NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

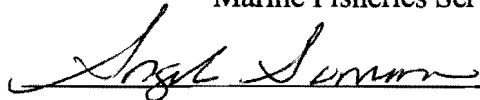**Agencies:** The National Science Foundation

And

The Permits and Conservation Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Activities Considered: Marine Seismic Survey in the Central Pacific Ocean and Issuance of an Incidental Harassment Authorization Pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA)

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

Approved by: _____

Date: 11/23/11

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1531 et seq.) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency 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 the action of a federal agency "may affect" a listed species or critical habitat that has been designated for such species, that agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected.

This ESA section 7 consultation considers two proposed actions. The first action is the National Science Foundation's (NSF's) funding and Lamont-Doherty Earth Observatory's (L-DEO's) proposed conduct of a marine seismic survey in the central Pacific Ocean. As the conduct of this survey would result in takes of marine mammals incidental to this survey, L-DEO must also apply for an Incidental Harassment Authorization (IHA) under the Marine Mammal Protection Act (MMPA), 16 U.S.C. §1371 (a)(5)(D); therefore, NMFS' Office of Protected Resources Permits and Conservation Division (Permits Division) is proposing to issue an IHA. The issuance of the IHA is the second proposed action. Subsequently, the action agencies for this consultation are NSF, L-DEO and the Permits Division. The consulting agency is the Office of

Protected Resources, Endangered Species Act Interagency Cooperation Division (Interagency Cooperation Division).

This document represents NMFS' biological opinion (Opinion) on the effects of the proposed actions on endangered and threatened species and designated critical habitat, prepared in accordance with section 7 of the ESA. This Opinion is based on information provided in the IHA application, draft IHA, environmental assessment, monitoring reports from similar activities, published and unpublished scientific information on endangered and threatened species, scientific and commercial information such as reports from government agencies and the peer-reviewed literature, biological opinions on similar activities, and other sources of information.

Consultation History
On June 17, 2011, L-DEO submitted an application for an IHA from the Permits Division for the central Pacific Ocean survey. This request was accompanied by an environmental assessment regarding the potential impacts of the proposed survey on the environment.

Also on June 17, 2011, L-DEO and NSF requested formal consultation with the Interagency Cooperation Division on the proposed conduct of a marine seismic survey. This survey would be conducted from November 26 through December 29, 2011. The Interagency Cooperation Division initiated consultation with L-DEO and NSF on the proposed survey on June 17, 2011.

On September 9, 2011, the Interagency Cooperation Division received a request for initiation of consultation from the Permits Division regarding the proposed issuance of an IHA for harassment of marine mammals incidental to the proposed survey. Included with the request was a draft EA, a draft IHA and L-DEO's application for an IHA. The Interagency Cooperation Division initiated consultation with the Permits Division on the proposed survey and IHA on September 9, 2011.

BIOLOGICAL OPINION

Description of the Proposed Actions
The proposed action for this consultation involves two related actions. NSF is funding a marine seismic survey to be conducted by L-DEO (principal Investigator James Gaherty) using acoustic sources deployed from the R/V Langseth on the high seas in the central Pacific Ocean. L-DEO will operate the Langseth as well as direct the operation of all acoustic sources for this cruise. As this survey is expected to incidentally harass marine mammals L-DEO has also requested an IHA. The Permits Division proposes to issue an IHA pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act, 16 U.S.C. 1371 (a)(5)(D) to L-DEO. The IHA would be valid from November 26 through January 19, 2012, to account for delays due to equipment failure and inclement weather and would authorize the incidental harassment of blue whales and sperm whales as well as other non-ESA listed whales. The Permits Division estimates that the

proposed action would incidentally harass 2 blue whales and 41 sperm whales. Listed sea turtles would also be harassed during the conduct of seismic activities.

Overview of the Seismic Survey

All acoustic sources will be deployed from the *R/V Marcus G. Langseth*. These acoustic sources are comprised of a 36-airgun array, a multibeam echosounder (MBES), a subbottom profiler (SBP), ocean bottom seismometers (OBSs) and magneto-telluric (MT) instruments. The MBES and the SBP would operate continuously including simultaneously with the airgun array throughout the entire cruise. The *R/V Langseth* would tow a hydrophone streamer to receive the returning acoustic signals. This survey also requires short- and longer-term deployment and retrieval of OBSs and MT instruments which would record returning acoustic signals for later analysis. The purpose of this survey is to collect observations to characterize the detailed structure of oceanic lithosphere and develop a comprehensive theory for lithospheric plate formation and evolution.

The *R/V Langseth* is expected to depart Honolulu, Hawaii around November 26, 2011 and return to Honolulu around December 29, 2011 barring logistical problems and inclement weather. Transit to the survey site will take approximately three days. Upon reaching the survey areas approximately 34 short-period OBSs will be deployed and then seismic operations will begin with deployment of the hydrophone streamer. After seismic operations the short-period OBSs will be recovered and 27 broad band OBSs and 5 MT instruments will be deployed to be recovered during a future cruise in about a year.

Seismic operations will occur for 11 days and consist of a total of about 2,120 kilometers (km) of transect lines within the central Pacific Ocean. These line estimates include turns the vessel will make along the survey and additional operations associated with equipment testing, startup, line changes, and repeat coverage as necessary. Seismic operations will occur along two semi-circular arcs (180°) centered at the mid-point of the 600-km long transect line with radii of 50 and 150 km, respectively (See Figure 1). During the cruise one 600-km of transect line will be shot twice (once with the streamer and once with the OBSs as receivers).

Source Vessel and Equipment

The *Langseth* has a length of 71.5 m, a beam of 17.0 m, and a maximum draft of 5.9 m. It is the sole source vessel for this survey. The *Langseth* was designed with a propulsion system designed to be as quiet as possible to avoid interference with the seismic signals. The ship is powered by two Bergen BRG-6 diesel engines, each producing 3550 hp, which drive the two propellers directly. Each propeller has four blades, and the shaft typically rotates at 750 revolutions per minute (rpm). Although the vessel is equipped with an 800 hp bowthruster, it will not be used during seismic acquisition. Typical cruising speed for the Langseth is 18.5 km/hour but during seismic acquisition will travel at 7.4–9.3 km/hour (4.6-5.8 miles/hour). As the vessel tows the airgun array and streamer the turning rate and maneuverability of the vessel will be limited.

Airguns

A 36-airgun array would be used during the proposed study. This array is comprised of a mixture of Bolt 1500LL and 1900LL (1,900 psi) airguns, each ranging in size from 40–360 in^3 as

appropriate. Airguns would be arranged in a configuration of four identical linear strings with a total discharge volume of 6,600 in^3. Energy for the airgun array would be compressed air supplied by compressors on board the *Langseth*. Each string contains 10 airguns, with 9 of them to be fired simultaneously and 1 reserved as a spare. The first and last airguns in each string would be spaced 16 m (52 ft) apart, with the four strings distributed across an area of approximately 24 m x 16 m (79 ft x 52 ft). The array would be towed about 100 m (328 ft) behind the *Langseth* at a 9 m (29.5 ft) depth.

Airguns would fire for a brief (about 0.1 second) pulse[1] at intervals of every 22 s (about every 50 m) for seismic surveying with the hydrophone streamer, or every 300 s (about every 650 m) when recording data on the OBSs. The airguns would be silent during intervening periods. The airgun array is predominantly low-frequency[2] with a dominant frequency component of 0–188 Hz.

Source output (downward) from the 36-airgun array would be 259 dB re 1 µPa m (0-pk) and 265 dB re 1 µPa • m (pk-pk). The nominal source levels of the array at various tow depths are nearly identical. Because the actual source is a distributed sound source (36 airguns) rather than a single point source, the highest sound levels measurable at any location in the water will be less than the nominal source level.

Receiving System
The receiving system will consist of a hydrophone streamer, numerous OBSs and five MT instruments. The *Langseth* will deploy a 6-km long streamer. As the airgun array is towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the on-board processing system.

Two types of OBSs will be deployed to record the returning acoustic signals for later analysis. Both types of OBSs contains an acoustic release transponder which interrogates the OBS at a frequency of 9–11 kHz. A response is received at a frequency of 9–13 kHz. The burn wire release assembly is then activated, and the instrument is released from the anchor to float to the surface. Approximately 27 broad band OBSs and 5 MT instruments will remain in place for about a year and recovered during a future cruise.

Multi-beam Bathymetric Echosounder (MBES)
The proposed study would use a MBES to map the ocean floor. The MBES sonar would be operated continuously from the *Langseth* and simultaneously with the airgun array. The hull-mounted Kongsberg EM 122 would operate at 10.5-13 kHz (usually 12 kHz), and have a maximum source level of 242 dB re 1 µPa (rms). The transmitting beamwidth is 1 or 2° fore-aft and 150° athwartship.

For deep-water operation, each "ping" consists of eight (in water depths greater than 1000 m) or four (in water depths less than 1000 m) successive fan-shaped transmissions which ensonifies a sector that extends 1° fore-aft. The successive transmissions span an overall cross-track angular

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1   Pulse duration is defined as the time at which 5 percent to 95 percent of the pulse energy has arrived.
2   Frequencies are categorized as low-frequency (< 1,000 Hz), mid-frequency (1-10 kHz), and high-frequency (> 10 kHz).

extent of about 150°, with 2-ms gaps between pings for successive sectors. Continuous wave signals (waves of constant energy and frequency) increase from 2 to 15 ms long in water depths up to 2600 m and frequency-modulated (FM) chirp signals up to 100 ms long are used in water depths greater than 2600 m.

Sub-Bottom Profiler (SBP)

The proposed survey would also use a Knudsen 3260 sub-bottom profiler to provide information about the sea floor. The SBP would operate simultaneously with the airgun array and the MBES. Energy from the SBP is directed downward by a hull-mounted 3.5 kHz transducer. The SBP has a maximum source level of 222 dB re 1 µPa• m. Nominal beam width is 27 degrees, and pulse duration is up to 64 ms. The interval between SBP pulses would be 1 s, with a common mode of operation being five pulses at 1-s intervals followed by a 5-s pause.

Monitoring and Reporting

L-DEO proposes to document the nature and extent of any effects on listed species through the use of observers, monitoring efforts and reporting. Vessel-based Protected Species Visual Observers (PSVOs) on the *Langseth* would watch for marine mammals and sea turtles near seismic sources and the vessel during all daytime airgun operations, as well as during any day- or night-time start-ups of the array. PSVOs would also watch for marine mammals and turtles near the vessel for at least 30 min prior to the planned start of seismic operations after an extended shut-down of the airguns. When feasible, observations would also be made during daytime periods without seismic operations (e.g., during transits). PSVOs would also monitor while the airgun array and streamers are being deployed or recovered from the water. When marine mammals or sea turtles are observed within, or about to enter, designated exclusion zones [See *Exclusion Zone* (EZ) section below], airgun operations would immediately be powered-down (or shut-down if necessary). Airgun operations would not resume until the animal(s) leaves the EZ, as determined by the PSVOs.

Although at least four PSVOs will be based aboard the Langseth, three PSVOs are typically on watch at a time, two on the observation tower conducting visual observations and the third monitoring the PAM equipment. On the tower, two observers are on watch during all daylight hours except during meal times when one observer may be on watch. Observers typically observe for no more than four hours. The crew of the *Langseth* would also be instructed to assist in detecting marine mammals and turtles as well as implementing mitigation measures as possible.

During daytime, the PSVOs would systematically scan the area around the vessel with reticle binoculars (e.g., 7×50 Fujinon), Big-eye binoculars (25×150), and the naked eye. Laser rangefinding binoculars (Leica LRF 1200 laser rangefinder or equivalent) would be available to assist with distance estimation. At night, the PSVOs would use night vision devices when required. Laser rangefinding binoculars will be available to assist with visual distance estimation. When stationed on the observation platform on the *Langseth*, eye level is about 21.5 m (70.5 ft) above sea level and PSVOs would be able to see around the entire vessel and to a distance of about 10 km with the naked eye, 5 km or further with the big eyes, 200 m with night vision and 2-3 km or further with the reticle binoculars.

