the number of nesting turtles has appeared to decline over a six-year period.

At a nesting site in Costa Rica, an estimated 0.2 percent of 11.5 million eggs laid during a single arribada produced hatchlings (in NMFS and USFWS 1998d). In addition, some female olive ridleys nesting in Costa Rica have been found to be afflicted with the fibropapilloma disease (Aguirre, et al. 1999). At Playa La Flor, the second most important nesting beach for olive ridleys on Nicaragua, Ruiz (1994) documented 6 arribadas (defined as 50 or more females resting simultaneously). The main egg predators were domestic dogs and vultures (Coragyps atratus and Cathartes aura).

In the western Pacific, information on the size of olive ridley nesting aggregations are limited although they do not appear to be recovering (with the exception of the nesting aggregation at Orissa, India). There are a few sightings of olive ridleys from Japan, but no report of egg-laying. Similarly, there are no nesting records from China, Korea, the Philippines, Taiwan, Viet Nam, or Kampuchea and nesting records in Indonesia are not sufficient to assess population trends (Eckert 1993, Suwelo 1999). In Thailand, olive ridleys occur along the southwest coast, on the

Surin and Similan islands, and in the Andaman Sea. On Phra Thong Island, on the west coast of Thailand, the number of nesting turtles declined markedly between 1979 and 1990.

Olive ridley turtles have been observed in Indonesia and surrounding waters, and some olive ridley turtles have been documented as nesting in this region recently. On Jamursba-Medi beach, on the northern coast of Irian Jaya, 77 olive ridley nests were documented from May to October, 1999 (Teguh 2000 in Putrawidjaja 2000).

Olive ridleys nest on the eastern and western coasts of peninsular Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 eggs (2,400 nests, with approximately 100 eggs per nest; see Siow and Moll 1982, in Eckert 1993), while only 187 nests were reported from the area in 1990 (Eckert 1993). In eastern Malaysia, olive ridleys nest very rarely in Sabah and only a few records are available from Sarak (in Eckert 1993).

Olive ridleys are the most common species found along the east coast of India, migrating every winter to nest en-masse at three major rookeries in the state of Orissa, Gahirmatha, Robert Island, and Rushikulya (Pandav and Choudhury 1999). According to Pandav and Choudhury (Pandav and Choudhury 1999), the number of nesting females at Gahirmatha has declined in recent years, although after three years of low nestings, the 1998-1999 season showed an increasing trend (Noronha Environmental News Service, April 14, 1999), and the 1999-2000 season had the largest recorded number of olive ridleys nesting in 15 years (The Hindu, March 27, 2000; The Times of India, November 15, 2000). During the 1996-1997 and 1997-98 seasons, there were no mass nestings of olive ridleys. During the 1998-1999 nesting season, around 230,000 females nested during the first arribada, lasting approximately a week (Pandav and Kar 2000); unfortunately, 80 percent of the eggs were lost due to inundation and erosion (Shanker and Mohanty 1999). During 1999-2000, over 700,000 olive ridleys nested at Nasi Island and Babubali Island, in the Gahirmatha coast.

Diving Behavior

Although olive ridley turtles are probably surface feeders, they have been caught in trawls at depths of 80-110 m (NMFS and USFWS 1998), and a post-nesting female reportedly dove to a maximum depth of 290 m. The average dive length for an adult female and adult male is reported to be 54.3 and 28.5 min, respectively (Lutcavage and Lutz 1997).

Vocalizations and Hearing

There is no information on olive ridley sea turtle vocalizations or hearing. However, we assume that their hearing sensitivities will be similar to those of green, hawksbill, 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. 1999a) (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 (Patterson 1966).

4.3.13 Leatherback Sea Turtle

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

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

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

Distribution

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

Leatherback sea turtles have been documented in Alaska waters as far north as approximately 60º latitude (approximately 50 miles north of the northern edge of the TMAA) and as far west in the Gulf of Alaska as the Aleutian Islands (Eckert 1993). In contrast with other sea turtles, leatherback sea turtles have physiological traits that allow for the conservation of body heat which enable them to maintain body core temperatures well above the ambient water temperatures (Eckert 1993; Greer et al. 1973; Pritchard 1971). Shells, or carapaces, of adult leatherbacks are 4 cm (1.5 inches) thick on average, contributing to the leatherback's thermal tolerance that enables this species to forage in water temperatures far lower than the leatherback's core body temperature (Bostrom et al.

2010). In an analysis of available sightings (Eckert 2002), researchers found that leatherback turtles with carapace lengths smaller than 100 cm (39 inches) were sighted only in waters 79 ºF or warmer, while adults were found in waters as cold as 32ºF to 59ºF off Newfoundland (Goff and Lien 1988). As a result, they are more capable of surviving for extended periods of time in cooler waters than the hard-shelled sea turtles (Bleakney 1965; Lazell Jr. 1980).

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.

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.

Anthropomorphic 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.

The foremost threat is the number of leatherback turtles killed or injured in fisheries. Spotila (2004) concluded that a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s is 1,500 animals. He estimates that this represented about a 23 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related.

Leatherback sea turtles are exposed to commercial fisheries in many areas of the Atlantic Ocean. For example, leatherback entanglements in fishing gear are common in Canadian waters where Goff and Lien (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. 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 combine to kill about 300 leatherback sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

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

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

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

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

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

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

Status and Trends

The leatherback turtle was listed under the Endangered Species Act as endangered throughout its range in 1970. There is a recovery plan for this species (NMFS and USFWS 1998a).

Leatherback turtles are considered critically endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2010) and are protected by the Convention on International Trade in Endangered Species (CITES).

The Pacific Ocean leatherback population is generally smaller in size than that in the Atlantic Ocean. Because adult female leatherbacks frequently nest on different beaches, nesting population estimates and trends are especially difficult to monitor. In the Pacific, the IUCN notes that most leatherback nesting populations have declined more than 80 percent. In other areas of the leatherback's range, observed declines in nesting populations are not as severe, and some population trends are increasing or stable. In the Atlantic, available information indicates that the largest leatherback nesting population occurs in French Guyana, but the trends are unclear. Some Caribbean nesting populations appear to be increasing, but these populations are very small when compared to those that nested in the Pacific less than 10 years ago. Nesting trends on U.S. beaches have been increasing in recent years.

Diving

The leatherback sea turtle is one of the deepest divers in the ocean, with dives as deep as 3,937 ft (1,200 m), although it spends most of its time feeding at a depth of less than 328 ft (100 m). Leatherback turtles primarily feed on gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas) (Bjorndal 1997; NMFS and USFWS 1998a). The leatherback dives continually and spends short periods of time on the surface between dives (Eckert et al. 1989; Southwood et al. 1999). Typical dive durations averaged 6.9 to 14.5 min (min) per dive, with a maximum of 42 min (Eckert et al. 1996). Sea turtles typically remain submerged for several min to several hours depending upon their activity state (Standora et al. 1984). Long periods of submergence hamper detection and confound census efforts. During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 15 ft (5 m) of the surface (Eckert 2002).

Social Behavior

Male leatherbacks do not return to land after they hatch from their nests whereas mature females return to land only to lay eggs (Spotila 2004). Aside from this brief terrestrial period, which lasts approximately three months during egg incubation and hatching, leatherback turtles are rarely encountered out of the water. Hatchling leatherbacks are pelagic, but nothing is known about their distribution during the first 4 years of life (Musick and Limpus 1997).

The Pacific coast of Mexico is generally regarded as the most important leatherback breeding ground in the world, although nesting on Pacific beaches under U.S. jurisdiction has always been rare (NMFS and USFWS 1998a). Based on a single aerial survey in 1980 of Michoacán, Guerrero, and Oaxaca, and on published and anecdotal data, Pritchard (Pritchard 1982) estimated that 30,000 females nested annually in these three Mexican states. Lower-density nesting was (and still is) reported farther north in Jalisco (NMFS and USFWS 1998a) and in Baja California, where the northernmost eastern Pacific nesting sites are found (Fritts et al. 1982). Leatherbacks nest along the western coast of Mexico from November to February, although some females arrive as early as August (NMFS and USFWS 1998a), and in Central America from October to February (Lux et al. 2003). This species nests primarily on beaches with little reef or rock offshore. On these types of beaches erosion reduces the probability of nest survival. To compensate, leatherbacks scatter their nests over large geographic areas and lay on average two times as many clutches as other species (Eckert 1987). Females may lay up to nine clutches in a season (although six is more common), and the incubation period is 58–65 days. At Playa Grande, Costa Rica, and in French Guiana, the mean inter-nesting period was 9 days (Lux et al. 2003). Post-nesting adults appear to migrate along bathymetric contours from 656 to 11,483 ft (200 to 3,500 m) (Morreale et al. 1994), and most of the eastern Pacific nesting stocks migrate south (NMFS and USFWS 1998a). Other principal nesting sites in the Pacific Ocean indicate that gene flow between eastern and western Pacific nesting populations is restricted (Dutton et al. 2005; Dutton et al. 2006; Dutton et al. 1999; Dutton et al. 1996; Dutton et al. 2003).

Vocalization and Hearing in Sea Turtles

Sea turtles do not have an external ear pinnae or eardrum. Instead, they have a cutaneous layer and underlying subcutaneous fatty layer that function as a tympanic membrane. The subcutaneous fatty layer receives and transmits sounds to the middle ear and into the cavity of the inner ear (Ridgway et al. 1969). Sound also arrives by bone conduction through the skull. Sound arriving at the inner ear via the columella (homologous to the mammalian stapes or stirrup) is transduced by the bones of the middle ear.

Sea turtle auditory sensitivity is not well studied, though a few preliminary investigations suggest that it is limited to low frequency bandwidths, such as the sounds of waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. It has been suggested that sea turtles may use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al. 1983).

Lenhardt et al. (1983) applied audio frequency vibrations at 250 hertz (Hz) and 500 Hz to the heads of loggerheads and Kemp's ridleys submerged in salt water to observe their behavior, measure the attenuation of the vibrations, and assess any neural-evoked response. These stimuli (250 Hz, 500 Hz) were chosen as representative of the lowest sensitivity area of marine turtle hearing (Wever and Vernon 1956). At the maximum upper limit of the vibratory delivery system, the sea turtles exhibited abrupt movements, slight retraction of the head, and extension of the limbs in the process of swimming. Lenhardt et al. (1983) concluded that bone-conducted hearing appears to be a reception

mechanism for at least some of the sea turtle species, with the skull and shell acting as receiving surfaces. Finally, sensitivity even within the optimal hearing range was low as threshold detection levels in water are relatively high at 160 to 200 decibels referenced to one micro Pascal at a distance of one meter (dB re 1 μPa-m), which is the standard reference measure for underwater sound energy in this regard)(Lenhardt et al. 1994).

Ridgway et al. (1969) used aerial and mechanical stimulation to measure the cochlea in three specimens of green turtle, and concluded that they have a useful hearing span of perhaps 60 to 1,000 Hz, but hear best from about 200 Hz up to 700 Hz, with their sensitivity falling off considerably below 200 Hz. The maximum sensitivity for one animal was at 300 Hz, and for another was at 400 Hz. At the 400 Hz frequency, the green turtle's hearing threshold was about 64 dB in air (approximately 126 dB in water). At 70 Hz, it was about 70 dB in air (approximately 132 dB in water). We may be able to extrapolate this data to pertain to all hard-shell sea turtles (i.e., the olive ridley, green, loggerhead, and Kemp's ridley turtles). No audiometric data are available for the leatherback turtle, but based on other sea turtle hearing capabilities, they probably also hear best in the low frequencies.

For exposures to impulsive sound, a recent study on the effects of air guns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds (McCauley et al. 2000). Loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km, with received levels of 166 dB re 1 μPa-m and 175 dB re 1 μPa, respectively (McCauley et al. 2000). The sea turtles' response was consistent: above a level of about 166 dB re 1 μPa, the sea turtles noticeably increased their swimming activity. Above 175 dB re 1 μPa, their behavior became more erratic, possibly indicating that they were agitated (McCauley et al. 2000).

Currently it is believed that the range of maximum sensitivity for sea turtles is 200 to 800 Hz, with an upper limit of about 2,000 Hz (Lenhardt 1994; Moein et al. 1994). Green turtles are most sensitive to sounds between 200 and 700 Hz, with peak sensitivity at 300 to 400 Hz (Ridgway et al. 1969). They possess an overall hearing range of approximately 60 to 1,000 Hz (Ridgway et al. 1969). Juvenile loggerhead turtles hear sounds between 250 and 1,000 Hz and, therefore, often avoid low-frequency sounds (Bartol et al. 1999a). Finally, sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB re 1 μPa-m (Lenhardt 1994). Given the lack of audiometric information for leatherback turtles, the potential for TTS among leatherback turtles must be classified as unknown but would likely follow those of other sea turtles. In terms of sound emission, nesting leatherback turtles produce sounds in the 300 to 500 Hz range (Mrosovsky 1972).

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR §402.02). The environmental baseline for this Opinion includes the effects of a wide variety of natural phenomena and human activities in the action area.

5.1 Natural Phenomena

The natural phenomena include changes in oceanic temperature regimes and ambient noises in the ocean environment which vary both in location and season. The North Pacific Ocean is dominated in the winter by an atmospheric phenomenon called the Aleutian Low. The Aleutian Low is a semi-permanent low pressure area that develops late in the year, dominates the winter, and begins to break down during the spring to be replaced by an extensive high pressure system during the summer (Beamish 1993). It can produce changes in atmospheric temperature, storm tracks, ice cover, and wind direction in the Bering Sea, Aleutian Islands and Gulf of Alaska (Wyllie-Echeverria and Wooster 1998). Short-term El Niño Southern Oscillation events intensify the Aleutian Low Pressure cell, which enhances wind forcing and precipitation in the North Pacific. This increases the advection of warm water into the northern region of the North Pacific Ocean, which in turn raises sea surface temperatures in the portions of the Bering Sea, Aleutian Islands, and Gulf of Alaska and can trigger a series of oceanographic events that increase ocean productivity. These events cause the marine ecosystems of the portions of the North Pacific Ocean to oscillate between "warm" climatic regimes and "cold" climatic regimes.

5.1.1 Ambient Noise

Ambient noise levels are higher in the northern hemisphere, where sources of anthropogenic sounds are more pervasive. However, even in relatively quiet regions in the southern hemisphere, ambient noise levels will commonly vary by 20 dB and will vary by 30 dB with lower frequency because of biological sources and sea surface noise (Cato and McCauley. 2001). There are numerous ambient sources of noise that have frequencies that are comparable to SURTASS LFA sonar:

- *Wind and waves* are common and interrelated sources of ambient noise in all of the world's oceans. All other factors being equal, ambient noise levels tend to increase with increasing wind speed and wave height (Richardson et al. 1995). Noise generated by surface wave activity and biological sounds is the primary contributor over the frequency range from 300 Hz to 5 kHz. The wind-generated noise level decreases smoothly with increasing acoustic frequency (i.e., there are no spikes at any given frequency).
- *Precipitation.* At some frequencies, rain and hail will increase ambient noise levels. Significant noise is produced by rain squalls over a range of frequencies from 500 Hz to 15 kHz. Large storms with heavy precipitation can generate noise at frequencies as low as 100 Hz and significantly affect ambient noise levels at a considerable distance from a storm's center. Lightning strikes associated with storms are loud, explosive events that deliver an average of 100 kilojoules per meter (kJ/m) of energy (Considine 1995). Hill (1985) estimated the source level for cloud-to-water pulse to be 260.5 dB. It has been estimated that over the earth's oceans the frequency of lightning averages about 10 flashes per second, or 314 million strikes per year (Kraght 1995).
- *Seismic Phenomena*. In the Pacific Ocean, about 10,000 natural, seismic phenomena like earthquakes, underwater volcanic eruptions, and landslides occur each year (Fox et al. 2001). These phenomena produce sounds with source levels exceeding 210 dB.
- *Biological noises* are sounds created by animals in the sea and may contribute significantly to ambient noise in many areas of the oceans (Curtis et al. 1999). Because of the habits, distribution, and acoustic characteristics of these sound producers, certain areas of the oceans are louder than others. Only three groups of marine animals are known to make sounds: crustaceans (such as snapping shrimp), true fish, and marine mammals (Urick 1983). The most widespread, broadband

noises from animal sources (in shallow water) are those produced by croakers (representative of a variety of fish classified as drumfish) (100 Hz to 10 kHz) and snapping shrimp (500 Hz to 20 kHz). Sound-producing fishes and crustaceans are restricted almost entirely to bays, reefs, and other coastal waters, although there are some pelagic, sound-producing fish. In oceanic waters, whales and other marine mammals are principal contributors to biological noise. For example, dolphins produce whistles associated with certain behaviors, and the baleen whales are noted for their low frequency vocalizations.