Passive Acoustic Monitoring (PAM)

Passive acoustic monitoring would also be conducted during all proposed seismic operations and during most periods when the *Langseth* is underway but not operating the airguns. PSVOs would monitor PAM in real-time 24 hours per day as practical during daytime and nighttime operations to alert visual observers when vocalizing cetaceans are detected. Any bearings to cetaceans determined using PAM would be relayed to the visual observer.

The PAM system that would be used consists of a low-noise, towed hydrophone array connected to the vessel by a tow cable. The tow cable is 250 m long, and the hydrophones are fitted in the last 10 m of cable. The array would be deployed from a winch on the back deck of the *Langseth*. The PAM hydrophone array is typically towed at depths of less than 20 m (66 ft).

One acoustic PSVO (in addition to the four PSVOs) would monitor the PAM system by listening to the signals from two channels via headphones and/or speakers and watching real-time spectrographic display for frequency ranges produced by cetaceans. Shifts for acoustic PSVOs monitoring the acoustical data would range from one to six hours in length, with all PSVOs expected to rotate through the PAM position. When a vocalization is detected, the acoustic acoustic PSVO would contact the PSVO immediately to alert the visual observer of the vocalizing animal(s) in case a power-down or shut-down is required. The theoretical distance for cetacean call detection by PAM is in the tens of kilometers, but detection is dependent on several factors including call intensity, ship noise, ambient noise in the water column, and physical/oceanographic conditions. PAM can detect marine mammal vocalization at frequencies up to 250 kHz.

A report will be submitted to NMFS within 90 days after the end of the cruise. The report will describe the operations that were conducted and sightings of marine mammals and turtles near the operations. The report will provide full documentation of methods, results, and interpretations of monitoring efforts. The 90-day report will summarize the dates and locations of seismic operations, and all marine mammal and turtle sightings (dates, times, locations, activities, associated seismic survey activities). The report will also include estimates of the amount and nature of any potential "take" of marine mammals and sea turtles by harassment or in other ways.

Mitigation

L-DEO has adopted mitigation measures to minimize adverse affects to listed species. These measures include airgun power-down and shut-down procedures, emergency shut-down and ramp-up procedures within calculated exclusion zones.

Proposed Exclusion Zones for Power Down and Shut Down Procedures

L-DEO predicted the propagation of sound from the airgun array and from a single 1900LL 40-in^3 airgun, which will be used during power downs and shut downs during the proposed survey. Table 1 provides the expected distances at which received levels of sound were approximately 160, 180, and 190 dB re 1μPa (rms) for this survey. The 180 dB re 1μPa (rms) distance represents the exclusion zone criterion and the thresholds for power-down or shut down for cetaceans and sea turtles during the proposed survey (see *Mitigation and Monitoring* section below). Estimated propagation distances to the 180 dB radii range from 40 m (0.02 nm) to 940

m (0.51 nm) depending on seismic source and volume (see Table 1 below). The 160 dB re 1µPa (rms) distance represents the safety zone criterion and alerts L-DEO of the potential need to power down or shut down if marine mammals or sea turtles are likely to enter the 180 dB re 1µPa (rms) exclusion zone. Estimated propagation distances to the 160-dB radii ranges from 385 m (0.21 nm) to 3850 m (2.08 nm).

Empirical propagation measurements for the Langseth's airguns were taken during a calibration study in 2007-2008 in the Gulf of Mexico (Tolstoy et al 2009). For the study the 36-airgun array was towed at 6 m (19.6 ft) in deep water (~1,600 m; 5,249 ft) as well as shallow water (~50 m; 131 ft). Results for the Gulf of Mexico study showed that received levels of sound around the airguns varied with water depth as well as array tow depth. To estimate the distances at which received levels of sound would be approximately 160, 180 and 190 dB re 1µPa (rms) for the airgun array for this survey L-DEO used the empirical received sound level radii from the Gulf of Mexico study and applied correction factors to account for the differences in tow depths (6 m in the Gulf of Mexico study versus 9 m in the proposed survey). The correction factors were the ratios of the 160, 180 and 190 dB re 1µPa (rms) distances for the Gulf of Mexico study at 6 m versus 9 m. To estimate the distances at which received levels of sound would be approximately 160, 180 and 190 dB re 1µPa (rms) for the single airgun, L-DEO modeled the distances for the single airgun to be use d in this study since the empirical measurements were not reported for the single airgun in the Gulf of Mexico study.

Table 1. Distances to which sound levels ≥ 190, 180 and 160 dB re 1 µPa$_{rms}$ are expected to be received from the single airgun and the airgun array.

Source and Volume	Tow Depth (m)	Water Depth*	Estimated RMS Radii (m)		
			190 dB	180 dB	160 dB
Single Bolt airgun (40 in^3)	9	Deep	12	40	385
4 strings 36 airguns (6600 in^3)	9	Deep	400	940	3850

Power Down and Shut Down Procedures

If a marine mammal or turtle is detected outside the 180 dB (rms) EZ but is likely to enter it, L-DEO would power-down the airgun array before the animal is within the EZ. If a mammal or turtle is already within the EZ when first detected, the airguns would be powered-down immediately. A power-down may also occur when the vessel is moving from one track line to another (i.e., during a turn). Power-down procedures involve reducing the number of operating airguns, typically to a single airgun (e.g., 40 in^3), to minimize the EZ so that marine mammals or turtles are no longer in or about to enter the 180 dB radii. The continued operation of at least one

airgun during a power-down is intended to alert marine mammals and turtles to the presence of the seismic vessel in that area. If, during operation of the single airgun (as in during power down), a marine mammal or turtle is detected within the EZ L-DEO would initiate shut down procedures (i.e., all operating airguns are turned off).

Following a power-down or shut-down, airgun activity would not resume until the marine mammal or sea turtle has cleared the EZ, or until the PSVO is confident the animal has left the vicinity of the vessel. This is considered to have occurred if the animal:

- is visually observed to have left the EZ, *or*
- has not been seen within the zone for 30 minutes (in the case of mysticetes and large odontocetes, including sperm whales), *or*
- the vessel has moved outside the EZ for sea turtles (8 min of travel: the time it would take the Langseth to move outside the 180-dB EZ).

Ramp-up Procedures
Following a power-down or shut-down and subsequent clearing of the EZ, the airgun array would resume operations according to the following procedures.

If after eight minutes with either no airgun operations or a power-down of airguns, L-DEO will implement ramp-up procedures for the array. This eight minute period is based on the time it would take the Langseth to move outside the 180-dB EZ (940 m) at a speed of 7.4 km/hr (4.6 nm/hr) for mammals and turtles. Ramp up from a state of no airgun operations would begin with the smallest airgun in the array (40 in^3). Airguns would be added in a sequence such that the increase in source level would not exceed 6 dB/5min over a total duration of about 35 minutes. Ramp up from a reduced power state, such as during maintenance of an airgun string while the remaining strings keep firing, would include the start-up of the returned string. During ramp-up, the PSVOs would monitor the EZ for the full airgun array, and if marine mammals or turtles are sighted then power-down, or shut-down would be implemented.

Initiation of ramp-up procedures from a shut-down requires that the full EZ be visible by the PSVOs, whether the ramp-up is conducted in daytime or nighttime. Thus, the airgun array would likely not be ramped-up from a complete shut-down at night or in thick fog, because the outer part of the EZ for the array may not be visible during those conditions. Ramp-up of airguns would be allowed under reduced visibility conditions only if at least one airgun (e.g., 40 in^3 or similar) has operated continuously, on the assumption that marine mammals and turtles would be alerted to the approaching seismic vessel by sounds from the single airgun and could move away. Ramp up of the airguns would not be initiated if a sea turtle or marine mammal is sighted within or near the applicable EZ during the day or near the vessel at night.

Marine Mammal Protection Act Incidental Harassment Authorization

The Permits Division has also proposed to issue an IHA to L-DEO for the harassment of marine mammals incidental to the seismic surveys. This IHA is valid from November 26, 2011 to January 19, 2012. The proposed IHA includes the requirements L-DEO must comply with as part of its authorization. Following are the sections of the IHA that are relevant to listed species:

1.	Mitigation and Monitoring Requirements

L-DEO is required to implement the following mitigation and monitoring requirements when conducting this survey to achieve the least practicable adverse impact on affected marine mammal species or stocks:

(a) Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (PSVOs) (except during meal times and restroom breaks, when at least one PSVO will be on watch) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from civil twilight-dawn to civil twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew shall also assist in detecting marine mammals, when practicable. PSVOs will have access to reticle binoculars (7x50 Fujinon), big-eye binoculars (25x150), and night vision devices. PSVO shifts shall last no longer than 4 hours at a time. PSVOs will also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

(b) PSVOs will conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water.

(c) Record the following information when a marine mammal is sighted:

> (i) species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

> (ii) time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, and sun glare; and

> (iii) the data listed under Condition 1(c)(ii) will also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

(d) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One PSVO) and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

(e) Do and record the following when an animal is detected by the PAM:

(i) notify the on-duty PSVO(s) immediately of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;

(ii) enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

(f) Visually observe the entire extent of the exclusion zone (EZ) (180 dB re 1 μPa [rms] for cetaceans using NMFS-qualified PSVOs, for at least 30 minutes (min) prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the EZ, L-DEO must delay the seismic survey until the marine mammal(s) has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the PSVO shall wait 30 min. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), L-DEO may start the second airgun without observing the entire EZ for 30 min prior, provided no marine mammals are known to be near the EZ (in accordance with Condition 1[h] below).

(g) Establish a 180 dB re 1 μPa (rms) EZ for marine mammals before the 36 airgun array (6,600 in^3) is in operation; and a 180 dB re 1 μPa (rms) EZ before a single airgun (40 in^3) is in operation, respectively. See Table 1 (attached) for distances and EZs.

(h) Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shutdown for more than 8 min, which means start the smallest gun first and add airguns in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs shall monitor the EZ, and if marine mammals are sighted, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from shut-down requires that the PSVOs be able to view the full EZ as described in Condition 1(f) (above).

(i) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant EZ. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the EZ, further mitigation measures, such as a power-down or shut-down, will be taken.

(j) Power-down or shut-down the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant EZ. A shut-down means all operating airguns are shut-down (i.e., turned off). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun, which reduces the EZ to the degree that the animal(s) is no longer in or about to enter it.

(k) Following a power-down, if the marine mammal approaches the smaller designated EZ, the airguns must then be completely shut-down. Airgun activity will not resume until the PSVO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 min for species with shorter dive durations (small odontocetes) or 30 min for species with longer dive durations (mysticetes and large odontocetes, including sperm whales).

(l) Following a power-down or shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described in Condition 1(h).

(m) Marine geophysical surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant EZs are visible and can be effectively monitored.

(n) No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant EZ cannot be effectively monitored by the PSVO(s) on duty.

2.   Reporting Requirements

L-DEO is required to:

(a) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the *Langseth*'s central GOA cruise. This report must contain and summarize the following information:

> (i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;

> (ii) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shut-downs), observed throughout all monitoring activities.

> (iii) An estimate of the number (by species) of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on modeling results) to the

seismic activity at received levels greater than or equal to 160 dB re 1 µPa (rms) and/or 180 dB re 1 µPa (rms) with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

(iv) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (ITS); and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act-listed marine mammals.

(b) Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, within 30 days after receiving comments from NMFS on the draft report. If NMFS decides that the draft report needs no comments, the draft report shall be considered to be the final report.

3.   Reporting Prohibited Take

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA (if issued), such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), L-DEO shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov).

The report must include the following information:
- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Activities will not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with L-DEO to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. L-DEO may not resume their activities until notified by NMFS via letter, email, or telephone.

4. <u>Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death</u>
In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSVO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), L-DEO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov).

The report must include the same information identified in the paragraph above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate.

5. <u>Reporting an Injured or Dead Marine Mammal not Related to L-DEO Activities</u>
In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSVO determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), L-DEO will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov), within 24 hours of the discovery. L-DEO will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.

6. L-DEO is required to comply with the Terms and Conditions of the Incidental Take Statement (ITS) corresponding to NMFS' Biological Opinion issued to both NSF and NMFS' Office of Protected Resources (attached).

Approach to the Assessment

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

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

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

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

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

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In

particular, we examine the scientific and commercial data available to determine if an individual's probable response to an Action's effects on the environment (which we identify in our *response analyses*) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns 1992). Reductions in at least one 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. As a result, 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 (e.g., Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). 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. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

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

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

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

To conduct these analyses, we rely on all of the evidence available to us. This evidence might consist of monitoring reports submitted by past and present permit holders; reports from NMFS Science Centers; reports prepared by natural resource agencies in States, Tribes, and other countries; reports from non-governmental organizations involved in marine conservation issues; the information provided by the Permits and Conservation Division when it initiates formal consultation; and the general scientific literature. We supplement this evidence with reports and other documents – environmental assessments, environmental impact statements, and monitoring reports – prepared by other federal and entities such as LGL, Ltd that have bearing on the conclusions in this Opinion.

During the consultation, we also conducted electronic searches of the general scientific literature using search engines, including *Agricola, Aquatic Sciences and Fisheries Abstracts, Conference Papers Index, Oceanic Abstracts, BioOne, Science Direct, Ingenta Connect, JSTOR, Web of Science - Science Citation Index, First Search (Article First, ECO, WorldCat),* and *Google Scholar*. We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion (for example, a study that suggests whales or turtles will exhibit a particular response to a seismic source) as well as data that does not support that conclusion.

Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

The action area for this consultation will encompass the transit area to and from port in Hawaii as well as the survey area delineated by international waters bounded by 7-12°N and 142-148°W, (Fig. 1), to the extent that the acoustic signals produced by the proposed survey decrease to background noise levels in the central Pacific Ocean.

The survey site is approximately 1,300 km (701.9 nm) south of Hawaii in waters approximately 5,000 m (16,404 ft) deep. L-DEO will survey approximately 2,120 km of track line and ensonify about 13,714 km of ocean to 160 dB re 1 μPa (rms).
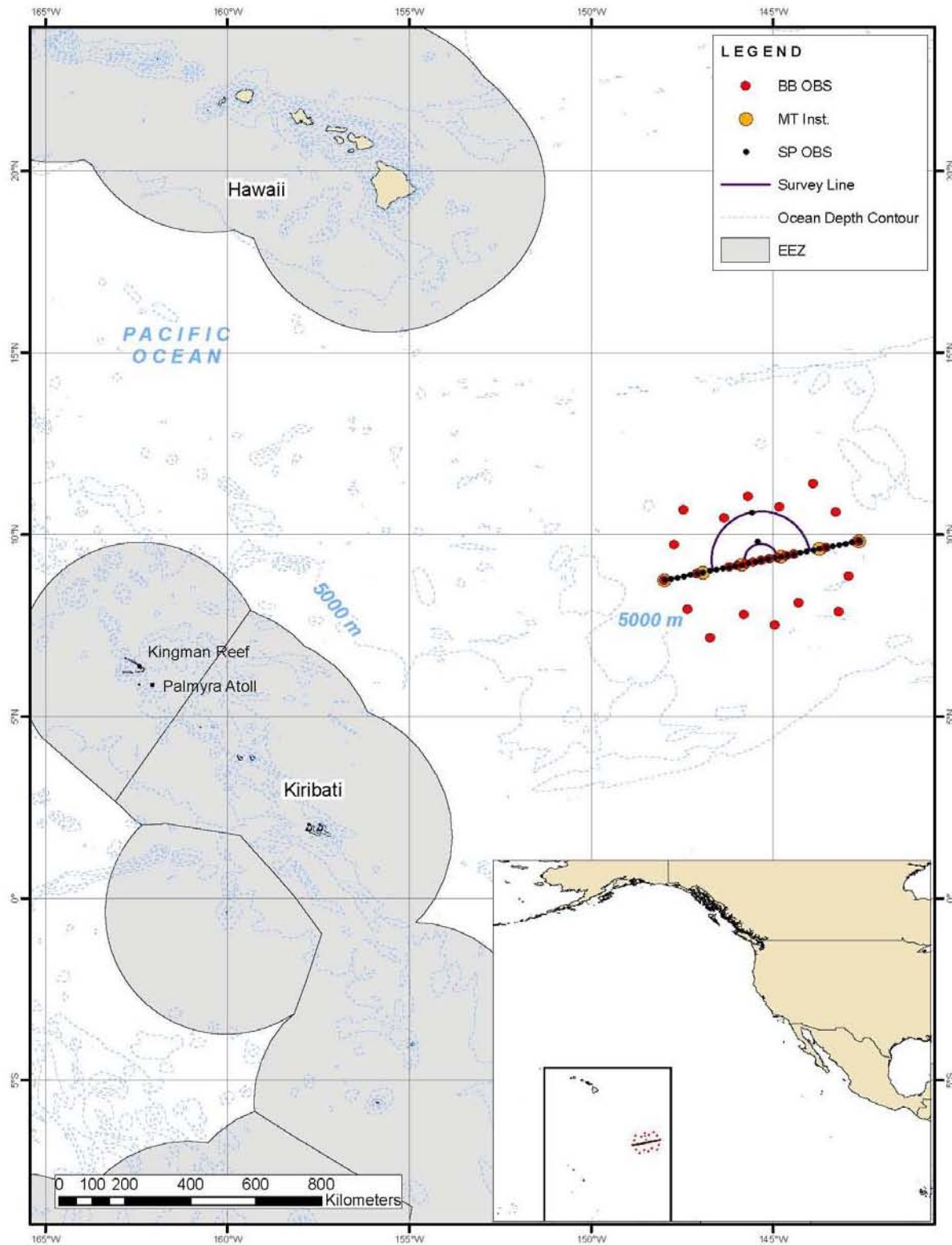
Figure 1: Proposed seismic survey area for the central Pacific Ocean

Status of Listed Resources

NMFS has determined that the actions considered in this Opinion may affect the following listed resources provided protection under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*; ESA):

Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Hawaiian Monk Seal	*Monachus schauinslandi*	Endangered
Green sea turtle	*Chelonia mydas*	Endangered/ Threatened3
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Olive ridley	*Olivacea* kempii	Endangered /Threatened4
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
North Pacific Loggerhead Distinct Population Segment	*Caretta caretta*	Endangered

No designated critical habitat occurs within the action area.

Species Not Considered Further in this Consultation

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

Fin whale calls are detected year-round in the Northern Pacific (Moore et al. 2006; Stafford et al. 2007, 2009). In the central North Pacific, the Gulf of Alaska, and the Aleutian Islands, call rates peak during fall and winter (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2009).

A recent review of fin whale distribution in the North Pacific noted the lack of sightings across the pelagic waters between eastern and western winter areas (Mizroch et al. 2009). In Hawaii, fin whales are considered uncommon (DoN 2005). Thompson and Friedl (1982) suggested that fin whales migrate to Hawaiian waters during the fall and winter; but during spring–summer, their occurrence in Hawaii is

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3 Green turtles are listed as threatened under the ESA, except for breeding colonies found in Florida and the Pacific coast of Mexico, which are listed as endangered. Due to the inability to distinguish between populations away from the nesting beach, green turtles are considered endangered within the Action Area in the Pacific for this consultation.
4 Olive ridley sea turtles are listed as threatened, except for the Mexico Pacific coast breeding colonies, which are listed as endangered. Due to the inability to distinguish between populations away from the nesting beach, olive ridley turtles are considered endangered within the Action Area for this consultation.

considered rare (DoN 2005). Two fin whales were sighted northwest of Hawaii during shipboard surveys in July–December 2002 (Barlow et al. 2004). No sightings were made west of the proposed survey area during the Pacific Islands Cetacean and Ecosystem Assessment Survey in July–November 2005 (Barlow et al. 2008). Given the sparsity of sightings of these whales in the action area and the short duration of this survey (11 days), we conclude that the potential for this species to be exposed to the proposed survey is discountable; therefore fin whales are not likely to be adversely affected and we will not consider this species further in this Opinion.

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

Hawaii is the primary wintering area for whales from feeding areas in the Gulf of Alaska, southeast Alaska, and northern British Columbia (B.C.), Canada; some individuals from the Bering Sea feeding area also winter in Hawaii (Calambokidis et al.2008). Humpbacks use the Hawaiian islands area for breeding from December to April with peak abundance around the islands occurring from late February through early April (Mobley et al. 2001). However, humpbacks are not expected to occur further than 100 km from the Hawaiian coastline (DoN 2005). No sightings were made southwest of Hawaii, during the Pacific Islands Cetacean and Ecosystem Assessment Survey during July–November 2005 (Barlow et al. 2008). Since the seismic survey will occur 1,300 km offshore where humpback whales are not expected to occur and the short duration of this survey (11 days), we conclude that the potential for this species to be exposed to the proposed survey is discountable; therefore humpback whales are not likely to be adversely affected and we will not consider this species further in this Opinion.

Sei Whale
The distribution of the sei whale is not well known, but this whale is found in all oceans and appears to prefer mid-latitude temperate waters (Jefferson et al. 2008). Sei whales migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985a). During summer in the North Pacific, the sei whale can be found from the Bering Sea to the northern GOA and south to southern California, and in the western Pacific from Japan to Korea. Its winter distribution is concentrated at about 20°N, and sightings have been made between southern Baja California and the Islas Revilla Gigedo off the Pacific coast of Mexico (Rice 1998). No breeding grounds have been identified for sei whales; however, calving is thought to occur from September to March.

Sei whales are noted for their erratic appearance in specific feeding grounds, being plentiful in some years and absent (sometimes for years or even decades) in others (Horwood 1987). Sei whales have been sighted near the Hawaiian islands and to the northwest during surveys in July–December 2002; most of those sightings were made during the month of November (Barlow et al. 2004). Sei whales, including subadults, were seen east of Oahu in November 2007 (Hopkins et al. 2009). As breeding and calving areas in the Pacific are unknown, the sightings of subadult

sei whales suggest that Hawaii may be an important reproductive area for this species (Hopkins et al. 2009). Sightings of *B. edeni/borealis* were made to the west of the proposed seismic survey area during the Pacific Islands Cetacean and Ecosystem Assessment Survey in July–November 2005 (Barlow et al. 2008) and within the proposed survey area during summer–fall 2006 (Jackson et al. 2008). Given the difficulty in distinguishing sei from Bryde's whales, those could have been sei whales, but in both cases Bryde's whales were positively identified and sei whales were not.

Given the rarity of these whales in the action area and the short duration of this survey (11 days), we conclude that the potential for this species to be exposed to the proposed survey is discountable; therefore sei whales are not likely to be adversely affected and we will not consider this species further in this Opinion.

Hawaiian Monk Seals

Hawaiian monk seals are found throughout the Northwest Hawaiian Islands particularly throughout the population's six main reproductive sites: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals and throughout the main Hawaiian Islands where births have been documented on most of the major islands (Baker and Johanos, 2004). Smaller breeding sub-populations also occur on Necker Island, and Nihoa Island, and monk seals have been observed at Gardner Pinnacles and Maro Reef (NMFS 2007). Additional sightings and at least one birth have occurred at Johnston Atoll approximately 1,400 km west of the survey area. In addition to these sightings, a juvenile male and eleven adult males were translocated to Johnston Atoll (nine from Laysan Island and two from FFS) over the past 20 years. Two Hawaiian monk seal sightings were reported in the late 1980s at Palmyra Atoll near the proposed survey area, and one tagged seal was observed near Wake Island, ~3700 km west of Hawaii (Westlake and Gilmartin 1990 *in* LGL, Ltd 2011).

The best estimate of the total Hawaiian monk seal population size is 1,161 (Caretta et al 2011). However, the only complete and systematic surveys for monk seals in the main Hawaii Islands were conducted in 2000 and 2001(Baker and Johanos 2004) using information on seal sightings reported by a variety of sources. The total number of individually identifiable seals documented in this way in 2008 was 113 animals, the current best minimum abundance estimate.

Satellite tracking of Hawaiian monk seal foraging behavior at the six main Hawaiian Island reproductive sites indicated that foraging trips varied by sex and by age and ranged from <1 km up to 217 km from haul-out sites (Stewart et al. 2006). Satellite tracking of Hawaiian monk seals in the main Hawaiian Islands revealed home ranges of 34 to 800 km^2. Preliminary results from 11 monk seals tracked in the main Hawaiian islands using satellite-linked transmitters in 2005 indicate that seals dive primarily within the 200 m isobath and remain close to shore (Littnan et al., 2006). Inter-island movements were demonstrated by several animals.