5.1.2 Natural Mortality

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

Sea turtles are also affected by disease and environmental factors. Turtles can be injured by predators such as birds, fish, and sharks (George 1997). Hypothermic or cold stunning occurs when a turtle is exposed to cold water for a period of time. Cold stunned turtles often have decreased salt gland function which may lead to plasma electrolyte imbalance and a lowered immune response (George 1997).

Steller sea lions shift diet composition in response to changes in prey availability of pollock (*Theragra chalcogramma*), hake (*Merluccius productus*), herring (*Clupea pallasi*) and salmon (*Oncorhynchus spp*.) (Sigler et al. 2009).

5.2 Human Activities

Human activities that have occurred and may continue in the action area include whaling, anthropogenic noise, shipping, seismic surveys for oil and gas development, Navy research and training, fisheries, scientific research, and commercial and private marine mammal watching. Each of these activities is discussed further below.

5.2.1 Whaling

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 IWC's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the Endangered Species Act of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were captured and killed in the Pacific Ocean with an unknown number of additional animals captured and killed before 1900 (Perry et al. 1999a). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada. 1972); 46,000 fin whales between 1947-1987 (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).

5.2.2 Anthropogenic Noise

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). 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; NRC 2000; NRC 2003; NRC 2005; Richardson et al. 1995). As discussed in the preceding section, 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) 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.

5.2.3 Surface Shipping

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 (Navy 2001a). 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 21st century. The National Research Council (NRC 2003) 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.

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. The number of observed physical

injuries to humpback whales as a result of ship collisions has increased in Hawaiian waters (Glockner-Ferrari et al. 1987). On the Pacific coast, a humpback whale is probably killed about every other year by ship strikes (Barlow *et al*. 1997). From 1996-2002, eight humpback whales were reported struck by vessels in Alaskan waters. In 1996, a humpback whale calf was found stranded on Oahu with evidence of vessel collision (propeller cuts; NMFS unpublished data). From 1994 to 1998, two fin whales were presumed to have been killed in 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. Based on the data available from Douglas et al. (2008), Jensen and Silber (2004), and Laist et al. (2001), there have been at least 25 incidents in which marine mammals are known to have been struck by ships in the Puget Sound region and southwestern British Columbia. The marine mammals that were involved in almost half of these incidents died as a result of the strike and they suffered serious injuries in four of those strikes.

Fin whales were struck most frequently, accounting for almost 30 percent of the total number of incidents and two-thirds of the incidents in which the whale died as a result of the collision. Northern resident killer whales were struck slightly less frequently, although a cluster of ship strikes in 2006 accounted for four of the six ship strikes involving this population of killer whales. Humpback whales were third in frequency, followed by southern resident killer whales, offshore killer whales, and blue whales. About two-thirds (17 out of the 25) of the incidents occurred in waters off British Columbia, although the locations were variable.

Historical records suggest that ship strikes fatal to whales first occurred late in the 1800s as ships began to reach speeds of 13-15 kn, remained infrequent until about 1950, and then increased during the 1950s-1970s as the number and speed of ships increased. Of 11 species known to be hit by ships, fin whales are struck most frequently; right whales, humpback whales, sperm whales, and gray whales are hit commonly (Laist et al. 2001; Vanderlaan and Taggart 2007). In some areas, one-third of all fin whale and right whale strandings appear to involve ship strikes (Laist et al. 2001). All sizes and types of vessels can hit whales; most lethal or severe injuries are caused by ships 80 m or longer; whales usually are not seen beforehand or are seen too late to be avoided; and most lethal or severe injuries involve ships travelling 14 kn or faster (Laist et al. 2001) . Ship strikes can significantly affect small populations of whales, such as northern right whales in the western North Atlantic. In areas where special caution is needed to avoid such events, measures to reduce the vessel speed below 14 kn may be beneficial (Laist et al. 2001).

5.2.4 Siesmic Surveys

Seismic survey airguns have source levels reaching and exceeding 250 dB (Richardson et al. 1995b), with a “shot” every 15 seconds, or 240 shots per hour, 24 hours per day. Even though each airgun shot of a few milliseconds may contains less acoustic energy than a single, 60-second SURTASS LFA sonar ping, annually seismic surveys put much more energy into the water than SURTASS LFA sonar transmissions. Seismic airguns operate 24 hours a day and seven days a week until the surveys are complete. For example, a seismic survey vessel normally works for at least two weeks straight, producing almost 81,000 shots.

5.2.5 Navy Research, Development, and Training

Since 1971 the U.S. Navy has conducted the biennial Rim of the Pacific exercises. These exercises, which historically have lasted for about a month, have involved forces from various nations on the Pacific Rim including

Australia, Canada, Chile, Japan, and the Republic of Korea. We have limited information on the particular components of those exercises since their inception, but we assume that most of those exercises involved many of the components that are part of contemporary Rim of the Pacific Exercises, although sonar systems and ordnance have evolved and changed over time.

We have limited information on the timing and nature of Rim of the Pacific Exercises prior to 2002 and we have no information on the potential effects on endangered and threatened marine animals in the Hawai'i Range Complex prior to 2006, when we started to consult with the U.S. Navy on the exercises. Between June and July 2006, the U.S. Navy conducted Rim of the Pacific exercises in the Hawai'i Range Complex. Based on the U.S. Navy's 7 December 2006 After-Action Report, over the 15 calendar days of the 2006 RIMPAC (U.S. Navy 2006c), hull-mounted mid-frequency sonars were employed for a total of 472 hours (with 8 hours of transmission lost to comply with shut-down protocols required by a Marine Mammal Protection Act permit). Over the 15 calendar day of the 2006 RIMPAC, active and passive sonobuoys were deployed for 115 hours (which does not translate to 115 hours of sonar transmissions because some of the sonobuoys were deployed but were not transmitting).

U.S. Navy watchstanders reported marine mammals on 29 occasions (with the exception of two reports of pilot whales, marine mammals were not identified to species). On 12 of those 29 occasions, for a total of 8 hours, mid-frequency sonar associated with the exercise was shut down to avoid exposing marine mammals that had been observed. On 2 other occasions, marine mammals were observed more than 1,000 yards from a vessel while mid-frequency sonar was active.

The After Action Report for the 2006 RIMPAC concluded that (a) there was no evidence of any behavioral effects on marine mammals throughout the exercise; and (b) there were no reported standing events or observations of behavioral disturbance of marine mammals linked to sonar use during the exercise. The observations contained in the report (1) do not identify or estimate the number of endangered or threatened species that might have been exposed to mid-frequency active sonar during the exercise, (2) did not allow the U.S. Navy to evaluate the efficacy of the mitigation measures the U.S. Navy had implemented during the exercises (that is, those measures the Navy had proposed to implement on their own as well as the additional measures they implemented to comply with the MMPA permit), and (3) did not allow the U.S. Navy to evaluate the efficacy of the monitoring program associated with the exercises.

Between June and July 2008, the U.S. Navy conducted another Rim of the Pacific exercise in the Hawai'i Range Complex, with the at-sea portions that involved mid-frequency active sonar occurring between 7 and 31 July 2008. Based on the U.S. Navy's 30 November 2008 After-Action Report, over the 25 calendar days of the 2008 RIMPAC (U.S. Navy 2008d), mid-frequency active sonars from hull-mounted (surface vessels), dipping, and DICASS sonobuoys were employed for a total of 547 hours. Of this total, active sonar was employed between the shoreline and the 200-meter bathymetric contour for about 6 hours.

Participants in the 2008 RIMPAC exercises reported 29 sightings of marine mammal groups totaling about 200 animals; dolphins represented 21 or 72 percent of these sightings (125 of the individuals). Six whale groups were sighted during the exercise, all in waters more than 100 nm west of the Island of Hawai'i. An aerial survey over a portion of the area in which the 2008 RIMPAC exercises occurred reported 24 sightings of marine mammal groups

involving eight species of small odonotocetes, Hawaiian monk seals, or unidentified dolphins (or sea turtles). A shipboard survey that also occurred in a portion of the area in which the 2008 RIMPAC exercises occurred reported 9 sightings of marine mammal groups consisting of either bottlenose dolphins, rough-toothed dolphins, or Hawaiian spinner dolphins. None of the observers reported unusual behavior or adverse behavioral responses to active sonar exposures or vessel traffic associated with the exercises.

The U.S. Navy has also conducted Undersea Warfare Exercises in the Hawai'i Range Complex for several years, but the components (number of vessels involved, a amount of active sonar produced, etc.) of these exercises can vary widely. For example, an Undersea Warfare Exercise conducted in the Hawai'i Range Complex from 13 to 15 November 2007, involved two ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 77 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys) (Navy 2008c). An Undersea Warfare Exercise conducted in the Hawai'i Range Complex from 25 to 27 March 2008, involved four ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 169 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys) (Navy 2008d). An Undersea Warfare Exercise conducted in the Hawai'i Range Complex from 27 to 31 May 2008, involved four ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 204 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys) (Navy 2008a; Navy 2008d).

Monitoring surveys associated with the November 2007 Undersea Warfare Exercises reported 26 sightings of five species during exercise, including green sea turtles and Hawaiian monk seals. None of the marine animals observed from survey vessels or aircraft were reported to have exhibited unusual behavior or changes in behavior during the surveys. Monitoring surveys associated with the March 2008 Undersea Warfare Exercises reported 47 sightings of five species during exercise, including humpback whales (40 sightings of 68 individuals) and an unidentified sea turtle. None of the marine animals observed from survey vessels or aircraft were reported to have exhibited unusual behavior or changes in behavior during the surveys.

5.2.6 Fisheries

Foreign high-seas driftnet fishing in the North Pacific Ocean for squid, tuna and billfish ended with a United Nations moratorium in December, 1992. Except for observer data collected in 1990-1991, there is virtually no information on the incidental take of threatened and endangered species by the driftnet fisheries prior to the moratorium. The high seas squid driftnet fishery in the North Pacific was observed in Japan, Korea, and Taiwan, while the large-mesh fisheries targeting tuna and billfish were observed in the Japanese fleet (1990-91) and the Taiwanese fleet (1990). A combination of observer data and fleet effort statistics indicate that 4,373 turtles, mostly loggerheads and leatherbacks, were entangled by the combined fleets of Japan, Korea and Taiwan during June, 1990 through May, 1991, when all fleets were monitored. Of these incidental entanglements, an estimated 1,011 turtles were killed (77 percent survival rate).

Numerous longline fisheries occur in the Pacific Ocean. These fisheries have had significant impacts on threatened and endangered species. One of these, the Japanese tuna longliners in the Western Pacific Ocean and South China Sea has been estimated to capture 21,200 sea turtles, including green, leatherback turtle, loggerhead, olive ridley and hawksbill sea turtles each year. These interactions kill about 12,300 of these sea turtles each year.

Other fisheries include coastal fisheries off Japan, coastal setnet and gillnet fisheries off Taiwan, foreign and U.S. purse seine fisheries for tuna in the eastern tropical Pacific Ocean, and multi-gear fisheries in the North Pacific Ocean (Bering Sea, Aleutian Islands, and Gulf of Alaska). Several of these fisheries have been implicated in the declining trend of several threatened and endangered species.

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale species and sea turtles. For example, in 1978, Nishimura and Nakahigashi (1990) estimated that 21,200 turtles, including greens, leatherback turtles, loggerheads, olive ridleys and hawksbills, were captured annually by Japanese tuna longliners in the Western Pacific and South China Sea, with a reported mortality of approximately 12,300 turtles per year. Using commercial tuna longline logbooks, research vessel data and questionnaires, Nishimura and Nakahigashi (1990) estimated that for every 10,000 hooks in the Western Pacific and South China Sea, one turtle is captured, with a mortality rate of 42 percent.

NMFS has observed 3,251 sets, representing approximately 3,874,635 hooks (data from February 1994 through December 31, 1999). The observed entanglement rate for sperm whales would equal about 0.31 whales per 1,000 sets or 0.0002 per 1,000 hooks. At those rates, we would expect about 200 sperm whales entanglements per 1,000 sets. However, only one sperm whale has been entangled in this gear; as a result, NMFS believes that the estimated entanglement rate substantially overestimates a sperm whale's actual probability of becoming entangled in this gear and the potential hazards longline gear poses to sperm whales.

5.2.7 Commercial and Private Marine Mammal Watching

In addition to being exposed to commercial vessel traffic, fishing vessels, and fishing gear, the endangered whales being considered in this Biological Opinion are also exposed to private and commercial vessels engaged in marine mammal watching (within the Action Area and elsewhere within their range in the Pacific Ocean). Recent studies of whale watching activities worldwide have found that the business of viewing whales and dolphins in their natural habitat has grown rapidly over the past decade into a 21 billion dollar ($US) industry involving over 119 countries and territories and over 13 million participants (Hoyt 2001; O'Connor et al. 2009).

In 1988, a workshop sponsored by the Center for Marine Conservation and NOAA-Fisheries 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 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 closer than 100 yards (91.4 m) in Hawaii and Alaska waters. 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 min; (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 has several potential negative consequences for endangered whales and other marine mammals. 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 marine mammals may abandon waters that are important to their ecology if levels of disturbance associated with whale watching and research become too high. In the Notice of Availability of Revised Whale Watch Guidelines for Vessel Operations in the Northeastern United States (64 FR 29270; June 1, 1999), NMFS noted that whale watch vessel operators seek out areas where whales concentrate, which has led to numbers of vessels congregating around groups of whales that are foraging, rearing newborn calves, or engaged in courtship behavior.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Watkins 1986a; 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.

5.2.8 Scientific Research

Marine mammals have been the subject of field studies for decades. The primary objective of most of these studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits for various non-lethal forms of "take" of marine mammals in the proposed action area from a variety of activities, including aerial and vessel surveys, photo-identification, remote biopsy sampling, and attachment of scientific instruments.

For example, existing permits authorized activities in 2012 allow investigators to harass, pursue, shoot, and wound about 675 endangered North Pacific right whales each year for photo-identification and behavioral observation; harass, pursue, and shoot up to 60 of these right whales per year to place tags; harass, pursue, shoot, and wound 108 animals to take biopsy samples. Since the right whale population in the North Pacific has been estimated to consist of between 29 and 100 individuals (fewer than 30 individual whales have been identified since the 1950s), existing permits allow investigators to harass each of these endangered whales several times for different research purposes.