As only two Hawaiian monk seal sightings have been reported at Palmyra Atoll near the proposed survey area since the 1980s, the seismic survey will occur approximately 1,400 km south of Johnston Atoll (where at least one birth has occurred), and the low population abundance of Hawaiian monk seals, we conclude that the potential for this species to be exposed

to the proposed survey activities is discountable; therefore Hawaiian monk seals are not likely to be adversely affected and we will not consider this species further in this Opinion.

Loggerhead Sea Turtles
A widely distributed species, loggerhead sea turtles occur in coastal tropical and subtropical waters around the world. Loggerheads feed in all marine habitats, including coastal bays and estuaries, shallow water along the continental shelves, and the high seas (Bowen et al. 1995; Yokota et al. 2006; Reich et al. 2009). During migration through the open sea they forage primarily in surface waters on jellyfish, pteropods, floating mollusks and egg clusters, flying fish, and squid (Polovina et al. 2003, 2004).

All loggerheads in the North Pacific originate at Japanese nesting beaches (Hatase et al. 2002) and comprise the North Pacific Distinct Population Segment of loggerhead sea turtles. In the central Pacific, loggerheads are mainly found in pelagic waters. They are rarely sighted on the islands of Hawaii, but are seen in offshore waters north of Hawaii (DoN 2005). No incidental takes of loggerhead sea turtles in the longline fishery have been reported for waters south of Hawaii (McCracken 2000; Kobayashi and Polovina 2005). Loggerheads are frequently taken in pelagic longline fisheries in the North Atlantic. As no sightings have been reported for offshore waters south of Hawaii, we conclude that the potential for this species to be exposed to the proposed survey activities is discountable; therefore North Pacific loggerhead sea turtles are not likely to be adversely affected and we will not consider this species further in this Opinion.

Status of Species Considered in this Biological Opinion
The remainder of this section 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 proposed survey. Each narrative presents 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. A summary of information on the threats to the species and the species' status given those threats is provided as points of reference for the subsequent jeopardy determinations. That is, NMFS relies 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.

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), sperm whale (NMFS 2010c), a status report on large whales prepared by Perry et al. (1999a) and 5-year status reviews and for the green sea turtles, hawksbill sea turtles, olive ridley sea turtles and leatherback sea turtles (NMFS and USFWS 2007).

Blue Whale

Distribution
Blue whales are found along the coastal shelves of North America and South America (Rice 1974; Donovan 1984; Clarke 1980) in the North Pacific Ocean. In the North Pacific Ocean, blue whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Blue whales in the eastern Pacific winter from

California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985).

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

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

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

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

Blue whales have also been reported year-round in the northern Indian Ocean, with sightings in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Mizroch *et al.* 1984). The migratory movements of these whales are unknown. Historical catch records suggest that "true" blue whales and "pygmy" blue whale (*B. m. brevicada*) may be geographically ddistinct (Brownell and Donaghue 1994, Kato *et al.* 1995). The distribution of the "pygmy" blue whale is north of the Antarctic Convergence, while that of the "true" blue whale is south of the Convergence in the austral summer (Kato *et al.* 1995). "True" blue whales occur mainly in the higher latitudes, where their distribution in mid-summer overlaps with that of the minke whale (*Balaenoptera acutorostrata*). During austral summers,

"true" blue whales are found close to the edge of Antarctic ice (south of 58° S) with concentrations between 60°-80° E and 66°-70° S (Kasamatsu *et al.* 1996).

Population Structure

For this and all subsequent species, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Cole (1957, Futuyma (1986) and Wells and Richmond (1995) and is more restrictive than those uses of 'population' that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see review by Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as 'population decline,' 'population collapse,' 'population extinction,' and 'population recovery' apply to the restrictive definition of 'population' but do not explicitly apply to alternative definitions. As a result, we do not treat the different whale "stocks" recognized by the International Whaling Commission or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those "stock" distinctions in these narratives.

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

In addition to these subspecies, the International Whaling Commission's Scientific Committee has formally recognized one blue whale population in the North Pacific (Donovan 1991), although there is increasing evidence there may be more than one blue whale population in the Pacific Ocean (Gilpatrick *et al.* 1997, Barlow *et al.* 1995, Mizroch *et al.* 1984a, Ohsumi and Wada 1974). For example, studies of the blue whales that winter off Baja California and in the Gulf of California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick *et al.* 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (the southern whales forage off California; Sears *et al.*1987; Barlow *et al.*1997; Calambokidis *et al.* 1990).

A population or "stock" of endangered blue whales occurs in waters surrounding the Hawaiian archipelago (from the main Hawaiian Islands west to at least Midway Island), although blue whales are rarely reported from Hawaiian waters. The only reliable report of this species in the central North Pacific was a sighting made from a scientific research vessel about 400 km northeast of Hawaii in January 1964 (NMFS 1998). However, acoustic monitoring has recorded blue whales off Oahu and the Midway Islands much more recently (Barlow *et al.* 1994, McDonald and Fox 1999, Northrop *et al.* 1971; Thompson and Friedl 1982).

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

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

Threats to the Species
Natural threats. Natural causes of mortality in blue whales are largely unknown, but probably include predation and disease (not necessarily in their order of importance). Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1920), which are believed to have caused fin whales to die as a result of renal failure (Lambertsen 1986). Killer whales and sharks are also known to attack, injure, and kill very young or sick fin and humpback whale and probably hunt blue whales as well (Perry *et al.* 1999).

Anthropogenic threats. Two human activities are known to threaten blue whales: whaling and shipping. Historically, whaling represented the greatest threat to every population of blue whales and was ultimately responsible for listing blue whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. Before fin whales became the focus of whaling operations, populations of blue whales had already become commercially extinct (IWC 1995).

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

Although the International Whaling Commission banned commercial whaling in the North Pacific in 1966, Soviet whaling fleets continued to hunt blue whales in the North Pacific for several years after the ban. Surveys conducted in these former-whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell 1996). By 1967, Soviet scientists wrote that blue whales in the North Pacific Ocean (including the eastern Bering Sea and Prince William Sound) had been so overharvested by Soviet whaling fleets that some scientists concluded that any additional harvests were certain to cause the species to become extinct in the

North Pacific (Latishev 2007). As its legacy, whaling has reduced blue whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push blue whales closer to extinction. Otherwise, whaling currently does not threaten blue whale populations.

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow *et al.* 1997). In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears *et al.* 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987, Macfarlane 1981). The number of blue whales struck and killed by ships is unknown because the whales do not always strand or examinations of blue whales that have stranded did not identify the traumas that could have been caused by ship collisions. In the California/Mexico stock, annual incidental mortality due to ship strikes averaged 0.2 whales during 1991-1995 (Barlow *et al.* 1997), but we cannot determine if this reflects the actual number of blue whales struck and killed by ships.

Status
Blue whales were listed as endangered under the ESA in 1973. Blue whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for blue whales.
It is difficult to assess the current status of blue whales because (1) there is no general agreement on the size of the blue whale population prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population prior to whaling, although some authors have concluded that their population numbers about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser *et al.* 1981; U. S. Department of Commerce 1983). These estimates, however, are more than 20 years old.

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

The size of the blue whale population in the North Atlantic is also uncertain. The population has been estimated to number from a few hundred individuals (Allen 1970; Mitchell 1974) to 1,000 to 2,000 individuals (Sigurjónsson 1995). Gambell (1976) estimated that 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 (review by Yochem and Leatherwood 1985) with an average rate of increase that has been estimated at between 4 and 5 percent per year. Butterworth *et al.* (1993), however, estimated the Antarctic population at 710 individuals. More recently, Stern (2001) estimated the blue whale population in the Southern Ocean at between 400 and 1,400 animals (c.v. 0.4). The pygmy blue whale population has been estimated at 6,000 individuals (Yochem and Leatherwood 1985). The information available on the status and trend of blue whales do not allow us to reach any conclusions about the extinction risks facing blue whales as a species, or particular populations of blue whales. With the limited data available on blue whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate).

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

Blue whales are usually found swimming alone or in groups of two or three (Ruud 1956, Slijper 1962, Nemoto 1964, Mackintosh 1965, Pike and MacAskie 1969, Aguayo 1974). However, larger foraging aggregations and aggregations mixed with other species like fin whales are regularly reported (Schoenherr 1991, Fiedler *et al.* 1998). Little is known of the mating behavior of blue whales.

Vocalizations and Hearing
The vocalizations that have been identified for blue whales include a variety of sounds described as low frequency moans or long pulses (Cummings and Thompson 1971, 1977; Edds 1982, Thompson and Friedl 1982; Edds-Walton 1997). Blue whales produce a variety of low frequency sounds in the 10-100 Hz band (Cummings and Thompson 1971, Edds 1982, Thompson and Friedl 1982, McDonald *et al.* 1995, Clark and Fristrup 1997, Rivers 1997). The most typical

signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. The sounds last several tens of seconds. Estimated source levels are as high as 180-190 dB (Cummings and Thompson 1971). Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups. The seasonality and structure of long patterned sounds suggest that these sounds are male displays for attracting females, competing with other males, or both. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function. Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish and Mitchell 1971; Cummings and Thompson 1971, 1977, 1994; Cummings and Fish 1972; Thompson *et al.* 1996; Rivers 1997; Tyack and Clark 1997; Clark *et al.* 1998).

Blue whale moans within the low frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). A short, 390 Hz pulse also is produced during the moan. One estimate of the overall source level was as high as 188 dB, with most energy in the 1/3-octave bands centered at 20, 25, and 31.5 Hz, and also included secondary components estimates near 50 and 63 Hz (Cummings and Thompson 1971).
As with other vocalizations produced by baleen whales, the function of blue whale vocalizations is unknown, although there are numerous hypotheses (which include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by Thompson *et al.* 1992 for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Payne and Webb 1971, Edds-Walton 1997). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999). Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Sperm Whale
Distribution

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

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

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

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

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

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

Population Structure

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

Sperm whales may not form "populations" as that term is normally conceived. Jaquet (1996) outlined a hierarchical social and spatial structure that includes temporary clusters of animals, family units of 10 or 12 females and their young, groups of about 20 animals that remain together for hours or days, "aggregations" and "super-aggregations" of 40 or more whales, and "concentrations" that include 1,000 or more animals (Peterson 1986, Whitehead and Wiegart 1990, Whitehead et al. 1991). The "family unit" forms the foundation for sperm whale society and most females probably spend their entire life in the same family unit (Whitehead 2002). The dynamic nature of these relationships and the large spatial areas they are believed to occupy might complicate or preclude attempts to apply traditional population concepts, which tend to rely on group fidelity to geographic distributions that are relatively static over time.

Atlantic Ocean

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

Female and immature animals stay in Atlantic temperate or tropical waters year round. In the western North Atlantic, groups of female and immature sperm whales concentrate in the Caribbean Sea (Gosho et al. 1984) and south of New England in continental-slope and deep-ocean waters along the eastern United States (Blaylock et al. 1995). In eastern Atlantic waters, groups of female and immature sperm whales aggregate in waters off the Azores, Madeira, Canary, and Cape Verde Islands (Tomilin 1967).

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

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

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

Indian Ocean

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

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

Sperm whales are widely distributed throughout the Hawaiian Islands throughout the year and are the most abundant large whale in waters off Hawaii during the summer and fall (Rice 1960, Shallenberger 1981, Lee 1993, and Mobley et al. 2000). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawaiian Islands throughout the year (Thompson and Friedl 1982). The primary area of occurrence for the sperm whale is seaward of the shelf break in the Hawaiian Islands.

Sperm whales have been sighted in the Kauai Channel, the Alenuihaha Channel between Maui and the island of Hawaii, and off the island of Hawaii (Lee 1993, Mobley et al. 1999, Forney et al. 2000). Additionally, the sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Twenty-one sperm whales were sighted during aerial surveys conducted in Hawaiian waters conducted from 1993 through 1998. Sperm whales sighted during the survey tended to be on the outer edge of a 50 - 70 km distance from the Hawaiian Islands, indicating that presence may increase with distance from shore. However, from the results of

these surveys, NMFS has calculated a minimum abundance of sperm whales within 46 km of Hawaii to be 43 individuals (Forney et al. 2000).

Sperm whales south of the equator are generally treated as a single "population," although the IWC divides these whales into nine different divisions that are based more on evaluations of whaling captures than the biology of sperm whales (Donovan 1991). Several authors, however, have argued that the sperm whales that occur off the Galapagos Islands, mainland Ecuador, and northern Peru are geographically distinct from other sperm whales in the Southern Hemisphere (Rice 1977, Wade and Gerrodette 1993, and Dufault and Whitehead 1995).

Threats to the Species
Natural threats. Sperm whales are hunted by killer whales (Orcinus orca), false killer whales (Pseudorca crassidens), and short-finned pilot whales (Globicephala melas; Arnbom et al. 1987, Palacios and Mate 1996, Rice 1989, Weller et al. 1996, Whitehead 1995). Sperm whales have been observed with bleeding wounds on their heads and tail flukes after attacks by these species (Arnbom et al. 1987, Dufault and Whitehead 1995). In October 1997, 25 killer whales were documented to have attacked a group of mature sperm whales off Point Conception, California (personal communication from K Roberts cited in Perry et al. 1999) and successfully killing one of these mature sperm whales. Sperm whales have also been reported to have papilloma virus (Lambertson et al. 1987).

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

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

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

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

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

When the IWC introduced the International Observer Scheme in 1972, the IWC relaxed regulations that limited the minimum length of sperm whales that could be caught from 11.6 meters to 9.2 meters out of a concern that too many male sperm whales were being caught so reducing this size limit would encourage fleets to catch more females. Unfortunately, the IWC's decision had been based on data from the Soviet fleets who commonly reported female sperm whales as males. As a result, the new regulations allowed the Soviet whalers to continue their harvests of female and immature sperm whales legally, with substantial consequences for sperm whale populations. Berzin noted in a report he wrote in 1977, "the result of this was that some breeding areas for sperm whales became deserts" (Berzin 2007).

Although the IWC protected sperm whales from commercial harvest in 1981, whaling operations along the Japanese coast continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). More recently, the Japanese Whaling Association began hunting sperm whales for research. In 2000, the Japanese Whaling Association announced that it planned to kill 10 sperm whales in the Pacific Ocean for research, which was the first time sperm whales have been hunted since the international ban on commercial whaling. Despite protests from the U.S. government and members of the IWC, the Japanese government harvested 5 sperm whales and 43 Bryde's whales in the last six months of 2000. According to the Japanese Institute of Cetacean Research (Institute of Cetacean Research undated), another 5 sperm whales were killed for research in 2002 – 2003. The consequences of these deaths on the status and trend of sperm whales remains uncertain, given that they probably have not recovered from the legacy of whaling; however, the renewal of a program that intentionally targets and kills sperm whales before we can be certain they recovered from a history of over-harvest places this species at risk in the foreseeable future.

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

In U.S. waters in the Pacific Ocean, sperm whales are known to have been incidentally captured only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991 - 1995 (Barlow et al. 1997). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on fish caught in longline gear in the Gulf of Alaska. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and DeMaster 1998). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear.

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

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

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

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

Waring et al. (2007) concluded that the best estimate of the number of sperm whales along the Atlantic coast of the U.S. was 4,029 (coefficient of variation = 0.38) in 1998 and 4,804

(coefficient of variation = 0.38) in 2004, with a minimum estimate of 3,539 sperm whales in the western North Atlantic Ocean.

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

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

The information available on the status and trend of sperm whales do not allow us to make a definitive statement about the extinction risks facing sperm whales as a species or particular populations of sperm whales. However, the evidence available suggests that sperm whale populations probably exhibit the dynamics of small populations, causing their population dynamics to become a threat in and of itself. The number of sperm whales killed by Soviet whaling fleets in the 1960s and 1970s would have substantial and adverse consequence for sperm whale populations and their ability to recover from the effects of whaling on their population. The number of adult female killed by Soviet whaling fleets, including pregnant and lactating females whose death would also have resulted in the death of their calves, would have had a devastating effect on sperm whale populations. In addition to decimating their population size, whaling would have skewed sex ratios in their populations, created gaps in the age structure of their populations, and would have had lasting and adverse effect on the ability of these populations to recover (for example, see Whitehead 2003).

Populations of sperm whales could not have recovered from the overharvests of adult females and immature whales in the 30 to 40 years that have passed since the end of whaling, but the information available does not allow us to determine whether and to what degree those populations might have stabilized or whether they have begun the process of recovering from the effects of whaling. Absent information to the contrary, we assume that sperm whales will have elevated extinction probabilities because of both exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) as well as endogenous threats caused by the legacy of overharvests of adult females and immature whales on their populations (that is, a population with a disproportion of

adult males and older animals coupled with a small percentage of juvenile whales that recruit into the adult population).

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

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

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

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins et al. 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis et al. 1995). Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changing the abundance of sperm whales should affect the distribution and abundance of other marine species.

Green Sea Turtle

Distribution
Green turtles are found in the Pacific Ocean, Atlantic Ocean, Indian Ocean, Caribbean 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 to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C. An east Pacific green turtle equipped with a satellite transmitter was tracked along the California coast and showed a distinct preference for waters with temperatures above 20°C (Eckert, unpublished data).

Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher densities of their food items associated with these oceanic phenomena. For example, in the western Atlantic Ocean, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS 1998). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS 2000).

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

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

Smaller nesting aggregations include: Angola, Bangladesh, Bikar Atoll, Brazil, Chagos Archipelago, China, Costa Rica, Cuba, Cyprus, Democratic Republic of Yemen, Dominican Republic, d'Entrecasteaux Reef, French Guiana, Ghana, Guyana, India, Iran, Japan, Kenya,

Madagascar, Maldives Islands, Mayotte Archipelago, Mexico, Micronesia, Pakistan, Palmerston Atoll, Papua New Guinea, Primieras Islands, Sao Tome é Principe, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Taiwan, Tanzania, Thailand, Turkey, Scilly Atoll, United States (Hawaii), Venezuela, and Vietnam (Seminoff 2002).

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

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

Green turtles in the northwest 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). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs *et al.* 1998). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg *et al.* 1999). Fibropapillomatosis is considered to decrease growth rates in afflicted turtles and may inhibit the growth rate of Hawaiian green turtle populations (Balazs *et al.* 1998).

Anthropogenic threats. Three human activities are known to threaten green sea turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of green sea turtle 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 populations of green sea turtles still lose large numbers of eggs, juveniles, and adults to subsistence hunters, local communities that have a tradition of harvesting sea turtles, and poachers in search of turtle eggs and meat.

Directed harvests of eggs and other life stages of green sea turtles were identified as a "major problem" in American Samoa, Guam, Palau, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Republic of the Marshall Islands, and the Unincorporated Islands (Wake, Johnston, Kingman, Palmyra, Jarvis, Howland, Baker, and Midway). In the Atlantic, green sea turtles are captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Bräutigam and Eckert 2006); the turtle fishery along the Caribbean coast of Nicaragua, by itself, has captured more than 11,000 green sea turtles each year for the past 10 years (Bräutigam and Eckert 2006, Lagueux 1998). Severe overharvests have resulted from a number of factors in modern times: (1) the loss of traditional restrictions limiting the number of turtles taken by island residents; (2) modernized hunting gear; (3) easier boat access to remote islands; (4) extensive commercial exploitation for turtle products in both domestic markets and international trade; (5) loss of the spiritual significance of turtles; (6) inadequate regulations; and (7) lack of enforcement (NMFS and USFWS 1998a).

Green sea turtles are also captured and killed in commercial fisheries. Gillnets account for the highest number of green sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges. Along the Atlantic coast of the U.S., NMFS estimated that almost 19,000 green sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 514 of those sea turtles dying as a result of their capture. Each year, several hundred green sea turtles are captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries in Pamlico Sound. Although most of these turtles are released alive, these fisheries are expected to kill almost 100 green sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown. Green sea turtles are also threatened by domestic or domesticated animals which prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

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

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

(Oman). The number of females nesting annually in the Indian Ocean has increased at the Comoros Islands, Tromelin and maybe Europa Island (Iles Esparses; Seminoff 2002).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert 1993, Seminoff 2002). They are also thought to be declining in the Atlantic Ocean. However, like several of the species we have already discussed, the information available on the status and trend of green sea turtles do not allow us to make a definitive statement about the global extinction risks facing these sea turtles or risks facing particular populations (nesting aggregations) of these turtles. With the limited data available on green sea turtles, we do not know whether green sea turtles exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if green sea turtles are threatened more by exogenous threats such as anthropogenic activities (entanglement, habitat loss, overharvests, etc.) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate). Nevertheless, with the exception of the Hawaiian nesting aggregations, we assume that green sea turtles are endangered because of both anthropogenic and natural threats as well as changes in their population dynamics.

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

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

In a study of the auditory brainstem responses of subadult green sea turtles, Bartol and Ketten (2006) reported responses to frequencies between 100 and 500 Hz; with highest sensitivity between 200 and 400 Hz. They reported that two juvenile green turtles had hearing sensitivities that were slightly broader in range: they responded to sounds at 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 insculpta*). 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 have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966).

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

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

Leatherback turtles are uncommon in the insular Pacific Ocean, but individual leatherback turtles are sometimes encountered in deep water and prominent archipelagoes. To a large extent, the oceanic distribution of leatherback turtles may reflect the distribution and abundance of their macroplanktonic prey, which includes medusae, siphonophores, and salpae in temperate and boreal latitudes (NMFS and USFWS 1996). There is little information available on their diet in subarctic waters.

Population Structure
Leatherback turtles are widely distributed throughout the oceans of the world. The species is divided into four main populations in the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest

there. The four main populations are further divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India, Sri Lanka, and the Andaman and Nicobar Islands.

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

Anthropogenic threats. Leatherback sea turtles are endangered by several human activities, including fisheries interactions, entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris (NMFS and USFWS 1997).

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

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

In the Pacific Ocean, between 1,000 and 1,300 leatherback sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set longline fisheries based out of Hawaii 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 Hawaii are estimated to have captured about 19 leatherback sea turtles, killing about 5 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future (NMFS 2008). Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawaii 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 (Castroviejo et al. 1994; Graff 1995). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux et al. 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio, 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95% (Eckert and Lien, 1999). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS 2001). There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

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

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

leatherback is now on the verge of extinction in the Pacific Ocean (e.g. Spotila et al. 1996, Spotila, et al. 2000).

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

In the Atlantic and Caribbean, the largest nesting assemblages of leatherbacks are found in the U.S. Virgin Islands, Puerto Rico, and Florida. Since the early 1980s, nesting data has been collected at these locations. Populations in the eastern Atlantic (i.e. off Africa) and Caribbean appear to be stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking and it is certain that some nesting populations (e.g., St. John and St. Thomas, U.S. Virgin Islands) have been extirpated (NMFS and USFWS 1995). Data collected in southeast Florida clearly indicate increasing numbers of nests for the past twenty years (9.1-11.5% increase), although it is critical to note that there was also an increase in the survey area in Florida over time (NMFS 2001). However, the largest leatherback rookery in the western North Atlantic remains along the northern coast of South America in French Guiana and Suriname. Recent information suggests that Western Atlantic populations declined from 18,800 nesting females in 1996 (Spotila et al. 1996) to 15,000 nesting females by 2000 (Spotila, personal communication cited in NMFS 2001). The nesting population of leatherback turtles in the Suriname-French Guiana trans-boundary region has been declining since 1992 (Chevalier and Girondot, 1998). Poaching and fishing gear interactions are believed to be the major contributors to the decline of leatherbacks in the area.

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

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

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

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

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

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

Diving and Social Behavior

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

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

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

Hearing

There is no information on leatherback sea turtle hearing. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtles: their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol et al. 1999, Ridgway et al. 1969).

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

Olive Ridley Sea Turtle

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 Pacific 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 (Sternberg 1981, Groombridge 1982).

In the eastern Pacific, POlive 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 Pacific ridley turtles.

Most records of Olive ridley turtles are from protected, relative shallow marine waters. Deraniyagalia (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, Pacific 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 that occurs along the Pacific coast of the Americas from Mexico to Columbia (Chaloupka *et al*. 2004).

Threats to the Species
Natural threats. 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.