Existing permits (activites anticipated in 2012) authorize investigators to make close approaches of other endangered whales species for photographic identification, behavioral observations, passive acoustic recording, aerial photogrammetry, and underwater observation. Existing permits authorize approximately 16,100 close

approaches of blue whales, 22,000 close approaches of fin whales, 41,000 close approaches of humpback whales, 675 close approaches of north Pacific right whales, 3,900 close approaches of sei whales, and 17,500 close approaches of sperm whales per year in the Pacific Ocean for these purposes. In addition, existing permits authorize close approaches to take biopsy samples of 2,570 blue whales, 4,565 fin whales, 5,790 humpback whales, 108 North Pacific right whales, 592 sei whales, and 3,050 sperm whales per year in the Pacific Ocean.

In practice, the actual number of close approaches does not appear to have closely approximated the number of close approaches authorized by existing permits. Nevertheless, because existing permits authorize the number of close approaches, nothing prevents the different whale species from being exposed to those levels of close approaches by investigators each year.

After decades of this research, the cumulative impact of current research on the population ecology of endangered whales remains unknown (Moore et al. 2003). This is particularly problematic because so much research occurs in areas that are critical to the population ecology of whales, such as the calving areas in Hawaii and feeding areas in Alaska. Events or activities that disrupt the behavior of animals in these critical areas could have substantial, long-term consequences for their ecology.

The Impact of the Whale Watching and Research on Listed Resources

The primary lines of evidence that might suggest that existing levels of whale watching and close approaches for field investigations would not be expected to have adverse consequence for individual whales or populations of those whales consist of the trend of the whale populations and a few published papers. Specifically, several investigators offer the increasing trend of the whale populations, particularly populations of humpback whales, to conclude that current levels of research have not had adverse consequence.

This evidence is not compelling for several reasons. First, the trend of these whale populations remains uncertain (one of the objectives of the proposed investigations is to collect the data necessary to provide a basin-wide estimate of humpback whale populations) and changes in those trends may reflect improvements in sampling techniques or changes in their geographic distribution. Second, if we allow that whale abundance for some populations are increasing, those populations might recover at a faster rate without the chronic effects of human disturbance. Finally, the activities in question would have primarily sub-lethal consequences on individual whales (that is, they would affect their growth, health, or reproductive success) whose consequences on whale populations would be delayed in time and would be concealed by any imprecision in population estimates.

The second line of evidence consists of reports from investigators and published literature that suggests that the response of whales to research were short-lived, which we interpret to mean that the responses would not be expected to affect the fitness of individual whales. Annual reports from the North Gulf Oceanic Society and two other investigators reported that most whales did not react to approaches by their vessels or only small numbers of whales reacted. For example, in their 1999 report on their research activities, the North Gulf Oceanic Society noted that they observed signs that whales were “disturbed” in only 3 out of 51 encounters with whales and that the whales’ behavioral responses consisted of breaching, slapping tail and pectoral fin, and diving away from research vessel.

Gauthier and Sears (1999), Weinrich et al. (1992), Clapham and Mattila (1993), Clapham et al. (1993) concluded that close approaches for biopsy samples or tagging did cause 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.

Several lines of evidence suggest that the consequences of these human activities might be greater than we expect for individual whales, if not for whale populations. First, it is important to note that Clapham and Matilla (1993) noted that any human observations of a whale's behavioral response may not reflect a whale's actual experience, so our use of behavioral observations as indicators of a whale's response to research may or may not be correct. The whales in the action area may have habituated to being closely approached by researchers and whale watch vessels, which would suggest that the whales would not perceive these close approaches as potential threats and, therefore, would not respond behaviorally to close approaches or experience stress responses (Fowler 1999; Romero and Wikelski 2002).

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 m away characterized by faster swimming and fewer long dives; and (2) "vertical avoidance" of vessels from 0 to 2,000 m away during which whales swam more slowly, but spent more time submerged. Watkins (1981c) found that both finback 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 Hawaii. 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.

Bauer (1986) and Bauer and Herman (1986) summarized the response of humpback whales to vessels in their summering areas and reached conclusions similar to those reached by Bauer and Herman (1986): these stimuli are probably stressful to the humpback whales in the action area, but the consequences of this stress on the individual whales remains unknown. Studies of other baleen whales, specifically bowhead and gray whales document similar patterns of short-term, behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel's engine was turned on even at distance of approximately 3,000 ft (900 m). 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 biopsy samples. They concluded that close vessel approaches caused these fin whales to stop feeding and swim away from the approaching vessel. The fin whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in their metabolic rates which might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed indefinitely after the exposure ended. They recommended keeping vessels more than 200 m from whales and having approaching vessels move at low speeds to reduce visible reactions in these whales.

The low, relative frequency of "no responses": when compared with "moderate" and "strong" behavioral responses noted in the literature would suggest that most of the whales that might be exposed to close approaches in Hawaiian waters are not habituated to those approaches and would still perceive the close approaches as potential threats. If these responses are representative of the most serious consequences these whales might experience as a result of their exposure to close approaches, the different species of whale have been exposed to a large number of stressful stimuli each year for several years. Because of the duration of the existing permits, those whales will continue to experience stressful stimuli for several years into the future.

Using the results produced by Weinrich et al. (1992) as representative of the range and relative frequency of behavioral responses these whales might exhibit to these close approaches produces the results presented in Table 7.

Table 7. Response of different species of whales to the number of close approaches (using the results produced by Weinrich et al. (1992) as representative of the range and frequency of responses).

Species	Low-level	Moderate	Strong
Blue whale	1,806	4,084	377
Fin whale	3,666	8,290	766
Humpback whale	6,563	14,841	1,371
Northern right whale	107	242	22
Sei whale	804	1,818	168
Sperm whale	5,365	12,132	1,121

The values described in that table describe the number of times whales might exhibit "low-level," "moderate," and "strong" responses to the estimated number of close approaches described in Table 7. Beale and Monaghan (2004) concluded that the level of disturbance was a function of the distance of humans to the animals, the number of humans making a close approach, and the frequency of the approaches. Their results suggest that the aggregate effects of the various human activities in Hawaiian waters are probably greater than the effects of the different activities individually.

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. However, there is increasing evidence that wild animals respond to human disturbance in the same way that they respond to predators. These responses manifest themselves as stress responses (in which an

animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid and Dill 2002; Romero 2004; Sapolsky 2000; Walker et al. 2005). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996; Müllner et al. 2004), and the death of individual animals (Daan et al. 1996).

Of the evidence available, we must accept the empirical studies as more informative. We must provisionally assume that close approaches for research are likely to be stressful for some of the whales although the significance of this stress response or its consequences on the fitness of individual whales remains unknown. Recognizing that the existing research permits require investigators to adopt the procedures developed by Clapham and Mattila (1993) for biopsy sampling of humpback whales in the West Indies, we provisionally assume that current levels of close approaches produce the same results as Clapham and Matilla (1993): short- to mid-term stress responses that have are not likely to produce long-term behavioral changes that have fitness consequences for individual whales or that might exacerbate the response of these whales to other potential stressors like sonar, contaminants, and generalized human disturbance.

5.3 The Impact of the Baseline on Listed Resources

The information available does not allow us to assess the actual or probable effects of natural and anthropogenic phenomena on threatened or endangered species in the action area. The age composition, gender ratios, population abundance, and changes in that abundance over time remain unknown for threatened and endangered species in the action area of this consultation. Without this information or some surrogate information, it would be difficult, if not impossible, to reliably assess the impact of the activities identified in this *Environmental Baseline* on threatened and endangered species in the action area.

6 EFFECTS OF THE PROPOSED ACTION

NMFS assesses the probable direct and indirect effects of federal actions and interrelated and interdependent actions on threatened and endangered species and designated critical habitat. The purpose of this assessment is to determine if it is reasonable to expect that (a) NMFS' proposed letters of authorization for the take of marine mammals incidental to the operation of SURTASS LFA sonar in the Pacific Ocean including mitigative measures the Navy would employ to avoid the potential, adverse effects of the sonar and (b) the U.S. Navy's employment of SURTASS LFA sonar will have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild (which is the jeopardy standard established by 50 CFR §402.02). Because this opinion has previously concluded that the proposed action is not likely to adversely affect critical habitat that has been designated for listed species, critical habitat is not considered in the analyses that follow.

6.1 Stressors Associated with the Proposed Action

The primary stressors associated with the SURTASS LFA sonar operations are:

(1) The ships and ship traffic associated with the proposed exercise;

(2) The low-frequency active component of the sonar system; and

(3) The high-frequency active component of the monitoring system.

Below we discuss these stressors and the potential effects they may have on listed species. Next we evaluate the available evidence to determine the likelihood of listed species to these species. Our analysis assumed that these stressors pose no risk to listed species if these stressors do not co-occur with those species in space or time. We recognize that the sonar could have indirect, adverse effects on listed species by disrupting marine food chains, a species' predators, or a species' competitors; however, we did not identify situations where this concern might apply to species under NMFS' jurisdiction.

6.1.1 Potential Effects of Vessel Operations

Operation of the USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE and USNS VICTORIOUS could have potential adverse effects on listed species through discharges, ship strikes, and the generation of engine and propeller noise. Operation of the vessels supporting SURTASS LFA will result only in discharges incidental to normal operations of a vessel. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) prohibits certain discharges of oil, garbage, and other substances from vessels. The Convention is implemented by the Act to Prevent Pollution from Ships (APPS; 33 U.S.C. 1901 et seq.), which establishes requirements for the operation of U.S. Navy vessels. The vessels supporting the SURTASS LFA sonar system will operate in compliance with these requirements. The sonar system itself will not result in the discharge of any pollutants regulated under APPS.

In addition, the USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE and USNS VICTORIOUS will operate at speeds of approximately 3 knots (3.5 miles per hour) during SURTASS LFA sonar operations and about 10 knots (11.6 miles per hour) during transit. As a result of ship design and their operation at relatively slow speeds, the USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE, and USNS VICTORIOUS produce far less engine and propeller noise than commercial and recreational vessels.

Furthermore, during SURTASS LFA sonar operations, the combination of ship speeds and the three elements of the U.S. Navy's monitoring and mitigation program would be expected to virtually eliminate the risk of ship strikes. Therefore, endangered or threatened marine mannals and sea turtles are not likely to be struck by the USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE, or USNS VICTORIOUS while these ships are underway and this potential risk is not discussed further in this Opinion.

6.1.2 Potential Effect of SURTASS LFA Active Sonar

This section of the Opinion assesses the potential exposure of listed species to sound pressure levels associated with SURTASS LFA sonar, including estimates of the intensity, duration, and frequency of any exposure. For listed species that are likely to be exposed to LFA sonar, the second step of our approach assesses the sensitivities of listed species to SURTASS LFA sonar or, alternatively, the potential effects of differing levels of low-frequency sound on listed species. For species that are likely to be exposed to LFA sonar and, if exposed, would respond to that exposure, the third step of our approach estimated the probable risks posed by SURTASS LFA sonar by combining

exposure estimates with species' responses to reach conclusions about the potential risk SURTASS LFA sonar poses to threatened and endangered species.

The LFA sonar system consists of up to 18 low-frequency acoustic-transmitting projectors that are suspended from a cable beneath a ship. The source level of an individual projector in the LFA sonar array is about 215 dB, and the sound field of the array can never have a sound pressure level higher than that of an individual projector. The typical LFA sonar signal is not a constant tone, but is a transmission of various signal types that vary in frequency and duration (including continuous wave and frequency-modulated signals). The Navy refers to a complete sequence of sound transmissions as a "ping" which can range from between 6 and 100 seconds, with no more than 10 seconds at any single frequency. The time between pings will typically range from 6 to 15 min. The Navy can control the average duty cycle (the ratio of sound "on" time to total time) for the system but the duty cycle cannot exceed 20 percent; based on operations since 2003, the duty cycle has averaged about 7.5 percent.

This Opinion assumes that the propagation of signals transmitted from low-frequency active sonar systems towed by the USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE and USNS VICTORIOUS would be affected by surface ducts, sound channels, convergence zones, and bottom interactions. For more complete discussion of sound propagation in marine environments, readers should refer to Richardson et al. (1995), Appendix B of the Navy's EIS on SURTASS LFA (Navy 2001a), and the Effects of the Action section of NMFS' 30 May 30 2002 and 12 August 2007, biological opinions on SURTASS LFA sonar.

The Navy operated the HF/M3 sonar continuously during the course of the missions they conducted 2002 through 2004. During 10 of the 16 missions reported in Annual Report 4, there were 16 HF/M3 alerts that were identified as possible marine mammal or sea turtle detections. Because these detections met the minimum criterion for identification of a marine animal (two HF/M3 detection alerts within six seconds), the Navy suspended or delayed LFA transmissions as appropriate given their mitigation protocols. As a result, marine mammals and sea turtles that had been detected were not exposed to sonar transmissions at received levels above 180 dB.

From February 2005 to February 2006, the R/V Cory Chouest (which the USNS ABLE replaced) participated in ten missions covering about 50.4 days with 88.9 hours of transmissions by the LFA array in the West and North Philippine Sea, the South China Sea, and near Guam. Each mission included the operation of the HF/M3 sonar and compliance with all other applicable mitigation requirements. During the same time interval, the USNS IMPECCABLE participated in six missions covering about 24.3 days with 43.5 hours of transmissions by the LFA array in the North and West Philippine Sea and the South China Sea (Navy 2007b).

During this suite of missions, LFA transmissions were delayed/suspended on 33 occasions. On the USNS IMPECCABLE, operations were delayed or suspended four times because of possible marine mammal or sea turtle detections and three times due to HF/M3 failures. In earlier LFA sonar missions that involved the R/V Cory Chouest, there were 12 delays or suspensions due to possible marine mammal or sea turtle detections, 13 times due to HF/M3 failure, and once due to a visual sighting of dolphins.

On the R/V Cory Chouest, there were 16 delays or suspensions due to HF/M3 sonar failure (Navy 2008a).

On the USNS IMPECCABLE, operations were delayed or suspended when marine mammals were detected by observers and once when they were detected by the HF/M3 sonar system (Navy 2009).

During the third suite of missions under the current MMPA regulations (2007-2012), LFA transmissions were delayed or suspended on seven occasions. During operations on the USNS IMPECCABLE in the first quarter (16 Aug to 15 Nov 2009), there were three periods of marine mammal vocalizations. These passive acoustic contacts coincided with three HF/M3 sonar alerts identified as possible marine mammals. There was no visual confirmation because of low visibility at night. These resulted in three suspensions of LFA operations. During operations on the USNS IMPECCABLE, there were three HF/M3 alerts that were identified as possible marine mammal, which coincided with passive acoustic detections noted above. These alerts resulted in three suspensions of LFA operations. One additional delay occurred do to HF/M3 malfunction (Navy 2010).

6.2 Mitigative Measures to Minimize the Likelihood of Exposure

Sound transmissions are usually measured in terms of sound pressure levels, which are denoted as decibels and which have a reference pressure value of 1 microPascal (µPa). The logarithmic nature of the decibel (dB) 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). Humans perceive a 10 dB increase in noise as a doubling of sound level, or a 10 dB decrease in noise as a halving of sound level.

The Navy proposes several measures to reduce or eliminate the likelihood of exposing marine mammals to LFA transmissions at high decibel levels:

1. Monitoring Program: the monitoring program includes visual, passive acoustic and active acoustic monitoring of a 180 dB mitigation zone and an additional 1 km buffer zone. The effectiveness of visual monitoring is limited to daylight hours, and its effectiveness declines during high sea states. The percentage of animals that will pass unseen is difficult to determine, but 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.

Based on actual trials, the passive acoustic detection has been more effective than visual monitoring. Thomas et al. (1986) and Clark and Fristrup (1997) concluded that the effective strip width and detection rates for passive acoustic monitoring are greater than for visual monitoring, but the percentage of animals that will be undetected by the methods is unknown. This would increase the detection rate of gray, humpback, fin, blue, and minke whales, and some of the beaked whale and dolphin species.