Anthropogenic threats. 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 (Cliffton et al. 1982 in nmfs and usfws 1998). 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 1998). 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 (Marquez et al. 1995; Arenas et al. 2000). 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 (Salazar et al. in press). 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). 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 of the Species
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 Olive 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 (Milláán 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 afflicted with the fibropapilloma disease (Aguirre, *et al*. 1999). At Playa La Flor, the second most important nesting beach for Pacific 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 reports 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 have declined markedly from 1979 to 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 ridley turtles 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 (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 Pacific 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% of the eggs were lost due to inundation and erosion (B. Pandav, personal communication, in Shanker and Mohanty 1999). During 1999-2000, over 700,000 Olive ridleys nested at Nasi islands and Babubali island, in the Gahirmatha coast.

Diving and Social Behavior
Although Olive ridley turtles are probably surface feeders, they have been caught in trawls at depths of 80-110 meters (NMFS and USFWS 1998), and a post-nesting female reportedly dove to a maximum depth of 290 meters. The average dive length for an adult female and adult male is reported to be 54.3 and 28.5 minutes, respectively (Plotkin 1994, in Lutcavage and Lutz 1997).

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 turtles: their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol *et al*. 1999, Ridgway *et al*. 1969).

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

Hawksbill Sea Turtle

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

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

are of post-hatchlings and juveniles that are believed to have originated from nesting beaches in Mexico.

Hawksbill sea turtles have stranded along the almost the entire Atlantic coast of the United States, although most stranding records occur south of Cape Canaveral, Florida, particularly in Palm Beach, Broward and Miami-Dade counties (Florida Sea Turtle Stranding and Salvage database). Hawksbill sea turtles are very rare north of Florida, although they have been recorded as far north as Massachusetts. During their pelagic-stage, hawksbills disperse from the Gulf of Mexico and southern Florida in the Gulfstream Current, which would carry them offshore of Georgia and the Carolinas. As evidence of this, a pelagic-stage hawksbill was captured 37 nautical miles east of Sapelo Island, Georgia in May 1994 (Parker 1995). There are also records of hawksbill sea turtles stranding on the coast of Georgia (Ruckdeschel *et al.* 2000), being captured in pound nets off Savannah, and being captured in summer flounder trawls (Epperly *et al.* 1995), gillnets (Epperly *et al.* 1995), and power plants off Georgia and the Carolinas.

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

Around the Hawaiian Islands, hawksbills are only known to occur in the coastal waters of the eight main and inhabited islands of the archipelago. Hawksbills forage throughout the Main Hawaiian Islands, although in much fewer numbers than green turtles. Hawksbills have been captured at several locations including Kiholo Bay and Kau (Hawaii), Palaau (Molokai), and Makaha (Oahu) (Hawaii Department of Land and Natural Resources, 2002). Strandings have been reported in Kaneohe and Kahana Bays (Oahu) as well as in other locations throughout the Main Hawaiian Islands (Eckert, 1993; National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998b). No reliable reports are known from Niihau (U.S. Department of the Navy, 2001a). Hawksbills are much more abundant in the shallow, offshore waters of the Hawaiian Islands than they are in deeper, offshore waters of the central Pacific Ocean.

Hawksbill sea turtles occupy different habitats depending on their life history stage. After entering the sea, hawksbill sea turtles occupy pelagic waters and occupy weedlines 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 (Hildebrand 1987, Amos 1989).

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.

Threats to the Species

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

Anthropogenic Threats. Three human activities are known to threaten hawksbill sea turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of hawksbill sea turtle populations was overharvest 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 (Bräutigam 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 1998b). 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 Tokunaga *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 *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 1998b). In addition to the demand for the hawksbill's shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Before the U.S. certified Japan under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles.

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

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

Status

Hawksbill sea turtles were listed as endangered under the ESA in 1970. Under 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 (Groombridge 1982). 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 (Meylan 1989).

In Hawaii, a few females nest each year on Maui and Molokai but the majority of hawksbill nesting in the Hawaiian Islands takes place on the Big Island of Hawaii. Since 1991, a total of 72 nesting females have been tagged on beaches including Kamehame, Pohue, Punalu'u, Apua Point, Keauhou, Halape, Horseshoe, Koloa, Ninole, Kawa, Kahakahakea, Awili Point, and Waimanu. From 1989 through the 2008 nesting season, 89 nesting female hawksbills have been tagged on the Island of Hawaii at various locations, 12 tagged in the last 2 years of that period (Seitz and Kagimoto 2008). These do not include nesting females from Maui or Molokai which would add a small number to the total. While it seems more females are nesting on the Hawaiian Islands in recent years these are still small numbers of turtles. The information that we have at present does not allow us to make any definite statements about the trends of hawksbills inhabiting these islands.

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

Hawksbill sea turtles, like green sea turtles, are thought to be declining globally as a direct consequence of a historical combination of overexploitation and habitat loss. However, like several of the species we have already discussed, the information available on the status and trend of hawksbill sea turtles do not allow us to make definitive statements about the global extinction risks facing these sea turtles or the risks facing particular populations (nesting

aggregations) of these turtles. However, the limited data available suggests that several hawksbill sea turtles populations exist at sizes small enough to be classified as "small" populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) while others are large enough to avoid these problems. Exogenous threats such as overharvests and entanglement in fishing gear only increase their probabilities of becoming extinct in the foreseeable future.

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

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 turtles with their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol *et al*. 1999, Ridgway *et al*. 1969).

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Environmental Baseline

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

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

affect the likelihood that these endangered and threatened species will survive and recover in the wild.

Natural Mortality

Natural mortality rates in cetaceans and pinnipeds, 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 and red tide toxins. 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.

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

Sea turtles are exposed 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.

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). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs et al. 1998). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (Prorocentrum spp.) known to produce a tumor promoter, okadaic acid (Landsberg et al. 1999). Fibropapillomatosis is considered to decrease growth rates in afflicted turtles and may inhibit the growth rate of Hawaiian green turtle populations (Balazs et al. 1998).

Human-Induced Mortality
Large whale population numbers in the proposed action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the 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).

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale and sea turtle species. For example, 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 Hawaii 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 Hawaii are estimated to have captured about 45 loggerhead sea turtles, killing about 10 of these sea turtles. This fishery has interacted with 3 loggerhead and 9 leatherback sea turtles in 2009 and7 loggerhead and 8 leatherback sea turtles in 2010 (NMFS 2011). These fisheries are expected to continue at similar rates of interaction and deaths into the foreseeable future. Loggerhead sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawaii and American Samoa. Green, hawksbill and Pacific ridley sea turtles are not expected to be captured in the longline fishery.

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.

Ship Strikes
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.

Despite these reports, the magnitude of the risks ship traffic poses to large whales on or around the Action Area is difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the territorial seas and the Exclusive Economic Zone of the continental United States and have virtually no information on interactions between ships and commercial vessels in the western North Pacific Ocean. With the information available, we assume that interactions occur but we cannot estimate the number of interactions or their significance to the endangered whales of the western North Pacific Ocean.

Habitat Degradation
Chronic exposure to the neurotoxins associated with paralytic shellfish poisoning (PSP) via zooplankton prey has been shown to have detrimental effects on marine mammals. Estimated ingestion rates are sufficiently high to suggest that the PSP toxins are affecting marine mammals, possibly resulting in lower respiratory function, changes in feeding behavior and lower reproduction fitness (Durbin et al. 2002). Other human activities, including discharges from wastewater systems, dredging, ocean dumping and disposal, aquaculture and additional impacts from coastal development are also known to impact marine mammals and their habitat. In the North Pacific, undersea exploitation and development of mineral deposits, as well as dredging of major shipping channels pose a continued threat to the coastal habitat of right whales. Point-source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, potential oil spills, as well as substantial commercial vessel traffic, and the impact of trawling and other fishing gear on the ocean floor are continued threats to marine mammals in the proposed action area.

The impacts from these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (*e.g.*, DDT, PCBs, and polyaromatic hydrocarbons) and immunosuppression (De Swart et al. 1996; Harder et al. 1992; Ross et al. 1995). Organochlorines are chemicals that tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing, some of these contaminants can be passed from the mother to developing offspring. Contaminants like organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (O'Hara and Rice 1996; O'Hara et al. 1999; O'Shea and Brownell Jr. 1994).

The effects of climate change on marine species in the action area remain largely unknown. Gaps in information on species movements and distribution, the difficulty involved with studying highly mobile animals such as marine mammals and turtles, as well as insufficient historical information and long-term data sets on habitat and distribution all complicate any potential conclusions on the effects of climate change for these species (Kintisch 2006; Simmonds and Isaac 2007). However, possible effects of climatic variability include the

following: alteration of ecological community composition and structure, possibly resulting in species relocating from areas they currently use in response to changes in oceanic conditions; use of an altered range as temperature-dependent distribution limits change; changes to migration patterns or community structure; changes to species abundance; increased susceptibility to disease and contaminants; alterations to prey composition and availability; and altered timing of breeding (MacLeod *et al.* 2005; Robinson *et al.* 2005; Kintisch 2006; Learmonth *et al.* 2006; McMahon and Hays 2006). Such changes could affect reproductive success and survival, and therefore have consequences for the recovery of both large whales and sea turtles (Robinson *et al.* 2005; Learmonth *et al.* 2006; Cotté and Guinet 2007).

Anthropogenic Noise

The marine mammals and sea turtles 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). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta et al.(2001)and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson. 1996). The 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.

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

The Impact of the Baseline on Listed Resources
Although listed resources are exposed to a wide variety of past and present state, Federal or private actions and other human activities that have already occurred or continue to occur in the action area as well as Federal projects in the action area that have already undergone formal or early section 7 consultation, and State or private actions that are contemporaneous with this consultation, the impact of those activities on the status, trend, or the demographic processes of threatened and endangered species remains largely unknown.

Historically, commercial whaling had occurred in the action area and had caused all of the large whales to decline to the point where the whales faced risks of extinction that were high enough to list them as endangered species. Since the end of commercial whaling, the primary threat to these species has been eliminated. However, all of the whale species have not recovered from those historic declines and scientists cannot determine if those initial declines continue to influence current populations of most large whale species. Species like North Pacific right whales have not begun to recover from the effects of commercial whaling on their populations and continue to face very high risks of extinction in the foreseeable future because of their small population sizes (on the order of 50 individuals) and low population growth rates. Relationships between potential stressors in the marine environments and the responses of these species that may keep their populations depressed are unknown.

Recent attention has focused on the emergence of a wide number of anthropogenic sound sources and their role as a pollutant in the marine environment. Relationships between specific sound sources, or anthropogenic sound generally, and the responses of marine mammals and sea turtles to those sources are still subject to extensive scientific research and public inquiry but no clear patterns have emerged.

Few of the anthropogenic phenomena in the Action Area that represent potential risks to whales in the Action Area seem likely to kill whales. Instead, most of these phenomena — anthropogenic sound sources, pollution, and many fishery interactions — would affect the behavioral, physiological or social ecology of whales in the region. Reports suggest that the response of whales to many of the anthropogenic activities in the Action Area are probably short-lived, which suggests that the responses would not be expected to affect the fitness of

individual whales. Most of these reports relate to humpback whales during their winter, breeding season; there are very few reports of the behavioral responses of other whale species to human activity in the action area.

Despite continued declines in the Northwest Hawaiian Islands, the increasing rate at which monk seals are sighted in the Main Hawaiian Islands and the increased number of pups born in the Main Hawaiian Islands suggests that the stress regime created by the activities discussed in this *Environmental Baseline* is not having a negative impact on these seals. In the case of monk seals, however, increases in their occurrence in the Main Hawaiian Islands may represent a re-distribution from the Northwest Hawaiian Islands, which would imply that environmental conditions may merely be worse in the Northwest Hawaiian Islands.

The stress regime created by the activities discussed in this *Environmental Baseline* continues to have a serious and adverse impact on leatherback and loggerhead sea turtles. For several years, NMFS' biological opinions have established that the leatherback and loggerhead sea turtles populations in the Pacific Ocean face high probabilities of extinction as a result of both environmental and demographic stochasticity. Demographic stochasticity, or chance variation in the birth or death of an individual of the population, is facilitated by the increases in mortality rates of loggerhead populations resulting from the premature deaths of individual sea turtles associated with human activities (either removal of eggs or adult females that are killed on nesting beaches or that die as a result of being captured in fisheries) or incidental capture and mortality of individuals in various fisheries.