During operations under the 2009 LOA the Navy reported that there were no visual sightings of marine mammals during SURTASS LFA sonar exercises. However, during a non-operational period (no LFA transmissions) on the USNS IMPECCABLE in the fourth quarter (16 May to 15 August 2010), there was one visual sighting of marine mammals. The sighting was at 185 degrees True at 1.8 km (1.12 nmi). They were identified as most likely to be gray whales (8 – 10) (Navy 2010).

During operations on the USNS IMPECCABLE in the first quarter (16 Aug to 15 Nov 2009), there were three periods of marine mammal vocalizations. These passive acoustic contacts coincided with three HF/M3 sonar alerts identified as possible marine mammals. There was no visual confirmation because of low visibility at night. These resulted in three suspensions of LFA operations (Navy 2010).

2. High Frequency Marine Mammal Monitoring Sonar. The HF/M3 sonar appears to be the most effective measure the Navy uses to detect animals within 1 to 2 kilometers of the projectors. Recent testing of the HF/M3 sonar demonstrated a probability of single-ping detection above 95 percent within the LFA mitigation zone for most marine mammals (Navy 2005). If any of these monitoring methods detects animals within this zone, the projectors w ould be shut down until the animal(s) move out of the mitigation zone. Combined with the visual monitoring and passive acoustic monitoring protocols, this should minimize the risk of marine mammals being exposed to sound pressure levels in excess of 180 dB.

During the first suite of missions under the current MMPA regulations, LFA transmissions were delayed or suspended on 43 occasions. On the USNS IMPECCABLE, operations were delayed or suspended one time when marine mammals were detected by marine mammal observers, 19 times when they were detected by the HF/M3 system, and 7 times due to the failure of the HF/M3 sonar or the passive array. On the R/V Cory Chouest, there were 16 delays or suspensions due to HF/M3 sonar failure (Navy 2008a).

During the second suite of missions under the current MMPA regulations, LFA transmissions were delayed or suspended on eight occasions. On the USNS ABLE, operations were delayed or suspended once when marine mammals were detected by marine mammal observers, once when they were detected by the HF/M3 system, and three times due to the failure of the HF/M3 sonar. On the USNS IMPECCABLE, operations were delayed or suspended when marine mammals were detected by observers and once when they were detected by the HF/M3 sonar system (Navy 2009).

During operations on the USNS IMPECCABLE under the 2009 LOA, there were three HF/M3 alerts that were identified as possible marine mammal, which coincided with passive acoustic detections noted above. These alerts resulted in three suspensions of LFA operations (Navy 2010).

Because these detections met the minimum criterion for identification of a marine animal (two HF/M3 detection alerts within six seconds), the Navy followed the appropriate mitigation protocols and LFA transmissions were suspended or delayed. As a result, marine mammals that had been detected were not exposed to sonar transmissions at received levels above 180 dB.

3. LFA Mitigation Zone. Inside the LFA mitigation zone during a ping, listed species could be exposed to sound levels at or above 180 dB and could experience threshold shifts (loss in hearing sensitivity) or more serious auditory injury. However, the LFA mitigation zone was established and designed to prevent marine mammal or sea turtles from being exposed to energy levels high enough to produce these outcomes. Several aspects of the LFA mitigation zone reduce a listed species' chances of being exposed to LFA sonar at sound pressure levels at or above 180 dB; (a) the mitigation zone extends

approximately 0.75 to 1.00 km [0.40 to 0.56 nm] from the transmitters and is supplemented by a 1-km buffer zone, (b) the detection probabilities associated with the High Frequency Marine Mammal Monitoring sonar exceed 95 percent for small dolphins at about 750 m [0.4 nm], whale calves at 1,000 m [0.56 nm] and large whales at more than 1,500 m [0.81 nm]; (c) the depth of the transmitters would reduce the risk of exposing animals located near the ocean's surface or in the mixed layer; and (d) marine mammals and larger sea turtles have a high probability of being detected within the LFA mitigation zone and, as a result, a low probability of being exposed to sound pressure levels greater than 180 dB.

For an animal to be exposed to LFA sonar transmissions at sound pressure levels greater than 180 dB, the animal would have to enter the LFA sonar mitigation zone without being detected by marine mammal observers or the HF/M3 sonar system and would have to remain in the LFA mitigation zone when LFA transmitters were operating. The monitoring results of the deployments of the SURTASS LFA sonar system from 2002 – 2006 support this conclusion. The active acoustic monitoring (HF/M3 sonar) resulted in a total of sixteen suspensions of operations in accordance with the terms and conditions of the existing permit. No contacts were reported within the 180-dB safety zone or the 1-km (0.5-nm) buffer zone during transmissions, which suggests that no marine mammals were subjected to LFA exposures that might have resulted in injuries. Based on this monitoring information, the probability of all of these events occurring, although possible, is extremely improbable.

4. Geographic Constraints (see discussion in Description of the Proposed Action of this Opinion). The SURTASS LFA sonar system would be operated in a manner that would not cause sonar sound fields to exceed 180 dB (re 1 µParms) within "coastal exclusion zones." For any annual Letter of Authorization, NMFS' regulations establish a minimum coastal exclusion zone of 12 nm (22 km) of any coastline, including offshore islands, and designated offshore areas that are biologically important for marine mammals outside the 12 nautical mile (22 km) coastal exclusion zone during seasons specified for a particular area (see Table 1). When in the vicinity of known recreational and commercial dive sites, SURTASS LFA sonar will be operated to ensure that the sound field at these sites would not exceed 145 dB.

The regulations promulgated under the Marine Mammal Protection Act require the Navy to operate SURTASS LFA sonar to ensure that sonar sound fields do not exceed 180 dB (re 1 µParms) within 12 nm of any coastline, including offshore islands, or within 12 nm plus a 1-km (0.5-nm) buffer zone of designated offshore areas that are biologically important for marine mammals that occur beyond that coastal exclusion zone during the seasons specified for a particular area (see Geographic Restrictions in the Description of the Proposed Action section of this biological opinion for complete descriptions of these coastal exclusion zones and the offshore biologically important areas). When in the vicinity of known recreational and commercial dive sites, regulations require the Navy to operate SURTASS LFA sonar to ensure that the sound field at these sites would not exceed 145 dB, adding an additional level of protection for marine mammals located in dive sites (as mentioned in the Description of the Proposed Action section of this opinion, the Navy will operate LFA sonar near the Hawaiian Islands Humpback Whale National Marine Sanctuary in a manner that prevents received levels from exceeding 180 dB from November through May 1).

From August 16, 2011, to August 15, 2012, the U.S. Navy proposes to limit their use of SURTASS LFA sonar for testing, training, and military operations to the Northwestern Pacific Ocean and the Hawaii operating area in accordance with the the U.S. District Court for the Northern District of California, San Francisco Division, Stipulated Settlement Agreement Order (signed 12 August 2008).

These operational constraints would further reduce the likelihood of exposing threatened and endangered species of whales to SURTASS LFA sonar at sound pressure levels exceeding 180 dB in areas that are critical to their ecology, critical to large portions of their populations, or both. In some areas, these operational constraints are likely to prevent listed species from being exposure to LFA sonar at received levels likely to elicit behavioral responses. For example, these constraints would reduce the likelihood of exposing endangered western Pacific gray whales to SURTASS LFA signals at sound pressure levels exceeding 180 dB during their migration from critical feeding grounds in the Sea of Okhotsk south to the China Sea.

6.3 Exposure

Exposure analyses are designed to identify the listed resources that are likely to co-occur with the potential stressors in space and time 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.

The duration of a typical ping produced by SURTASS LFA sonar would range from 6 to 100 seconds, with no more than 10 seconds at a single frequency; intervals between pings would range from 6 to 15 min. Pings would consist of various signal types that vary in frequency (between 100 and 500 Hz) and duration (including continuous wave and frequency-modulated signals). When the system is turned off, no additional energy would enter the ocean's environment.

The duration of an animal's exposure to SURTASS LFA signals will depend on their proximity to the transmitter and their location in the water column. Nevertheless, because of the length of individual pings, individual animals would be exposed to SURTASS LFA transmissions for periods ranging from 6 to 100 seconds.

Individual animals or groups of animals have a low statistical probability of being exposed to SURTASS LFA sonar signals on several, separate occasions. However, the number of times an animal would be exposed to sound pressure levels associated with SURTASS LFA sonar transmissions will depend on the deployment schedule of the four vessels.

The published data on marine mammals regarding responses to repeated exposure to low frequency sound are limited. However, the Navy conducted several simulations to estimate the potential effect of multiple exposures on marine mammals. One of the Navy's simulations assumed that a marine mammal was exposed to a total of ten SURTASS LFA sonar transmissions, or pings, at received levels between 150-159 dB. The simulation showed that the animal was exposed to two pings at 150 dB received level, none at 151 dB received level, three pings at 152 dB received level, etc. To arrive at a total single-ping equivalent for the entire exposure, the Navy first calculated the intensity level for each ping (i.e., 1 x 1015 µPa for each of the two 150 dB received level exposures, 1.58×10^{15} µPa for each of three 152 dB received level exposures, etc.). These intensity values were then squared and added

together; the estimates concluded that these different pings resulted in a total single ping equivalent of 160.47 dB (see Navy 2001a 4.2.3.1 "Effects pf Repeated Exposure"). In this example, the model results predict that this frequency of exposures had a 24.48 percent probability of producing a significant change in biologically important behavior.

From 16 August 2011 to 15 August 2012, the U.S. Navy proposes to conduct 16 missions that may extend for up to seven days in nine different sites in the Northwest Pacific Ocean using the USNS ABLE, USNS EFFECTIVE, USNS IMPECCABLE and USNS VICTORIOUS. In addition the Navy proposes to conduct an additional four missions of up to seven days each in the Hawaii Operating Area. Whenever practicable, the Navy also alters the timing of its operations to avoid potential interactions with humpback whales, particularly with calving areas in the west Philippine Sea and Hawaiian Islands. As a result, the U.S. Navy expects minimal exposure of humpback whales to LFA sonar transmissions in the Northwest Pacific Ocean because they generally would not be present during the periods that LFA operations occur (Table 8).

Table 8 and 9 summarize information on the percentage and number of individuals of the listed marine mammal populations (or “stocks”) that might be exposed to LFA sonar transmissions at the different mission sites from August 2011 to August 2012 (Carretta et al. 2010). The narratives that follow interpret and expand the information contained in these tables and represents exposure profiles for the threatened and endangered species that are likely to occur in the Action Area (exposure profiles summarize how exposure would occur; what species would be exposed; how much exposure would occur; when and where exposure would occur; if exposure would be expected to vary with the biology and ecology of the species or characteristics of the environment; the likelihood of exposure occurring; and uncertainty associated with these summaries; (EPA 1998).

Table 8. Pre-operational estimates of the percentage of listed marine mammal populations ("stocks") in the different mission areas and number of individuals that might be exposed to LFA sonar from August 2011 through August 2012.

Species	Operational Area															Total Exposure
	Site 1: East of Japan			Missions	1	Site 2: North Phillippine Sea			Missions	3	Site 3: West Phillippine Sea			Missions	3	
	# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		
		Percent	Number	Percent	Number		Percent	Number	Percent	Number		Percent	Number	Percent	Number	
Blue whale	9250	0.07	6	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	6
Fin whale	9250	0.07	6	0.00	0	0	0.00	0	0.00	0	9250	0.25	23	0.00	0	29
Gray whale	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0
Humpback whale	0	0.00	0	0.00	0	0	0.00	0	0.00	0	1107	0.11	1	0.00	0	1
North Pacific right whale	922	0.04	0	0.00	0	922	0.10	1	0.00	0	0	0.00	0	0.00	0	1
Sei whale	8600	0.23	20	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	20
Sperm whale	102112	0.03	31	0.00	0	102112	0.23	235	0.00	0	102112	0.09	92	0.00	0	357

Species	Operational Area															Total Exposure
	Site 4: Offshore Guam			Missions	3	Site 5: Sea of Japan			Missions	2	Site 6: East China Sea			Missions	1	
	# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		
		Percent	Number	Percent	Number		Percent	Number	Percent	Number		Percent	Number	Percent	Number	
Blue whale	2841	0.27	8	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	8
Fin whale	9250	0.25	23	0.00	0	9250	0.76	70	0.00	0	500	1.46	7	0.00	0	101
Gray whale	0	0.00	0	0.00	0	121	0.65	1	0.00	0	121	0.30	0	0.00	0	1
Humpback whale	10103	5.74	580	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	580
North Pacific right whale	0	0.00	0	0.00	0	922	0.09	1	0.00	0	922	0.04	0	0.00	0	1
Sei whale	8600	0.25	22	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	22
Sperm whale	102112	0.08	82	0.00	0	102112	0.05	51	0.00	0	102112	0.03	31	0.00	0	163

Species	Operational Area															Total Exposure
	Site 7: South China Sea			Missions	1	Site 8: Offshore Japan 25 - 40 North			Missions	1	Site 9: Offshore Japan 10 - 25 North			Missions	1	
	# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		# of "Stock"	120 - 180 dB Exposure		> 180 dB Exposure		
		Percent	Number	Percent	Number		Percent	Number	Percent	Number		Percent	Number	Percent	Number	
Blue whale	0	0.00	0	0.00	0	9250	0.11	10	0.00	0	0	0.00	0	0.00	0	10
Fin whale	9250	0.07	6	0.00	0	9250	0.04	4	0.00	0	0	0.00	0	0.00	0	10
Gray whale	121	0.25	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0
Humpback whale	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0
North Pacific right whale	922	0.04	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0
Sei whale	0	0.00	0	0.00	0	37000	0.03	11	0.00	0	0	0.00	0	0.00	0	11
Sperm whale	102112	0.03	31	0.00	0	102112	0.01	10	0.00	0	102112	0.01	10	0.00	0	51

Table 9. Pre-operational estimates of the listed marine mammal populations ("stocks") and number of instances in which listed marine mammals might be exposed to SURTASS LFA sonar during missions in the Hawai'i Operating Area from August 2011 - August 2012.

Species	Number of Animals in "Stock"	120 - 180 dB Exposure		> 180 dB Exposure
		Percent	Annual Estimate	Percent
Blue whale	1548	1.97	30	0.00
Fin whale	2099	5.08	107	0.00
Gray whale	0	0.00	0	0.00
Humpback whale	10103	0.90	91	0.00
North Pacific right whale	0	0.00	0	0.00
Sei whale	0	0.00	0	0.00
Sperm whale	6919	5.52	382	0.00
Hawaiian monk seal	1129	2.60	29	0.00

Marine animals might be exposed to SURTASS LFA sonar signals during pings that would last between 6 and 100 seconds (nominally 60 seconds) and could result in behavioral responses that could constitute harassment. The potential effects of these pings decrease with distance from the projectors; animals that occur within the column of water within 1,000 meters of these projectors during one of these pings would have the greatest risk of injury, although the probability of such exposure seems small given the short duration of a ping and the Navy's monitoring protocols. However, the Navy's ability to detect animals using these monitoring protocols may vary with the size of the animal: endangered whales, leatherback sea turtles, and large loggerhead sea turtles have the greatest probability of being detected by the monitoring systems associated with the SURTASS LFA sonar systems, which gives them the lowest probability of being exposed to signals at received levels approximating 180 dB. The probability of the Navy to detect pinnipeds and smaller turtles is lower. Testing and analyses of the system has shown that the probability of detecting a 2.5-meter dolphin with multiple pings within 1 km approaches 100 percent. Even though the Navy has not tested the system specifically with pinnipeds and sea turtles, the system should be able to detect adult animals of both groups.

Because of the operating constraints that have been placed on employment of SURTASS LFA sonar, animals with pelagic distributions have greater risk of being exposed to SURTASS LFA sonar signals or of being exposed to higher received levels than animals with coastal distributions. Within the ocean's surface layer (uppermost 150 feet) the marine sound field would be dominated by sounds generated by wave action, rain, and other surface activity; which would mask sounds generated by SURTASS LFA sonar. Animals with an offshore distribution that occur in this surface layer have a lower risk of being exposed to coherent LFA sonar signals, although they may be exposed to incoherent energy associated with these signals.

Below this surface layer and outside of the SURTASS LFA sonar mitigation zone, sound pressure levels from SURTASS LFA sonar transmissions would depend largely on physical, oceanic conditions, and the Navy's use of surface ducts, convergence zones, and sound channels, which would determine the transmission losses. In convergence zones, SURTASS LFA sonar signals would resurface from bottom layers at 33 to 67 km intervals (18 to 36 nm), depending upon the sound speed profile in an oceanic area. Between convergence zones, animals would

not be exposed to coherent SURTASS LFA sonar signals, but could be exposed to incoherent energy associated with those signals. Therefore, animals with offshore distributions have a higher risk of exposure to SURTASS LFA sonar transmissions if they occur in the LFA mitigation zone, if they dove to depths that might expose them to a surface duct or sound channel, or if they occurred in a convergence zone. In any of these scenarios, an animal would be exposed to SURTASS LFA sonar signals for all or part of the 6 to 100 second duration of a single ping.

6.4 Exposure-Response-Risk Analysis

The narratives that follow presents the results of our exposure, response, and jeopardy (risk) analyses by each species or species group (in the case of sea turtles) that might be exposed to one or more SURTASS LFA sonar missions. These analyses summarize the more extensive review of the information available on the possible responses of marine animals to sonar transmissions, which was presented in our 2007 programmatic biological opinion on the SURTASS LFA sonar system (NMFS 2007a).

6.4.1 Blue Whale

The exposure-response-risk analysis for the blue whale in presented in this section.

Exposure Analysis

The U.S. Navy's exposure models identified about 55 instances in which blue whales might be exposed to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2011 through mid-August 2012 (see Table 8 and **Error! Reference source not found.**; because of rounding, numbers cited in the text may differ from those in the tables), although the number of exposure events involving blue whales varies among the mission areas (we use the term "exposure events" rather than "number of blue whales" because individual whales might be exposed multiple times). Slightly more than half of these exposure events would occur in the Hawai'i Operating Area.

Blue whales undertake seasonal migrations and were historically hunted on their summer, feeding areas. For example, blue whales were taken off the west coast of Baja California as early as the mid-19th century (Scammon 1874 (1968)). The timing varied, but whalers located few blue whales in wintering areas from December to February. Observations made after whaling was banned revealed a similar pattern: blue whales spend most of the summer foraging at higher latitudes where the waters are more productive (Calambokidis et al. 2007; Calambokidis et al. 1990; Sears 1990). Like the other baleen whales, individual blue whales might migrate south prematurely and occur in the action area, but it is highly improbable. For these reasons, the instances in which blue whales might be exposed to LFA sonar transmissions in the Hawai'i Operating Area and offshore of Guam are most likely to occur during the winter months rather than the summer. Because we have almost no information on the number of blue whales that might actually occur in the various operating areas or their affinity for those waters, we must assume that those individuals could represent any gender or age.

Response Analysis

The information on how blue whales are likely to respond when exposed to low-frequency active sonar is limited. However, we assume that the behavioral responses that have been reported for fin, gray, humpback, and sei whales will be somewhat representative of the probable behavioral responses of blue whales. Based on the behavioral responses reported for those other species, we assume that exposing blue whales to SURTASS LFA sonar may have

short-term, adverse effects on individual whales, but that exposure should not elicit responses that suggest adverse effects on a baleen whale's ability to forage, detect predators, select a mate, or reproduce successfully. We also would not expect these responses to be symptomatic of chronic stress that might depress a whale's immune responses and increase their susceptibility to disease.

In subsequent narratives, we discuss the results of Watkins (1986a) who 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. Based on that review, he concluded that 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. Based on those data and the evidence that demonstrates the effectiveness of the mitigation associated with the SURTASS LFA sonar system, we would assume that blue whales exposed to LFA sonar transmissions when these whales are more than 1 kilometer from the source are not likely to experience physical injury or trauma or engage in behaviors that would affect their current or expected future reproductive success (which, as discussed earlier, incorporates their survival, longevity, and the number of offspring they would produce over their reproductive lifespan).

Risk Analysis

Because of the limited data and uncertainty about the relationships between an animal's behavioral responses and their population ecology, the U.S. Navy and NMFS have interpreted any data or other information conservatively when dealing with the SURTASS LFA program. As a result, when an animal's responses to LFA sonar transmissions appear to be part of the animal's normal behavioral repertoire (such as a tail flick or head turn), a low-level response to a novel stimulus (such as an alert response or a startle response), or a response with unknown consequence, the U.S. Navy and NMFS has chosen to treat these responses as symptomatic of potential disruptions one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population (that is, harassment).

Based on our response analyses, over the next 12 months we expect 55 events in which individual blue whales might be exposed to SURTASS LFA sonar transmissions and engage in evasive behavior or changes in their behavioral state each year as a result of that exposure. Because these 55 exposure events are expected to occur in different areas of the Northwest Pacific Ocean around the Mariana Islands, we assume that different blue whales would be exposed, although individual blue whales might be exposed multiple times on a single mission area. Regardless, only a small percentage of the blue whales that occur in the different mission areas are likely to engage in evasive behavior or changes in their behavioral state. As a result, these 55 instances of evasive behavior or changes in behavioral state over a twelve-month period are not likely to kill, injure, change the energy or time budget, or cause sustained physiological stress responses that might result in stress pathology in animals with the energy reserves of blue whales. Therefore, we do not expect those exposure events to cause blue whales to strand, suffer injury, die, experience measurable changes in their energy or time budgets, engage in life history trade-offs, or change their social interactions. More importantly, we would not expect blue whales exposed to active sonar to experience acute reductions in their reproductive success over the next calendar year or in the reproductive success we would expect in future years.

Instead, blue whales are likely to incur "canonical costs" as a result of these 55 exposure events; however, we do not expect 55 exposure events that result in short-term evasive behavior or changes in behavioral state to translate into chronic or cumulative reductions in the current or expected future reproductive success of these blue whales. Therefore, the 20 SURTASS LFA sonar missions are not likely to affect the performance of the populations blue whales represent or the species those population comprise. By extension, we would not expect those sonar missions to appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

6.4.2 Fin Whale

The exposure-response-risk analysis for the fin whale is presented in this section.

Exposure Analysis

The U.S. Navy's exposure models identified about 247 instances in which fin whales might be exposed to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2011 through mid-August 2012, although the number of exposure events involving fin whales also varies among the mission areas (see Tables 8 and 9).

Because we have almost no information on the number of fin whales that might actually occur in the various operating areas or their affinity for those waters, we must assume that those individuals could represent any gender or age.

Response Analysis

The best scientific and commercial data available suggest that exposing fin whales to SURTASS LFA sonar may have short-term, adverse effects on individual whales, but that exposure should not elicit responses that suggest adverse effects on a baleen whale's ability to forage, detect predators, select a mate, or reproduce successfully. We also would not expect these responses to be symptomatic of chronic stress that might depress a whale's immune responses and increase their susceptibility to disease. At received levels between 120 and 180 dB re $1\mu Pa_{rms}$, the information available would not lead us to expect baleen whales to respond in ways that would reduce their reproduction, numbers, or distribution. Based on the performance of the SURTASS LFA sonar system and the mitigative measures associated with the sonar system over the eight years of reporting, we do not expect any sperm whales to be exposed to received levels equal to or greater than 180 dB.

Watkins (1986a) reviewed 25 years of 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. Watkins reported 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, Watkins (1986a) 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 (1986a) concluded that fin and humpback whales had habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

Based on his review, Watkins concluded that whales seemed to react negatively when they were within 100 m of a sound 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. Based on those data and the evidence that demonstrates the effectiveness of the mitigation associated with the SURTASS LFA sonar system, we would assume that exposing fin whales to LFA sonar transmissions at distances greater than 1 kilometer is not likely to reduce the fitness of the whales that have been exposed.

Nevertheless, and as discussed in the Response Analysis section of this opinion, because of the limited data and uncertainty about the relationships between an animal's behavioral responses and their population ecology, the U.S. Navy and NMFS have interpreted any data or other information conservatively when dealing with the SURTASS LFA program. As a result, when an animal's responses to LFA sonar transmissions appear to be part of the animal's normal behavioral repertoire (such as a tail flick or head turn), a low-level response to a novel stimulus (such as an alert response or a startle response), or a response with unknown consequence, the U.S. Navy and NMFS has chosen to treat these responses as symptomatic of potential disruptions one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population (that is, harassment).

Risk Analysis

Because of the limited data and uncertainty about the relationships between an animal's behavioral responses and their population ecology, the U.S. Navy and NMFS have interpreted any data or other information conservatively when dealing with the SURTASS LFA program. As a result, when an animal's responses to LFA sonar transmissions appear to be part of the animal's normal behavioral repertoire (such as a tail flick or head turn), a low-level response to a novel stimulus (such as an alert response or a startle response), or a response with unknown consequence, the U.S. Navy and NMFS has chosen to treat these responses as symptomatic of potential disruptions one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population (that is, harassment).

Based on our response analyses, over the next 12 months we expect 247 events in which individual fin whales might be exposed to SURTASS LFA sonar transmissions and engage in evasive behavior or changes in their behavioral state each year as a result of that exposure. Because these 247 exposure events are expected to occur in different areas of the North Pacific Ocean, we assume that different fin whales would be exposed, although individual fin whales might be exposed multiple times on a single mission area. Regardless, only a small percentage of the fin whales that occur in the different mission areas are likely to engage in evasive behavior or changes in their behavioral state. As a result, these 247 instances of evasive behavior or changes in behavioral state over a twelve-month period are not likely to kill, injure, change the energy or time budget, or cause sustained physiological stress responses that might result in stress path-ology in animals with the energy reserves of fin whales. Therefore, we do not expect those exposure events to cause fin whales to strand, suffer injury, die, experience measurable changes in their energy or time budgets, engage in life history trade-offs, or change their social interactions. More importantly, we would not expect fin whales exposed to active sonar to experience acute reductions in their reproductive success over the next calendar year or in the reproductive success we would expect in future years.

Instead, fin whales are likely to incur "canonical costs" as a result of these 247 exposure events; however, we do not expect 247 exposure events that result in short-term evasive behavior or changes in behavioral state to translate into chronic or cumulative reductions in the current or expected future reproductive success of these fin whales. Therefore, the 20 SURTASS LFA sonar missions the U.S. Navy proposes to conduct are not likely to affect the

performance of the populations fin whales represent or the species those population comprise. By extension, we would not expect those sonar missions to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

6.4.3 Gray Whale (Western Pacific)

The exposure-response-risk analysis for the western Pacific gray whale is presented in this section.

Exposure Analysis

In accordance with the the U.S. District Court for the Northern District of California, San Francisco Division, Stipulated Settlement Agreement Order (signed 12 August 2008) the Navy's operations will be limited to in the Sea of Japan to waters deeper than 1,000 meters (or at least 30 nm offshore); this measure should reduce the potential received levels for western Pacific gray whales during their winter migration, which generally follows shallower coastal waters. Similarly, the Navy proposes to remain southeast of a line between 34º N, 126º E and 30º N, 122º E from December to March in the East China Sea, should further limit potential exposures of wintering and migrating western Pacific gray whales to LFA sonar transmissions. Finally, the Navy proposes to remain at least 60 nm offshore or 30 nm seaward of the 200-meter isobath in the South China Sea should limit potential exposures of western Pacific gray whales in potential breeding and calving areas near Hainan Island in the South China Sea.

The U.S. Navy's exposure models identified one instance in which western Pacific gray whales might be exposed to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2011 through mid-August 2012 (see Table 8 and **Error! Reference source not found.**). That one instance might occur during one of the two LFA sonar missions the U.S. Navy proposes to conduct in the Sea of Japan, which is likely to occur during the gray whale migration to or from the Sea of Okhostk.

Response Analysis

Richardson et al. (1995) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. Richardson et al. (1995) and Richardson and Wursig (1997) used controlled playback experiments to study the response of bowhead whales in Arctic Alaska. In their studies, bowhead whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB and seismic sources at estimated received levels of 110 to 132 dB. Richardson et al. (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 have 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 cited in Richardson et al. 1995). A study examined responses of gray whales migrating along the California coast to various sound sources located in their migration corridor (Malme et al. 1984; Malme et al. 1983). Gray whales 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.

This study was replicated in Phase II of the Low Frequency Sound Scientific Research Program using SURTASS LFA sonar stimuli. However, the Phase II research demonstrated that it may be invalid to apply the inshore (2 km

from shore) response model (when 50 percent of the whales avoided SURTASS LFA sonar stimuli at received levels of 141 +3 dB) to sources that are offshore (4 km from shore) of migrating whales, and that whales did not avoid offshore sources at received levels of 140 dB. This implies that the inshore avoidance model in which 50 percent of the whales avoid exposure to levels of 141 +3 dB may not be valid for whales in proximity to an offshore source (Buck and Tyack 2000).

Risk Analysis

If exposed to SURTASS LFA sonar transmissions, the evidence available suggests that western Pacific gray whales, like other baleen whales, are not likely to be killed or experience injury, masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or repro-ductive success of individuals that have been exposed.

Instead, the gray whale involved in the single exposure event that is likely to occur over the next 12 months is likely to incur "canonical costs" as a result of that exposure events; however, we do not expect that single exposure event to translate into chronic or cumulative reductions in the current or expected future reproductive success of this gray whale. Therefore, the SURTASS LFA sonar mission the U.S. Navy proposes to conduct in the Sea of Japan (which might result in exposing western Pacific gray whales) is not likely to affect the performance of gray whales as a population or as a 'species" (that is, the entity that has been listed as endangered). By extension, we would not expect those sonar missions to appreciably reduce the western Pacific gray whales' likelihood of surviving and recovering in the wild.

6.4.4 Humpback Whale

The exposure-response-risk analysis for the humpback whale is presented in this section.

Exposure Analysis

The U.S. Navy's exposure models identified about 671 instances in which humpback whales might be exposed to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2011 through mid-August 2012 (see Table 8 and **Error! Reference source not found.**). About 580 of these exposures would occur in waters off of Guam where humpback whales occur during the winter months.

Response Analysis

Like Richardson et al. (1995), we assumed that humpback whales might experience significant masking effects if they try to vocalize during LFA sonar transmissions. They are sensitive to low-frequency sounds. However, Biassoni et al. (2001) concluded that the intermittent sounds produced by LFA sonar were unlikely to mask humpback whale songs. Based on their studies, and the intermittent nature of the LFA sonar, they concluded that humpback whales could adapt to the presence of LFA sonar and concluded that singing whales could compensate for interference from sound sources like LFA sonar.

As discussed previous in these Response Analyses, the fitness consequences of these vocal adjustments remain unknown. However, like most other trade-offs animals must make, these vocal adjustments probably come at a cost (Patricelli and Blickley 2006). For example, vocalizing more loudly in noisy environments may have energetic costs that decrease the net benefits of vocal adjustment and alter the bird's energy budget (Brumm 2004b; 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 conspecific females (Brumm 2004a; 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 humpback whales whose song structures by males are used to attract mates.