The information available suggests that green, hawksbill, olive ridley and leatherback sea turtles have high probabilities of becoming extinct in the Pacific Ocean unless they are protected from the combined threats of entanglements in fishing gear, overharvests, and loss of their nesting habitat. The limited data available suggests that hawksbill and leatherback sea turtles in the Pacific Ocean exist at population sizes small enough to be classified as "small" populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) as evidenced by biases in the male to female ratios in the Pacific for leatherback and loggerhead sea turtles. The number of individuals of both species that continue to be captured and killed in fisheries in the action area contributes to the increased extinction risk of both of these species.

Effects of the Proposed Actions

Pursuant to Section 7(a)(2) of the ESA, federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed survey and issuance of the IHA by NMFS for "takes" of marine mammals during the seismic studies would expose listed species to seismic airgun pulses, as well as sound emitted from a multi-beam bathymetric echosounder and sub-bottom profiler. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed actions, the probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in the *Approach to the Assessment* section, for

any responses that would be expected reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment is to determine if it is reasonable to expect the proposed activities to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned about behavioral disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences. The proposed IHA would authorize non-lethal "takes" by harassment of listed species during survey activities. The ESA does not define harassment nor has NMFS defined the term pursuant to the ESA through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, "...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's regulatory definition of "harass"[5] pursuant to the ESA. For this Opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

Evidence Available for the Assessment
Given the nature of the proposed seismic activities, the effects of anthropogenic sound on ESA-listed whales and sea turtles are assessed in this consultation. Information on these effects is limited, and methods to acquire acoustic information, such as audiograms of large whales, are not available. The available information on hearing capabilities and mechanisms employed for receiving and interpreting sounds remains very limited due to the cryptic nature of some species and their rarity, the large size of many species, and the difficulties associated with performing field studies on these animals. Underwater hearing abilities have been studied experimentally in a few species. Where experimental data do not exist, some inference of the sound frequencies that are important to large whales and sea turtles can be made from the characteristics of the sounds they produce or from the physiology of their hearing organs.

Assumptions
In conducting the effects analysis for the proposed actions, several assumptions must be made due to gaps in available information. Definitive statements on the effects of sound from the proposed activities are complicated because detection of sounds by these animals depends on the acoustic properties of the source (spectral characteristics and intensity), transmission characteristics of the water, and sensitivity of hearing in each species. Furthermore, responses to

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5   An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)

sounds can be highly variable between individuals and may depend on an animal's activity at time of exposure, motivation for that activity, age, and any habituation or sensitization to sounds.

The effects analysis in this Opinion reviews information on the characteristics of sounds resulting from the proposed action, incorporates assumptions about large whale, pinniped and sea turtle hearing abilities based on available information (as presented in the *Status of Listed Resources* section), and examines published studies of animals' responses upon exposure to sounds. When the airguns, multi-beam bathymetric echosounder, and sub-bottom profiler would are operating simultaneously, the dominant sound at distances from the *Langseth* would be the low-frequency airguns given that transmission loss for higher-frequency sounds is relatively greater. We cannot however, rule out the engine noise from the Langseth as contributing to any disturbance that may occur to listed whales and sea turtles in the action area.

Based on the assumptions for what the different taxa can hear, we expect that sperm whales would be sensitive to mid- to high-frequency sounds and blue whales and sea turtles would be sensitive to lower frequency sounds such as those produced by seismic airguns. Published studies of these and other species' responses or lack of response to anthropogenic sounds are available; we assume that responses noted in these studies mean that individuals of similar species, for which no studies are available, would respond similarly. To examine the potential for sounds to mask the detection of natural sounds at similar frequencies, or to induce temporary or permanent reductions in an individual's hearing threshold, the analysis examined results from controlled exposure studies. Given fundamental similarities in ear anatomy among marine mammals, sperm whales were expected to experience similar types of physiological changes when exposed to similar sounds. There is no information regarding hawksbill, olive ridley and leatherback sea turtle hearing sensitivities. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtles (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), and therefore, we will assume information related to other sea turtle species apply to all other sea turtles as well.

Potential Stressors
The assessment for this consultation identified several possible stressors associated with the proposed seismic activities:
- disturbance from acoustic energy associated with airguns, sonars, OBSs and MT instruments,
- disturbance from sounds generated by vessel engines, and
- ship strikes

A more detailed review of the possible stressors is presented on the following pages along with a review of the available information and determination as to which of the possible stressors would be likely to occur and which would be negligible.

Disturbance from Acoustic Sources

Airgun Array
Sounds produced by the airguns are short pulses occurring for less than one second. For the proposed activity, the pulse duration is 0.1s and would occur at 22 s for seismic surveying with the hydrophone streamer, or every 300 s when recording data on the OBSs as the *Langseth* travels 7.4–9.3 km/h. Most of the energy in the sound pulses emitted by airguns occurs at low frequencies (0-188 Hz), with considerably lower levels for frequencies above 1,000 Hz, and smaller amounts of energy emitted up to ~150 kHz (LGL Ltd. 2011).

As described in LGL, Ltd (2011), airguns function by venting high-pressure, compressed air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure oscillations. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle, and coalesce pressure levels into one pulse. The resulting downward-directed pulse has a fraction of a second duration, with only one strong positive and one strong negative peak pressure (Caldwell and Dragoset 2000).

The strengths of airgun pulses can be measured in different ways. Peak-to-peak levels (pk-pk) are presented in units of dB re 1 μPa. The peak level (0-pk) for the same pulse is typically about 6 dB less. In the biological literature, levels of received airgun pulses are often described based on the "average" or "root-mean-square (rms)" level over the duration of the pulse. The rms value for a given pulse is typically about 10 dB lower than 0-pk, and 16 dB lower than pk-pk (McCauley *et al.* 2000b; Greene *et al.* 1997, McCauley *et al.* 1998 both *as cited in* NMFS 2006h). A fourth measure – sound energy level – is sometimes used and is expressed in dB re 1 $\mu Pa^2 \cdot s$; however, because seismic pulses are less than one second in duration, the numerical value of sound energy level is lower than the rms pressure level.

As mentioned in the *Description of the Proposed Actions* section, the 36-airgun array will have an estimated peak (0-pk) sound source level of 259 dB re 1 μPa and a peak to-peak of 265 dB. The source levels for airgun arrays are nominal source levels for sound directed downward, which represent the theoretical source level close to a single point source emitting the same sound as that emitted by the arrays. The actual source for airgun arrays is a distributed sound source (i.e., multiple guns) rather than a single point source. In order to communicate the levels of sound from the array, back calculations must be made from far field measurements to acquire a theoretical value of the source level. This theoretical source level is never actually realized for airgun arrays because airguns are distributed over several meters; the highest sound levels actually measurable in the water close to the airgun array (such as one meter) will never be as high as the nominal source level. For the *Langseth* array, the highest sound level actually measurable at any location in the water from the airguns is estimated at approximately 264 dB (pk-pk). Given that rms levels are typically 16 dB lower than pk-pk values, the estimated rms source level for the *Langseth* airgun array would be 248 dB (rms). In addition, because of the directional nature (downward) of the sound propagating from these airgun arrays, the effective source level for sound propagating in near-horizontal directions will be substantially lower than the nominal source level. The theoretical point source estimates for airgun arrays are useful,

however, for accurately reflecting received levels in the far-field (at more than 75 to 100 m; Caldwell and Dragoset 2000).

Pathways for received seismic sound include direct paths from the source, indirect paths that include reflection from the sea surface and bottom, and often indirect paths including segments propagating through bottom sediments. Sound propagating via indirect paths travels longer distances and often arrives later than sounds received via a direct path. However, sound may also travel faster through sediments than in water, and thus may arrive earlier than the direct arrival despite traveling a greater distance. Variations in travel time lengthen the duration of a received pulse; seismic pulses of about 10 to 20 ms in duration at the source can be longer when received at long horizontal distances. For example, for an airgun array operating in the Beaufort Sea, pulse duration was about 300 ms at a distance of 8 km, 500 ms at 20 km, and 850 ms at 73 km (Greene and Richardson 1988).

Multi-beam Bathymetric Echosounder (MBES)
The proposed activities would include multi-beam bathymetric echosounder (MBES) sonar, operated continuously, to map the ocean floor. The hull-mounted MBES has a narrow fore-aft beamwidth, operates at high frequencies (10.5–13 kHz), and has a maximum source level of 242 dB re 1 µPa.

For deep-water operation, each "ping" consists of eight (in water depths greater than 1000 m) or four (in water depths less than 1000 m) successive fan-shaped transmissions which ensonifies a sector that extends 1° fore-aft. The successive transmissions span an overall cross-track angular extent of about 150°, with 2-ms gaps between pings for successive sectors. Continuous wave signals (waves of constant energy and frequency) increase from 2 to 15 ms long in water depths up to 2600 m and frequency-modulated (FM) chirp signals up to 100 ms long are used in water depths greater than 2600 m.

Sub-Bottom Profiler (SBP)
The proposed survey would also use a Knudsen Chirp 3260 sub-bottom profiler to provide information about the sea floor. The SBP would operate simultaneously with the airgun array and the MBES. Energy from the SBP is directed downward by a hull-mounted 3.5 kHz transducer and varies with water depth. The SBP has a maximum source level of 204 dB re 1 µPa but varies with water depth. Nominal beam width is 27 degrees, and pulse duration would be up to 64 ms. The interval between SBP pulses would be 1 s, with a common mode of operation being five pulses at 1-s intervals followed by a 5-s pause.

Ocean Bottom Seismometers (OBS) and Magneto-Telluric (MT) instruments
The proposed action includes the deployment and retrieval of OBSs and MT instruments. Once an OBS or MT is ready to be retrieved, an acoustic release transponder interrogates the instruments at a frequency of 9–11 kHz, and a response is received at a frequency of 9–13 kHz.

Disturbance from vessel Noise and Risk of Ship Strike
The use of airguns requires a vessel to tow the array through the water column. The Langseth will tow the airgun array at speeds of 7.4-9.3 km/hr. A moving vessel poses some risk of disturbance and ship strike to large whales and sea turtles. Sounds emitted by large vessels can

be characterized as low-frequency, continuous, and tonal, and sound pressure levels at a source will vary according to speed, burden, capacity and length (Richardson *et al.* 1995). Although the Langseth contains quieting technologies that reduce their acoustic signature (relative to the acoustic signature of similarly-sized vessels) marine animals would still detect the Langseth and its acoustic equipment.

For vessels, the set of variables that help determine whether marine mammals are likely to be disturbed include: (1) the number of vessels in the area and the animal's assessment of the risks associated with those vessels; (2) the distance between vessels and marine mammals; (3) the vessel's speed and path; (4) the predictability of the vessel's path; (5) noise associated with the vessel and the rate at which the engine noise increases; and (7) the type of vessel.

It is not clear what environmental cue marine animals might respond to: the sounds of waters being displaced by the ships, the sounds of the ship's engines, or a combination of environmental cues surface vessels produce while they transit. In the case of a vessel towing an acoustic array, marine mammals may not distinguish between the operating acoustic equipment and the vessel's engines.

Marine mammals engage in avoidance behavior when vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Green 2004; Lusseau 2006). Several, authors, however, suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jackson 1994, Evans et al. 1992, 1994).

Sea turtles would be expected to detect approaching vessels via auditory and/or visual cues based on knowledge of their sensory biology (Bartol and Ketten 2006, Bartol and Musick 2003, Ketten and Bartol 2006, Lewenson et al. 2004). Little information is available on how turtles respond to vessel approaches. Hazel *et al* (2007) reported sea turtle reaction time was greatly dependent on the speed of the vessel; sea turtles were able to react faster to slower moving vessels than to faster moving vessels. Also, sea turtle reactions to vessels elicited short-term responses. Sea turtle hearing sensitivity is not well studied. Several studies using green, loggerhead, and Kemp's ridley turtles suggest that sea turtles are most sensitive to low-frequency sounds, although this sensitivity varies slightly by species and age class (Bartol *et al.* 1999, Ketten and Bartol 2006, Lenhardt 1994, Ridgway *et al.* 1969).