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.

Data generated by the research program associated the SURTASS LFA sonar showed that some humpback whales reduced their vocal activity. Those that continued singing, increased song length, but the tendency for these responses did not increase with increasing received levels (Clark and Tyack 1998; Fristrup et al. 2003; Miller et al. 2000). These whales showed some apparent avoidance responses and cessation of song during LFA sonar transmissions at received levels ranging from 120 to 150 dB. However, an equal number of singing whales exposed to the same levels did not stop singing during LFA sonar transmissions. Of the whales that did stop singing, few other behavioral changes were reported in response to subsequent LFA sound transmissions; most whales joined other whales or resumed singing within less then an hour of the possible response. Those that did not stop singing, sang longer songs during the period of LFA sonar transmissions, and returned to baseline after transmissions stopped (Miller et al. 2000) (Fristrup et al. 2003). In all cases, responding whales resumed normal activities within a few tens of min after initial exposure to LFA sonar transmissions.

These results are similar to those reported by Watkins (1986b) in his review of 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 whales seemed to react negatively when they were within 100 m of a sound 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. Based on those data and the evidence that demonstrates the effectiveness of the mitigation associated with the SURTASS LFA sonar system, we would assume that exposing humpback whales to LFA sonar transmissions at distances greater than 1 kilometer is not likely to reduce the fitness of humpback whales that have been exposed.

Risk Analysis

Based on our response analyses, over the next 12 months we expect 671 events in which individual humpback whales might be exposed to SURTASS LFA sonar transmissions and engage in evasive behavior or changes in their behavioral state each year as a result of that exposure. Because these 671 exposure events are expected to occur in different areas of the North Pacific Ocean, we assume that different humpback whales would be exposed, although individual humpback whales might be exposed multiple times on a single mission area. Regardless, only a small percentage of the humpback whales that occur in the different mission areas are likely to engage in evasive behavior or changes in their behavioral state. As a result, these 671 instances of evasive behavior or changes in behavioral state over a twelve-month period are not likely to kill, injure, change the energy or time budget, or cause sustained

physiological stress responses that might result in stress pathology in animals with the energy reserves of humpback whales. Therefore, we do not expect those exposure events to cause humpback whales to strand, suffer injury, die, experience measurable changes in their energy or time budgets, engage in life history trade-offs, or change their social interactions. More importantly, we would not expect humpback whales exposed to active sonar to experience acute reductions in their reproductive success over the next calendar year or in the reproductive success we would expect in future years.

Instead, humpback whales are likely to incur "canonical costs" as a result of these 671 exposure events; however, we do not expect 671 exposure events that result in short-term evasive behavior or changes in behavioral state to translate into chronic or cumulative reductions in the current or expected future reproductive success of these humpback whales. Therefore, the 20 SURTASS LFA sonar missions the U.S. Navy proposes to conduct are not likely to affect the performance of the populations the individual humpback whales represent or the species those populations comprise. By extension, we would not expect those sonar missions to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

6.4.5 North Pacific Right Whale

The exposure-response-risk analysis for the North Pacific right whale is presented in this section.

Exposure Analysis

Very little is known of the population size and distribution of right whales in the North Pacific and very few of these animals have been seen in the past 20 years. Nevertheless, Brownell et al. (2001) identified the waters within about 200 miles of the coast of Japan, including outlying islands as accounting for 37.4 percent of right whale sightings since 1900 in the Pacific. Best et al. (2001) suggested the Ryuku Islands, Yellow Sea, and Sea of Japan as important breeding and calving areas for Pacific right whales. The winter distribution of right whales in the Pacific remains unknown, although some right whales have been sighted as far south as 27ºN in the eastern North Pacific (Best et al. 2001). Right whales have also been sighted in Hawaii (Herman et al. 1980), California (Scarff 1986), Washington, and British Columbia.

The U.S. Navy's exposure models identified two instances in which North Pacific right whales might be exposed to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2011 through mid-August 2012 (see Table 8 and **Error! Reference source not found.**). One exposure event might occur in the North Phillipine Sea operating area and the second might occur in the Sea of Japan Operating Area. We do not have the data we would need to estimate the probable ages or genders those right whales might represent, so we assume that those individuals might represent any gender or age.

Response Analysis

A review of the reactions of fin, humpback, right and minke whales exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay is informative. Watkins (1986b) concluded that underwater sound was the primary cause of a reaction in these species of whales and that whales responded to acoustic stimuli in their range of hearing. Nevertheless, he 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. Although these data were

limited in time (they only covered 25 years of time, which may represent only one generation for some species of cetaceans) and spatial extent, they represent data from an area where right whales (in this case, North Atlantic right whales) would have been expected to exhibit somewhat long-term effects of masking from continuous shipping and industrial noise. Given that whales in Cape Cod Bay reacted negatively to these continuous sources of anthropogenic sounds only under specific circumstances and, over time, habituated to these sounds (rather than abandon the area), it seems unlikely that masking from an intermittent source like SURTASS LFA sonar would appreciably affect North Atlantic right whales. We assume that this conclusion would also apply to North Pacific right whales.

Although the number of studies is limited, the available evidence suggests that at received levels below 180 dB, exposure to LFA sonar transmissions are not likely to result in injury, masking, stranding, resonance effects, or other behavioral effects in North Pacific right whales. The best scientific and commercial data available suggest that LFA sonar transmissions could elicit short-term behavioral responses in North Pacific whales, as it would other baleen whales. However, those responses are not known to have long-term, adverse consequences for the biology or ecology of the individual whales exposed to the LFA signal. For example, the information available on bowhead whales, which have very sensitive hearing and are extremely sensitive to noise, suggests that bowhead whales will alter their migratory pathways to avoid industrial sound sources and may reduce their calling rates (Richardson et al. 1995), although these reactions varied by season and ambient sound levels.

More importantly, the best scientific and commercial data available suggest that exposure to SURTASS LFA sonar may have short-term, adverse effects on individual whales, but that exposure should not elicit responses that suggest adverse effects on the ability of baleen whales like North Pacific right whales to forage, detect predators, select a mate, or reproduce successfully. We also would not expect these responses to be symptomatic of chronic stress that might depress a whale's immune responses and increase their susceptibility to disease. At received levels between 120 and 180 dB re 1µPa, the information available would not lead us to expect North Pacific right whales to respond in ways that would reduce their reproduction, numbers, or distribution. Based on the performance of the SURTASS LFA sonar system and the mitigative measures the Navy uses with the sonar system over the past eight years, we do not expect any baleen whales to be exposed to received levels equal to or greater than 180 dB.

Risk Analysis

Numerous studies of the ecology of populations have demonstrated the relationship between a population's reproduction (which includes fecundity schedules, age at maturity, and reproductive lifespan), numbers (which includes age- or stage-specific abundance and survival rates), or distribution (which includes the number of populations and sub-populations, immigration rates, and emigration rates), and a population's risk of extinction (summarized in (Stearns 1992), see also (Caswell 1980; Caswell 2000; Caswell 2001; Gotelli 2001; McEwen and Wingfield 2003; Stark et al. 2004). In the absence of behavioral responses that reduce a population's reproduction, numbers, or distribution, the information available leads us to conclude that exposure to LFA sonar transmissions are likely to elicit short-term responses in North Pacific right whales that are known to have no long-term, adverse consequences for the biology or ecology of the individual whales exposed to an LFA signal.

Instead, the North Pacific right whales involved in the two exposure events that are likely to occur over the next 12 months are likely to incur "canonical costs" as a result of their exposure; however, we do not expect those two exposure events to result in short-term evasive behavior or a change in behavioral state to translate into chronic or

cumulative reductions in the current or expected future reproductive success of North Pacific right whales. Therefore, the SURTASS LFA sonar mission the U.S. Navy proposes to conduct in the North Phillippine Sea or offshore of Japan (which are the only missions that might result in exposing North Pacific right whales) are not likely to affect the performance of the single population of North Pacific right whales or the species that population represents. By extension, we would not expect those sonar missions to appreciably reduce the North Pacific whales' likelihood of surviving and recovering in the wild.

6.4.6 Sei Whale

The exposure-response-risk analysis for the sei whale is presented in this section.

Exposure Analysis

The U.S. Navy's exposure models identified about 53 instances in which sei whales might be exposed in the North Pacific to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2010 through mid-August 2011 (see Table 8 and **Error! Reference source not found.**). Navy models estimate that none of these whales are likely to be exposed to SURTASS LFA sonar trans-missions during other LFA missions the U.S. Navy plans to conduct from mid-August 2011 through mid-August 2012.

As discussed in the Status of the Species section of this Opinion, sei whales migrate over long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999a). Sei whales are often associated with deeper waters and areas along the continental shelf edge (Hain et al. 1985); however, this general offshore pattern of sei whale distribution is disrupted during occasional incursions into more shallow and inshore waters (Waring et al. 2004). 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° to 23°N (Gambell 1995; Masaki 1977). Horwood (1987) reported that 75 – 85 percent of the North Pacific population of sei whales resides east of 180° longitude.

Given that LFA sonar missions are planned for areas in which sei whales are known to occur at times when sei whales are likely to occur in those areas and given the spatial area ensonified by 'pings' from low-frequency active sonar are relatively large (pings remain above ambient sound levels for hundreds of kilometers), sei whales seem likely to be exposed to at least one of these pings. Nevertheless, the U.S. Navy identified about 53 instances in which sei whales might be exposed to mid-frequency active sonar each year during exercises they plan to conduct in the Hawai′i Operating Area. This conclusion implies that the density of sei whales in the Hawai′i Operating Area is not so low that these whales would not be exposed to mid-frequency active sonar in this area. Given that the area ensonified by low-frequency active sonar is substantially greater than the area ensonified by mid-frequency active sonar, if sei whales are likely to be exposed to mid-frequency active sonar in the Hawai'i Operating Area, they also seem likely to be exposed to low-frequency active sonar as well.

Based on the limited information available, we cannot estimate the number of sei whales that might be exposed to LFA sonar transmissions, which missions areas the exposure is likely to occur in, or the received levels associated with any exposure. However, we would expect at least one group, as sei whales generally travel in small groups of

up to six whales (Perry et al. 1999a), to occur in an area ensonified by low-frequency active sonar during one or more of the missions the U.S. Navy plans to conduct between mid-August 2011 and mid-August 2012.

Response Analysis

As discussed in the Status of the Species section of this Opinion, we have very limited information on the sounds produced by sei whales or their sensitivity to sounds in their environment; however, the information that is available suggests that they vocalize in the same frequency range as fin whales. Further, 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. Based on these similarities, we assume that the responses of sei whales exposed to received levels of LFA sonar would be similar to those of blue and fin whales.

Risk Analysis

The best scientific and commercial data available leads us to conclude that, like blue and fin whales, exposing sei whales to SURTASS LFA sonar may constitute an adverse experience in the life of individual sei whales, but is not likely to reduce the longevity or reproductive success of those whales. Consequently, that exposure is not likely to adversely affect the population dynamics of sei whales in ways that would be sufficient to reduce their reproduction, numbers, or distribution. As a result, these transmissions would not be expected to appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

6.4.7 Sperm Whale

The exposure-response-risk analysis for the sperm whale is presented in this section.

Exposure Analysis

The U.S. Navy's exposure models identified about 954 instances in which sperm whales might be exposed to SURTASS LFA sonar transmissions at received levels between 120 and 180 dB from mid-August 2011 through mid-August 2012, although the number of exposure events involving sperm whales also varies among the mission areas. The largest proportion of these exposure events are expected to occur in the Hawai'i Operating Areas or the North Phillippine Sea (see Table 8 and **Error! Reference source not found.**).

Because we have almost no information on the number or density of sperm whales that might actually occur in the various operating areas or their affinity for those waters, we must assume that those individuals could represent any gender or age.

Response Analysis

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). 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. 1999b). 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.

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_{rms} from impulsive sounds produced by 1 g TNT detonators (Madsen and Mohl 2000). 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_{rms} 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_{rms} (Johnson 2003).

A recent study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 µPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall-Howard 1999). Recent data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001a; Stone 2001b; Stone 2003). However, the compilation and analysis of the data led the author to conclude that seismic surveys did not result in observable effects to sperm whales (Stone 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

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 146 dB re 1 μPa_{rms} over octave band with most energy, the whales did not avoid the vessel or change their feeding efficiency (Madsen et al. 2002). 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. However, these responses are not likely to be sufficient to reduce the fitness of individual whales.

Risk Analysis

Based on our response analyses, over the next 12 months we expect 954 events in which individual sperm whales might be exposed to SURTASS LFA sonar transmissions and engage in evasive behavior or changes in their behavioral state each year as a result of that exposure. Because these 954 exposure events are expected to occur in different areas of the North Pacific Ocean, we assume that different sperm whales would be exposed, although individual sperm whales might be exposed multiple times on a single mission area. Regardless, only a small percentage of the sperm whales that occur in the different mission areas are likely to engage in evasive behavior or changes in their behavioral state. As a result, these 954 instances of evasive behavior or changes in behavioral state over a twelve-month period are not likely to kill, injure, change the energy or time budget, or cause sustained physiological stress responses that might result in stress pathology in animals with the energy reserves of sperm whales. Therefore, we do not expect those exposure events to cause sperm whales to strand, suffer injury, die, experience measurable changes in their energy or time budgets, engage in life history trade-offs, or change their social interactions. More importantly, we would not expect sperm whales exposed to active sonar to experience acute reductions in their reproductive success over the next calendar year or in the reproductive success we would expect in future years.

Instead, sperm whales are likely to incur "canonical costs" as a result of these 954 exposure events; however, we do not expect 954 exposure events that result in short-term evasive behavior or changes in behavioral state to translate into chronic or cumulative reductions in the current or expected future reproductive success of these sperm whales. Therefore, the 20 SURTASS LFA sonar missions the U.S. Navy proposes to conduct are not likely to affect the performance of the populations sperm whales represent or the species those population comprise. By extension, we would not expect those sonar missions to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

6.4.8 Hawaiian Monk Seal

The exposure-response-risk analysis for the Hawaiian monk seal is presented in this section.

Exposure Analysis

Although Hawaiian monk seals generally reside in coastal waters near haulout areas, they forage in deep water and dive to at least 490 m (1,608 ft) (Reeves et al. 1992), which could expose them to low frequency sounds from SURTASS LFA. The U.S. Navy's exposure models identified 31 instances in which Hawaiian monk seals might be exposed to SURTASS LFA transmissions at received levels ranging between 120 dB and 180 dB (see **Error! Reference source not found.**).

Response Analysis

If exposed to LFA sonar transmissions, the evidence available suggests that Hawaiian monk seals may detect LFA transmission. However, that exposure is not likely to kill or injure monk seals or cause them to experience temporary or permanent shifts in hearing sensitivity. As a result, the best scientific and commercial data available suggests that exposing Hawaiian monk seals, to LFA sonar transmissions is not likely to elicit short-term responses or responses that are known to have long-term, adverse consequences for the biology or ecology of monk seals. Therefore exposing monk seals to LFA sonar is not likely to adversely affect the fitness (longevity and reproductive

success) of individual members of these species and, based on the evidence available, does not appear likely to predispose them to experience fitness consequences when exposed to other stressors in their environment.

Risk Analysis

For these reasons, we conclude that exposing Hawaiian monk seals to SURTASS LFA sonar may constitute an adverse experience in the life of individual monk seals, but is not likely to reduce the longevity or reproductive success of those monk seals. Consequently, that exposure is not likely to adversely affect the population dynamics of Hawaiian monk seals in ways that would be sufficient to reduce their reproduction, numbers, or distribution. As a result, these transmissions would not be expected to appreciably reduce the Hawaiian monk seal's likelihood of surviving and recovering in the wild.

6.4.9 Sea Turtles

The exposure-response-risk analysis for sea turltes is presented in this section.

Exposure Analysis

Green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles could be exposed to SURTASS LFA sonar transmissions during the 20 missions the U.S. Navy proposes to conduct over the next twelve months. Green sea turtles that are exposed to these transmissions outside of the Hawai′i Operating Area probably will probably have originated from nesting aggregations in Australia; with the range complex, they will probability have originated from nesting aggregations in the Hawaiian Archipelago. If LFA sonar transmissions interact with loggerhead sea turtles, they will have originated from the Japanese nesting aggregations. If LFA sonar transmissions interact with leatherback sea turtles, they probably will have originated with nesting aggregations in Malaysia, Indonesia, West Papua, Papua-New Guinea (given its depressed condition, interactions with leatherback turtles from the Malaysian population have very small probabilities).

Because of limitations in our knowledge of sea turtles, we cannot estimate the number of individual sea turtles that are likely to be exposed to LFA sonar transmissions. We do not have population estimates for most populations of these sea turtles in the Pacific Ocean and know so little of the distribution in different areas of the Pacific Ocean that we could not estimate their relative abundance in the water column (with the exception of some areas around Australia). NMFS has struggled with this problem for several years with little success: our estimates of the number of sea turtles that interact with fisheries, for example, is based solely on the number of sea turtles that are captured in the fisheries because we have no way of estimating the number of sea turtles actually in the water column at any particular time in any particular area.

Nevertheless, sea turtles are not randomly distributed in the ocean. The associate with ocean fronts and eddies in the Pacific (Polovina et al. 2004). Loggerhead turtles representing several developmental stages are likely to occur in the waters around and east of Japan, including hatchlings being passively transported to rearing habitats elsewhere in the Pacific, adult or sub-adult females migrating to or from nesting beaches in Japan, and adult or sub-adult males. Because they tend to occur in shallower, surface waters where the sound field would be dominated by sounds produced by winds and waves, hatchling sea turtles are not likely to be exposed to LFA sonar transmissions. Adult and sub-adult sea turtles are known to associate with eddies and fronts associated with the southern edge of the Kuroshio Extension Current (between 28º and 40º N latitudes, from 160º west longitude east). These turtles spend

about 40 percent of their time at the surface and 90 percent of their time at depths less than 40 m. As a result, they tend to spend most of their time at depths where the sound field would be dominated by background sounds, even during sonar transmissions. However, some of their dives take them to depths where they could be exposed to LFA sonar transmissions.

Response Analysis

The information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz; (Bartol et al. 1999a; Lenhardt 1994; Lenhardt et al. 1983; O'Hara and Wilcox 1990; Ridgway et al. 1969). Ridgway et al. (1969) concluded that green turtles have a useful hearing range of perhaps 60 Hz to 1,000 Hz, but their best hearing occurs in the range of about 200 Hz to 700 Hz. These values probably apply to all four of the hardshell turtles (i.e., the green, hawksbill, loggerhead, and olive ridley sea turtles).

McCauley et al. (2000) studied the response of green and loggerhead sea turtles to 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. They reported that the sea turtles responded consistently above received levels of about 166 dB re 1 µPa: they increased their swimming activity compared to periods during which the airgun was not operating. Above 175 dB re 1 µPa their behavior became erratic and might have indicated an agitated state.

O'Hara and Wilcox (1990) exposed loggerhead sea turtles to low-frequency sound from two types of seismic airguns with source levels approximating 256 and 262 dB re 1µPa (the paper does not state whether this was peak, peak-to-peak, or root mean square). With airguns firing at a rate of four times per minute and source levels of 256 dB, the distribution of the loggerhead sea turtles was not significantly different than during control trials. When they increased source levels to about 262 dB, the sea turtles avoided the seismic airgun when it fired at four or eight times per minute. Although the sound source in this experiment is not directly comparable to LFA sonar, the results of this study illustrate the relative insensitivity of sea turtles (at least loggerhead sea turtles) to low-frequency sound. Based on this information sea turtles exposed to received levels of active low-frequency sonar may hear the sound. They are likely to experience physiological stress or physical discomfort if they are exposed at received levels greater than 180 dB and are likely to swim away to avoid continued exposure. At received levels lower than 180 dB, the evidence available leads us to conclude that sea turtles are not likely to respond to that exposure.

Risk Analysis

Based on this information sea turtles exposed to received levels of active low-frequency active sonar may hear the sound and are likely to experience physiological stress or physical discomfort if they are exposed at received levels greater than 180 dB and are likely to swim away to avoid continued exposure; at received levels lower than 180 dB, the evidence available leads us to conclude that sea turtles are not likely to respond to that exposure. Given the small number of times individual sea turtles are likely to be exposed to LFA sonar, the short duration of exposure events, and the low number of repeated exposure events (if any), we would not expect individual green sea turtles, hawksbill sea turtles, leatherback sea turtles, loggerhead sea turtles, and olive ridley sea turtles to experience reductions in their current or expected future reproductive success as a result of their exposure to SURTASS LFA sonar. As a result, we would not expect those exposures to have measurable effect on the status or trend of the populations those sea turtles might represent or the continued existence of green sea turtles, hawksbill sea turtles, leatherback sea turtles, loggerhead sea turtles, and olive ridley sea turtles as those species have been listed.

6.5 Effects of the HF/M3 Sonar

The source level required for the HF/M3 sonar to effectively detect marine mammals (and possibly sea turtles) out to the 180-dB LFA mitigation zone under the most adverse oceanographic conditions (low echo return and high ambient noise) is on the order of 220 dB re 1 µPa at 1 m (rms). The Navy designed the HF/M3 sonar and its employment to be as benign as possible within the marine environment in order to minimize potential effects to marine mammals and sea turtles (see NMFS 2002), biological opinion for a complete discussion of these features).

The HF/M3 sonar operated with a similar signal type, power level, and frequency as "fish finder" sonar. The evidence available suggests that this sonar does not harm or harass individual fish, schools of fish or marine mammals that prey on schools of fish. Further, as low-frequency hearing specialists, sea turtles are not likely to perceive the HF/M3 sonar. The use of HF/M3 sonar is intended to detect marine mammals within the LFA mitigation zone. This sonar provides monitoring capabililties out to 2 to 2.5km (1.08 to 1.35 nm). Testing documented in the final SURTASS LFA EIS (Navy 2007c) fould that HF/M3 sonar has a 95 percent probability of detecting most marine mammals in the LFA mitigation zone (NMFS 2007a). Finally, the use of operational procedures such as ramp up, further reduce the potential effects of the HF/M3 sonar on marine mammals and sea turtles to negligible levels. As a result, NMFS concludes that the employment of the HF/M3 sonar is not likely to adversely affect threatened or endangered species of marine mammals or sea turtles.

6.6 Cumulative Impacts (in the sense of NEPA)

Several organizations have argued that several of our previous biological opinions on the U.S. Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them. In each instance, we have 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 here: potential interactions between stressors associated with the activities the U.S. Navy plans to conduct on the Mariana Islands Range Complex, offshore of Japan, and on the Hawai'i Operating Area 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 "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 (Relyea 2009; 2003; 2005; 2001) 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 between mid-frequency active sonar and LFA 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 proposed SURTASS LFA missions will add low-frequency sound to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment, including listed species. During transmissions, LFA sonar will add to regional noise levels. However, there are no reliable methods for assessing potential interactions between these sound sources. In Environmental Impact Statements the U.S. Navy prepared for mid-frequency active sonar training exercises on several of their range complexes, the Navy conducted computer simulations to assess the potential cumulative impacts of mid-frequency active sonar. Those assessments concluded that the "cumulative impacts" of mid-frequency sonar would be "extremely small" because exercises would occur for a relatively short period of time, for relatively short periods of time in any given area; active sonar systems would not be stationary, and the information available suggests that the effects of any mid-frequency exposure would stop when transmissions stop.

Although the SURTASS LFA and MFA (AN/SQS 53C and AN/SQS 56) sonars are similar in the underlying transmission types, specifically frequency-modulated (FM) sweeps and continuous wave (CW) transmissions, LFA and MFA sonars are dissimilar in other respects (i.e., source level, pulse length, bandwidth). The duty cycle, (i.e., the amount of time *during sonar operations* that the sonar is actually transmitting), is different for SURTASS LFA sonar as opposed to MFA sonar. During SURTASS LFA sonar operations, LFA sonar transmits approximately 10% of the time (1 minute out of 10). During MFA sonar operations, MFA sonar transmits approximately 3.2% of the time (1 second out of 60 to 90 seconds). This means that for any given period of time that both SURTASS LFA and MFA sonars are operating concurrently, the most an animal could be simultaneously exposed from both transmissions is 1 sec for every 600 sec, or about 0.17% of the time that both sonars are operating.

The greatest risk of cumulative impacts from active sonar is likely to result from the behavioral and physiological responses of endangered and threatened species when they are exposed to ship traffic, active sonar, and explosions associated with U.S. Navy training exercises and other human activities in the various mission areas. For example, in July 2008, the U.S. Navy conducted a Rim of the Pacific Exercise; between August 2009 and August 2010, the U.S. Navy plans to conduct two Undersea Warfare Exercises; LFA sonar transmissions associated with six SURTASS LFA missions; about 180 anti-submarine warfare tracking exercises, 19 bombing exercises; 18 anti-surface warfare torpedo exercises; and about 250 anti-submarine warfare torpedo exercises. Over the same time interval, NMFS and the State of the Hawai'i are almost certain to prosecute commercial fisheries that are likely to expose marine mammals in waters off Hawai'i to fishing gear and fishing vessels; scientists and operators of whale watch vessels will make several hundred close approaches of marine mammals for research; and commercial and recreational vessel traffic (including the Hawai'i Superferry) will engage in hundreds of transits among the main

Hawaiian Islands. If individual blue, fin, humpback, sei, and sperm whales, Hawaiian monk seals, and endangered and threatened sea turtles are be exposed to one or more stressors associated with these activities, those exposures might interact to have consequences for those individuals that would not occur if they were only exposed to single stressors.

Depending on the timing of SURTASS LFA sonar missions off Japan and whether those missions coincide with training exercises the U.S. Navy conducts off Japan, endangered and threatened species in those waters might be exposed to LFA sonar transmissions at the same time they are exposed to ship traffic associated with aircraft, surface vessels, and submarines engaged in command and control activities, anti-air warfare (missile exercises and defensive counter air), anti-surface warfare (maritime interdiction, air interdiction of maritime targets, sink exercise), antisubmarine warfare, and strike warfare.

In June 2006 and 2007, the U.S. Navy conducted a Valiant Shield exercise off Guam in the western Pacific. Valiant Shield 2006 entailed 28 Navy vessels, more than 300 aircraft and more than 20,000 service members from the U.S. Navy, Air Force, Marine Corps, and Coast Guard. The 2006 Valiant Shield involved carrier strike groups associated with three aircraft carrier — the USS ABRAHAM LINCOLN, USS KITTY HAWK, and USS RONALD REAGAN — as well as the R/V CORY CHOUEST and USNS IMPECCABLE. Several submarines also participated in the exercise. The 2007 Valiant Shield exercises lasted for about a week and 7 to 10 days and produced slightly more than 1,200 hours of mid-frequency active sonar.

During the Valiant Shield exercise that the U.S. Navy conducted off Guam in 2007, the Navy estimated that there might be about 390 instances in which fin whales might be exposed to mid-frequency active sonar and 675 instances in which sperm whales might be exposed to LFA sonar (Navy 2007a). For MFA sonar exposures, the Navy expected individual whales to have accumulated acoustic energy in excess of 173 dB. In addition, the Navy concluded that one sperm whale might be exposed to underwater detonations during each of the exercises.

Depending on the timing of SURTASS LFA sonar missions off Guam and whether those missions coincide with training exercises the U.S. Navy conducts in the Marianas Range Complex, endangered and threatened species in those waters might be exposed to LFA sonar transmissions at the same time they are exposed to ship traffic associated with aircraft, surface vessels, and submarines engaged in command and control activities, anti-air warfare (missile exercises and defensive counter air), anti-surface warfare (maritime interdiction, air interdiction of maritime targets, sink exercise), antisubmarine warfare, and strike warfare.

Since 1997, the U.S. Navy has sponsored biennial joint training exercises in the western Pacific Ocean with the Australian military and other participants (which have occurred under the names Tandem Thrust or Talisman Sabre). The exercises have been conducted in and around training areas in Australia (1997, 2001, 2005, and 2007) or in and around the Guam and the Northern Mariana Islands (2000 and 2003). From 14 April to 5 May 2003, these exercises involved 17 ships and submarines, including the aircraft carrier USS CARL VINSON and the USS ESSEX Amphibious Ready Group. Although we do not have information on the number of hours of active sonar that had been employed during most of these exercises, more information is available for some of the recent exercises conducted in the Marianas Range Complex.

In September 2010, the U.S. Pacific Command conducted Valiant Shield 2010 exercise off Guam. A Navy carrier strike group and amphibious ready group participated in the exercise. The USNS ABLE (T-AGOS 20) was part of the exercise, with 8.4 hours of active transmissions over the course of the exercise. Other planned exercises (e.g., USWEX, Joint Multi-Strike Group Exercise) may include SURTASS LFA sonar in 2011 and 2012.

In the Hawaii Range Complex, the Navy conducted RIMPAC 2010 in June and July. SURTASS LFA sonar did not participate in this exercise. Currently, there are no plans for SURTASS LFA sonar to participate in RIMPAC 2012 or other planned exercises (e.g., USWEX, Joint Multi-Strike Group Exercise).

Despite the scale of the exercises, the evidence available suggests that endangered and threatened species of marine mammals probably were not exposed to active sonar during the exercise. Although the Navy and NMFS estimated that there might be about 150 instances in which blue whales would be exposed to mid-frequency active sonar, 60 instances in which fin whales might be exposed to this sonar, 280 instances in which humpback whales might be exposed to this sonar, and 1,670 instances in which sperm whales might be exposed to this sonar (Navy 2007a; Navy 2007b), independent monitoring associated with the exercise did not observe any endangered or threatened marine mammals (although 70 dolphins and beaked whales were detected and one sea turtle).

Many other countries have naval vessels that employ low- and mid-frequency active sonar and the endangered and threatened species we consider in this Opinion are probably exposed to those sonar systems at some point in their migrations (with the possible exception of Hawaiian monk seals). However, we do not have information on the frequency range of those sonar systems, the number of training exercises those navies conduct each year, where the training occurs, and the number of hours of active sonar those navies use during training exercises. Nevertheless, if endangered or threatened species were exposed to those sonar transmissions as well as active sonar employed by the U.S. Navy, the combined exposure could produce effects that we would not expect if those same species were only exposed to one sonar system.

Richardson et al. (1995) provided extensive information and arguments about the potential cumulative effects of man-made noise on marine mammals. Those effects included masking, physiological effects and stress, habituation, and sensitization. Those concerns were echoed by Clark and Fristrup (2001) and others. Although all of these responses have been measured in terrestrial animals reacting to airborne, man-made noises, those studies are counterbalanced by studies of other terrestrial mammals that did not exhibit these responses to similar acoustic stimuli.

The evidence available does not allow us to reach any conclusions about potential cumulative effects of LFA sonar, mid-frequency active sonar the Navy is using for other training activities in waters off Japan, Guam, and in the Hawai'i Operating Area, and other stressors that exist in the marine environment. However, based on the available evidence, these activities are most likely to have interactive effects on humpback whales because their vocalizations include low-frequency components and have an upper frequency limit reaching as high as 24 kHz (Au et al. 2006). As a result, it is reasonable to assume that the low- and mid-frequency active sonars are within the hearing and vocalization range of humpback whales.

Because both sources of active sonar are within their hearing range, humpback whales might experience masking and might have to make vocal adjustments when exposed to both low- and mid-frequency active sonar. By comparison, blue fin, gray, North Pacific right, and sei whales are low-frequency hearing specialists, are not likely to respond to mid-frequency active sonar, and are not likely to respond to interactions between the two types of sonar. Sperm whales are not likely to respond to interactions between low- and mid-frequency active sonar because their hearing sensitivity does not overlap with the range of low-frequency active sonar.

In addition, because some individual humpback whales have been reported to migrate between waters off Hawai′i and Japan, those individuals might be exposed to low- and mid-frequency active sonar in both locations. Similarly, individual humpback whales have been reported to migrate between waters off Hawai′i and waters of southern California and might be exposed to mid-frequency active sonar in both locations. Although we do not have specific information that allows us to make the same statements about blue, fin, gray, North Pacific right, sei, and sperm whales, their migratory patterns probably cause them to be exposed to low- and mid-frequency active sonar elsewhere in the North Pacific Ocean.

Although our conceptual assessment model allows us to assess potential interactions between sonar systems and between sonar exposures and other stressors, the information we would need to conduct such assessments is not available. However, some of the data available might suggest that the combination of stressors has not had an adverse effect on at least humpback whales. For example, we could point to the increasing abundance of humpback whales over the past 30 years and infer that the status of these whales has improved despite the combination of natural and anthropogenic stressors in those waters. As a result, the existing stress regime in waters off Hawai'i would not reduce the performance of the humpback whales that winter in waters off Hawai'i. That inference is certainly consistent with the evidence available and it might be appropriate to extend that inference to the other endangered and threatened species in waters off Hawai'i (for example, the Hawaiian nesting aggregation of green sea turtles has increased in abundance over the past 30 years as well).

Other inferences, however, that would undercut that inference are also consistent with the evidence. If humpback whales in waters off Hawai'i were an isolated and resident population, it would be appropriate to infer that the existing stress regime has not reduced their performance as a population. Because that is not the case and the humpback whales that winter in Hawai'i migrate there from foraging areas across the North Pacific Ocean (humpback whales have been reported to migrate to Hawai'i from foraging areas in Russian, the Bering Sea, Aleutian Islands, western Gulf of Alaska, southeast Alaska, and British Columbia) (Calambokidis et al. 2008). One inference that is consistent with the data is that the increase in humpback whales reflects conditions in foraging areas that allow their numbers to increase despite conditions in Hawai'i (the corollary being that as those conditions change, the population’s performance would change). Another inference that is consistent with the evidence available is that humpback whales continue to migrate to Hawai'i during the winter because these are their traditional wintering areas or because conditions in alternative wintering areas are worse.

The information available does not allow us to determine whether or to what degree there are any interactions between SURTASS LFA sonar missions, other activities the U.S. Navy is conducting or plans to conduct in Hawai'i, and other natural and anthropogenic stressors in the Action Area. The evidence available suggests that the population of at least humpback whales that winters in the Action Area has increased for the past 10 to 20 years,

despite the stress regime in those waters and that this increase does not mask demographic phenomena that are likely to reverse this trend in the future (for example, biases in the percentage of males or females in the population; gaps in the age structure of the population; reduced recruitment into the adult population; or a shift in the percentage of females with high reproductive success relative to the rest of the adult female population). Based on the admittedly limited evidence available, LFA sonar missions are not likely to interact to produce interactive, synergistic, or multiplicative effects that are greater than the effects considered elsewhere in this Opinion.

6.7 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.

7 CONCLUSION

After reviewing the current status of blue whales, fin whales, Western North Pacific gray whales, humpback whales, North Pacific right whales, sei whales, sperm whales, Steller sea lion (eastern population), Hawaiian monk seals, green sea turtle, hawksbill sea turtle, loggerhead sea turtle, olive ridley sea turtle, leatherback sea turtles, and Pacific salmon ESUs and DPSs, the environmental baseline for the action area, the effects of the Navy's SURTASS LFA activities and the cumulative effects, it is NMFS' biological opinion that the Navy's proposal to conduct SURTASS LFS activities from August 2011 through August 2012 are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

The opinion also concluded that SURTASS LFA activities the U.S. Navy plans to conduct are not likely to adversely affect critical habitat that has been designated for endangered or threatened species in the action area. Therefore they are not likely to result in the destruction or adverse modification of that habitat.

8 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 an Incidental Take Statement (ITS).

The measures described below, which are non-discretionary, must be implemented by NMFS' Permits, Conservation and Education Division so they become binding conditions of any permit issued to the U.S. Navy, as appropriate, in order for the exemption in section 7(o)(2) to apply. NMFS' Permits, Conservation, and Education Division has a continuing duty to regulate the activity covered by this Incidental Take Statement. If NMFS' Permits, Conservation and Education Division (1) fails to require the U.S. Navy to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

8.1 Amount or Extent of Take Anticipated

The effects analysis contained in this Opinion concluded that individual blue whales, fin whales, western Pacific gray whales, humpback right whales, sei whales, sperm whales, and Hawaiian monk seals and listed sea turtles have small probabilities of being exposed to the proposed operations of the SURTASS LFA sonar system in the Pacific Ocean. Any animals that would be exposed to LFA sonar transmissions would occur in portions of the Archipelagic Deep Basins Province, North Pacific Tropical Gyre (West) Province, North Pacific Tropical Gyre (East) Province, and Western Pacific Warm Pool Province in the Pacific Trade Wind Biome; the Kuroshio Current Province and Northern Pacific Transition Zone Province in the Pacific Westerly Winds Biome; the North Pacific Epicontinental Sea Province in the Pacific Polar Biome; and the China Sea Coastal Province in the North Pacific Coastal Biome.

Any threatened or endangered species that are exposed to LFA sonar transmissions may elicit behavioral responses that might be considered "harassment." NMFS does not expect any threatened or endangered species to be injured or killed as a result of exposure to LFA sonar transmissions (refer to the Effects of the Action section of this Biological Opinion and the August 2007 Biological Opinion on SURTASS LFA for further discussion).

The section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or the extent of land or marine area that may be affected by an action, if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (Federal Register 51, 3 June 1986, page 19953).

The amount of take resulting from LFA sonar transmissions was difficult to estimate because we have no empirical information on (a) the actual number of listed species that are likely to occur in the action area, (b) the actual number of individuals of those species that are likely to be exposed to LFA sonar transmissions, (c) the circumstances associated with any exposure, and (d) the range of responses we would expect different individuals of the different species to exhibit upon exposure.

Because this information was not available, this biological opinion relied on the Navy's computer simulations to estimate the "number" of certain marine mammals that might be harassed during the employment of SURTASS LFA sonar; the results of these simulations appear in Table 8 and **Error! Reference source not found.**. Because these estimates were produced by computer simulations, they should not be treated literally; instead, they should be treated as an index of the order of magnitude of potential exposure rather than the actual number of animals that would be exposed.

For the purposes of this biological opinion and incidental take statement, we assumed that any non-zero value in Table 8 indicated that an individual whale had a probability of being exposed to received levels that might be expected to result in behavioral responses characteristic of an animal that has been harassed. That assumption results in the estimates shown in Table 10.

Table 10. The number of endangered whales and pinnipeds that are likely to be "taken" in the form of harassment as a result of their exposure to U.S. Navy Surveillance Towed Array Sensor System Low Frequency Active Sonar.

Species	Total
Blue Whale	55
Fin Whale	247
Western Pacific Gray Whale	1
Humpback Whale	672
North Pacific Right Whale	2
Sei Whale	52
Sperm Whale	954
Hawaiian Monk Seal	31

Take of these species will have been exceeded if the monitoring program detects any individuals of these species that have been harmed, injured, or killed as result of exposure to LFA sonar transmissions (from which NMFS might infer that they had been exposed to received levels greater than 180 dB).

We did not conduct computer simulations for sea turtles because the data necessary to develop computer models were not available. In the *Exposure Analysis* subsection of this biological opinion, we established that we could not assign numerical limits for take estimates. Rather than specifying an amount of take for sea turtles, this incidental take statement specifies an extent of take as follows:

a. *Sea turtles*. Adult and sub-adult sea turtles may be taken, in the form of harassment, in the LFA mitigation zone and the additional buffer zone required by the letters of authorization. (Because they tend to remain at or within a few meters of the ocean surface, we do not expect hatchling or juvenile sea turtles to be exposed

to LFA sonar transmissions.) Because of their size and the density of their shells, we assume that the Navy's monitoring programs, particularly the HFM3 sonar system, will detect these larger turtles if they are in the mitigation zone. Take will have been exceeded if the monitoring program detects sea turtles that have been harmed, injured, or killed as result of exposure to LFA sonar transmissions.

8.2 Effect of the Take

In the accompanying biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species. The proposed action would not likely result in destruction or adverse modification of critical habitat. Studies of marine mammals and LFA sonar transmissions have shown behavioral responses by blue whales, fin whales, gray whales, and humpback whales to LFA sonar transmissions. Although the biological significance of the animal's behavioral responses remains unknown, exposure to LFA sonar transmissions could disrupt one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population. For the proposed action, behavioral responses that result from LFA sonar transmissions and any associated disruptions are expected to be temporary and would not affect the reproduction, survival, or recovery of these species.

8.3 Reasonable and Prudent Measures

The National Marine Fisheries Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. The authorization shall be valid for a period 16 August 2011 through 15 August 2012.

2. The authorization shall be valid only for the unintentional taking of endangered or threatened sea turtles and the species of marine mammals identified in 50 CFR 216.180(b) and condition 3(c) of the Authorization governing the taking of these animals incidental to the activity specified below and shall be valid only for takings consistent with the terms and conditions set out in 50 CFR 216.182 and the terms of NMFS' Letters of Authorization.

3. NMFS' Permits, Conservation and Education Division shall require the U.S. Navy to implement a program to mitigate the potential effects of LFA sonar transmissions on threatened or endangered species as specified in the final regulations for the Taking of Marine Mammals Incidental to Operation of the Surveillance Towed Array Sensor System Low Frequency Active Sonar (50 CFR 216 Subpart Q).

4. NMFS' Permits, Conservation and Education Division shall require the U.S. Navy to implement a program to monitor potential interactions between LFA sonar transmissions and threatened or endangered species.

8.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Endangered Species Act of 1973, as amended, NMFS' Permits, Conservation and Education Division and the U.S. Navy must comply with the following terms and

conditions, which implement the reasonable and prudent measures described above and outline reporting and monitoring requirements, as required by the section 7 regulations (50 CFR 402.14(i))

1. The authorization shall be valid only for the activities associated with the operation of the Surveillance Towed Array Sensor System Low Frequency Active Sonar onboard the USNS VICTORIOUS, USNS ABLE, USNS EFFECTIVE, and USNS IMPECCABLE. The signals transmitted by the SURTASS LFA source must be between 100 and 500 Hertz (Hz) with a source level for each projector no more than 215 dB (re: 1 micro Pascal (µPa) at 1 meter (m)) and a maximum duty cycle of 20 percent.

2. The U.S. Navy shall be required to (a) establish shut-down criteria for the SURTASS LFA sonar whenever a marine mammal is detected within the 1-km (0.54-nm) buffer zone beyond the SURTASS LFA safety zone (180-dB sound field), (b) not broadcast the SURTASS LFA sonar signal at a frequency greater than 500 Hz, and (c) plan its missions to ensure no greater than 12 percent of any marine mammal stock is incidentally harassed during the effective period of the letters of authorization.

3. If a marine mammal is detected within the area subjected to a sound pressure level of 180-dB or greater (safety zone) or within the 1 km (0.5 nm) buffer zone extending beyond the 180-dB safety zone, SURTASS LFA sonar transmissions shall be immediately delayed or suspended. Transmissions shall not resume earlier than 15 min after:

    a. All marine mammals have left the area of the safety and buffer zones; and

    b. There is no further detection of any marine mammal within the safety and buffer zones as determined by the visual and/or passive or active acoustic monitoring.

4. The High Frequency Marine Mammal Monitoring (HF/M3) sonar source described in 50 CFR 216.185 shall be ramped-up slowly to operating levels over a period of no less than 5 min. The HF/M3 source level shall not be increased if a marine mammal is detected during ramp-up. Ramp-up may continue once marine mammals are no longer detected. HF/M3 sonar shall be ramped-up:

    a, At least 30 min prior to any SURTASS LFA sonar transmissions;

    b. Prior to any SURTASS LFA sonar calibrations or testing that are not part of regular SURTASS LFA sonar transmissions; and

    c. Anytime after the HF/M3 source has been powered down for more than 2 min.

5. The SURTASS LFA sonar shall not be operated such that the SURTASS LFA sonar sound field exceeds 180 dB (re 1 microPascal (rms)):

a. At a distance of 12 nm (nm) (22 kilometers (km)) from any coastline, including offshore islands;

b. At a distance of 1 km seaward of the outer perimeter of any offshore area that has been designated as biologically important for marine mammals during the biologically important season for that particular area in accordance with 50 CFR 216.184(f).

6. The U.S. Navy shall deliver a report of data collected during the first six months of the Letters of Authorization not later than 90 days before the expiration of the Letters of Authorization followed by an annual report delivered not later than 45 days after the expiration of the Letters of Authorization. These reports must include numbers and locations of threatened and endangered species sightings, and all information required by the Letters of Authorization, including the results, if any, of coordination with coastal marine mammal stranding networks. The annual reports shall be submitted to the following NMFS offices: (1) Chief, Permits, Conservation, and Education Division, 1315 East-West Highway, Room 13635, Silver Spring, Maryland; and (2) Chief, Endangered Species Division, 1315 East-West Highway, Room 13635, Silver Spring, Maryland.

7. The Navy shall collect specific data on any apparent avoidance reactions of threatened or endangered species in response to exposure to LFA sonar transmissions, including the distance from the LFA sonar transmission, conditions of the exposure (location coordinates, depth of the species, time of day, ocean conditions, the animal's behavior before and after the exposure, and estimates of the received levels that elicited the response). These data must be reported in the annual reports described in condition 1 (above).

8 If the Navy's monitoring programs identify any threatened or endangered species that demonstrate acute effects in response to exposure to LFA sonar transmissions, such as injury or death, the Navy shall immediately initiate the source shut-down procedure for the sonar system.

9. The U.S. Navy shall carry out all mitigation, monitoring and reporting requirements contained in the Letters of authorization issued under section 101(a)(5)(A) of the Marine Mammal Protection Act.

10. If dead or injured marine mammals are observed during the studies and monitoring, the U.S. Navy shall contact NMFS and marine mammal stranding networks immediately (if available and as appropriate). The U.S. Navy shall coordinate with marine mammal stranding networks to help determine any potential relationship of any stranding to LFA sonar transmissions and to detect long-term trends in stranding.

These reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded reinitiation of consultation will be required. NMFS' Permits, Conservation,

and Education Division and U.S. Navy must immediately provide an explanation, in writing, of the causes of any take and discuss possible modifications to the reasonable and prudent measures with NMFS' Endangered Species Division.

9 REINITIATION STATEMENT

This concludes formal consultation on the Navy's proposal to employ the Surveillance Towed Array Sensor System Low Frequency Active Sonar in portions of the Northwest Pacific Ocean and NMFS' Permits, Conservation, and Education Division's proposed letters of authorization for the U.S. Navy's pursuant to the provisions of the Marine Mammal Protection Act of 1972. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

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