Because the Langseth would travel at speeds of about 7.4-9.3 km/hr the vessel would have a rather predictable path surveying the tracklines with occasional turns. This steady speed and pattern would create a steady increase or decrease in noise level making the Langseth's whereabouts predictable. Because the survey will be completed with only one the Langseth we would not expect vessel collisions to occur. We expect large whales to be able to detect the Langseth and sea turtles would either detect the vessel or be moved away from the vessel by pressure waves as the vessel moves through the area. Large whales should also be detected by the PSVOs further minimizing the risk of strikes.

EXPOSURE ANALYSIS

Exposure analyses identify the ESA-listed species that are likely to co-occur with the actions' effects on the environment in space and time, and identify the nature of that co-occurrence. The *Exposure Analysis* identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulation(s) those individuals represent.

NMFS applies certain acoustic thresholds to help determine at what point during exposure to seismic airguns (and other acoustic sources) marine mammals are considered "harassed", pursuant to the MMPA (65 FR 16374; March 28, 2000). These thresholds are used to develop safety radii around a source and the necessary power-down or shut-down criteria, and are applied to sea turtles for the proposed activities as well. Seismic airgun noise can propagate substantial distances (e.g., Nieukirk *et al.* 2004), although at lower sound levels than the designated acoustic thresholds. L-DEO estimated the safety radii around the proposed *Langseth* operations using an acoustic propagation model, adjusted with empirical data gathered in the Gulf of Mexico in 2009. The modeled distances to which sound levels (rms) might be received in deep (> 1,000m) waters as in this survey for the 36-airgun array and the 40 in^3 single airgun to be used during the proposed survey were provided in Table 1 on page 8.

The exposure analysis for this consultation is concerned with the numbers of blue and sperm whales and green, hawksbill, Olive ridley and leatherback sea turtles likely to be exposed to received levels greater than 180 dB re 1 µPa (rms), which constitutes the shut-down criterion for cetaceans that is also applied here to sea turtles. The maximum distance from airguns where received levels might meet the shut-down criterion of 180 dB (i.e., from the full 36-gun array and the single airgun) are estimated to be as follows:

- 36 airgun array: 0.940 km (0.51 nm)
- 40 in^3 single airgun: 0.040 km (0.02 nm)

These maximum distances all fall well within the visibility range from the *Langseth*. When stationed on the observation platform on the *Langseth*, eye level is about 21.5 m (70.5 ft) above sea level and PSVOs would be able to see around the entire vessel and to a distance of about 10 km with the naked eye, 5 km or further with the Big Eyes, 200 m with night vision and 2-3 km or further with the reticle binoculars. The 180 dB radius will not always reach these distances, as shorter radii will occur during the use of smaller numbers of airguns (e.g., the use of a single airgun during turns or power-down procedures). However, based on these maximum propagation distances, our concern is the probability of ESA-listed whales, and sea turtles occurring within this range from the *R/V Langseth* during seismic operations.

Marine Mammals

The IHA application contained the estimated number of ESA-listed whales that might be exposed to received levels equal to or greater than 160 dB re 1 µPa (rms) in the action area (LGL Ltd. 2011). LGL, Ltd (2011) states that an individual mammal would not be exposed numerous times during the survey since the seismic lines are widely spaced in the survey area. The whale exposure estimates are based on the best available information on whale densities and a planned

ensonified area of ~1,3714 km^2 (the planned track lines plus the contingency track line) that would be within the 160-dB isopleth on one or more occasions during the survey.

The resulting best estimates include 2 blue whales and 41 sperm whales. LGL, Ltd, (2011) estimated the percent of the population that would be exposed to acoustic sounds greater than 160 dB dB re 1 μPa. For blue whales and sperm whales they estimated less than 0.01% and less than 0.17% of the regional populations, respectively would be exposed to acoustic sounds greater than 160 dB dB re 1 μPa. These estimates are probably over-estimates as they assume that no animals would move away from the sounds.

From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual blue whales that might be exposed to survey activities, but they would comprise members of the Western North Pacific population. We assume these whales could represent any age class and either sex. Sperm whales that might be exposed to survey activities would be from the Hawaiian subpopulation of the North Pacific (females and immatures) or from other subpopulations in the North Pacific (mature bulls).

Mitigation measures and monitoring activities during the proposed survey include visual and passive acoustic monitoring, an exclusion zone within the 180 dB isopleths for cetaceans, speed and course alterations when practicable, power-down and shut-down procedures and ramp-up procedures for airguns. These measures are expected to reduce the risk that ESA-listed whales would occur within the 180 dB radius; therefore, any exposures that might occur are more likely to involve blue or sperm whales at received levels less than 180 dB re 1 μPa.

Sea Turtles

A few experiments where sea turtles were exposed to airgun sounds (e.g., see Moein *et al.* 1994; McCauley *et al.* 2000a; 2000b) indicate that avoidance of seismic sources by sea turtles may likely occur. However, monitoring reports from seismic surveys in other regions (including the Hess Deep area of the ETP) suggest that some sea turtles did not avoid airguns and were likely exposed to higher levels of seismic airgun pulses (Smultea and Holst 2003 *as cited in* NMFS 2006h). Accordingly, we expect some sea turtles may be exposed to the proposed activities.

Green turtles nest in most Pacific Island countries and territories including Hawaii and American Samoa (NMFS and USFWS 1998a). In nearshore waters of Hawaii, the green turtle is the most common turtle species. In Hawaii, most green turtles breed and nest at French Frigate Shoals from April through October (DoN 2005). Low-density nesting has also been recorded for Jarvis Island and Palmyra Atoll, and aggregations of resident greens are known to occur at Wake Island and Palmyra Atoll (WPRFMC 2009 *in* LGL, Ltd 2011). Sightings have also been made near Howland, Baker, and Jarvis islands and Kingman Reef (WPRFMC 2009 *in* L-DEO 2011). Some green turtles have been sighted or taken as bycatch in fisheries operations in offshore waters of Hawaii (McCracken 2000; DoN 2005). Green turtles in oceanic waters around Hawaii are most likely to be juvenile turtles in their pelagic life stage or reproductive turtles migrating between Hawaiian Islands. Few turtles are expected in the Action Area for this consultation.

Hawskbills primarily nest on the southeastern end of Hawaii and on the eastern end of Molokai from May through December but are also know to nest in American Samoa (LGL, Ltd 2011).

Hawksbills are much more abundant in the shallow, offshore waters of the Hawaiian Islands than they are in deeper, offshore waters of the central Pacific Ocean. Any hawksbills exposed to the survey activities are expected to be pelagic juveniles of both sexes.

Leatherbacks are regularly sighted in the offshore waters of Hawaii. The westward migration from foraging grounds along the west coast of North America to western Pacific nesting sites is believed to be south of Hawaii (DoN 2006 *in* LGL, Ltd 2011). Leatherback sea turtles would be members of either the eastern Pacific population (where females nest primarily in Mexico and Costa Rica) or the western Pacific population (where females nest in Indonesia, Papua New Guinea, Solomon Islands and Vanuatu) and of any sex or age. We cannot estimate the proportions of individual leatherback sea turtles in the Action Area belonging to each population, however, these turtles could be migrating, breeding or foraging.

Olive ridley sea turtles have been taken as bycatch in the Hawaiian longline fishery in the offshore waters to the north and south of Hawaii (McCracken 2000, Kobayashi and Polovina 2005 *in* LGL, Ltd 2011). Any olive ridley sea turtles exposed to the survey activities are expected to be members of either the eastern or western Pacific nesting populations that forage in the central North Pacific.

Mitigation measures and monitoring activities would also be applied for sea turtles during the proposed activities and include the same measures as applied for marine mammals. These measures are expected to reduce the risk that ESA-listed sea turtles would occur within the 180 dB radius; therefore, any exposures that might occur are more likely to involve sea turtles at received levels less than 180 dB re 1 µPa.

Exposure to MBES and SBP
The vessel-based sonar to be used during the proposed activities is downward-directed with a narrow fore-aft beamwidth. Any exposures to sonar pings that might occur would be expected to be brief, given the short duration of pulses and the fact the vessel will be transiting and ensonifying a narrow swath. The potential for exposure to these sources is further reduced by the measures in place to minimize exposure to seismic airguns within the 180 dB radius. Due to the directional nature of both the sub-bottom profiler and the echosounder, surface ducting of sound produced by this equipment is not expected to occur.

Sperm whales exhibit hearing at higher frequencies, and sound pulses from the multi-beam and sub-bottom sonar would be audible to individual sperm whales within the narrow extent of a transmitted sound beam. However, Kremser *et al.* (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal would have to pass at close range and be swimming at speeds similar to the vessel to be subjected to sound levels that could cause temporary threshold shifts.

Based on very preliminary information from a behavioral response study off southern California, in 2010 blue whales may be able to hear mid-frequency sounds. One blue whale was observed to cease deep diving behavior, surface and swim away from the mid-frequency source played around 140 db re1µ pa. These preliminary results, however, are just that and should be viewed with caution until further analysis and conclusions are reached for this event. Even so, that same

would hold true for blue whales as for sperm whales that an individual blue whale would have to pass at close range and be swimming at speeds similar to the vessel to be subjected to sound levels that could cause temporary threshold shifts.

For sea turtles, available information indicates detection of sounds in the low-frequency range below those produced by the MBES or SBP equipment. Based on this information, these species exposed to received levels of mid-frequency (1 kHz–10 kHz) sounds or higher are not likely to detect these sounds, and therefore, will not respond to these sounds.

Exposure to OBS and MT Instruments
Base on the hearing capabilities of cetaceans and the frequencies of the sound pulses from the OBS, we expect that sperm whales and maybe blue whales would hear the acoustic release transponder and the response.

RESPONSE ANALYSIS
As discussed in the *Approach to the Assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reducing the fitness of listed individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

Effects of exposure to airguns
A pulse of seismic airgun sound displaces water around the airgun and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as the listed whales and sea turtles considered in this Opinion. Possible responses considered in this analysis consist of (1) threshold shifts; (2) auditory interference (masking); (3) behavioral responses; and (4) non-auditory physical or physiological effects. The *Response Analysis* also considers information on the potential for stranding and the potential effects on the prey of ESA-listed whales and sea turtles in the Action Area.

Threshold Shifts
Few studies exist that examine hearing impairment in marine mammals or sea turtles resulting from exposure to a strong sound. An animal can experience temporary threshold shift (TTS) or permanent threshold shift (PTS). A threshold shift involves reduced sensitivity to sounds, requiring them to be stronger to be audible. Duration of TTS can be minutes, hours, or days, with eventual recovery to normal hearing thresholds. For sound exposures near the TTS onset threshold, hearing sensitivity recovers rapidly after exposure to the noise ends (LGL, Ltd 2011); however, few data on sound levels and durations necessary for mild TTS have been obtained for marine mammals, and none of the published data examine TTS elicited by exposure to multiple pulses of sound (LGL, Ltd 2011). PTS involves physical damage to the sound receptors in the ear, resulting in total or partial deafness, or impairment of hearing at specific frequency ranges. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal (Miller 2005).

Both TTS and PTS pose potential risks to marine mammals because they appear to extract a lot of information about their environment using hearing – e.g., information on the proximity of predators, the distribution and abundance of prey, changes in weather patterns and oceanic conditions, and information on and from other members of their species, among other information. Reducing the ability of these whales to hear natural sounds could have potential adverse consequences for the fitness of individuals experiencing threshold shifts.

For sperm whales, LGL, Ltd (2008) concluded from the available data that when exposed to single short pulses, the TTS threshold appears to be a function of the energy content of the pulse (Finneran et al. 2002, 2005 as cited in LGL, Ltd 2008). Given the available data, the received energy level of a single seismic pulse (with no frequency weighting) might need to be 186 dB SEL or ~196–201 dB re 1 µPa (rms) in order to produce brief, mild TTS. Exposure to several strong seismic pulses that each have received levels near 190 dB re 1 µPa (rms) might result in cumulative exposure of ~186 dB SEL and, thus, slight TTS, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. The distances from the Langseth's airguns at which the received energy level (per pulse, flat-weighted) would be expected to be greater than or equal to 190 dB re 1 µPa (rms) are estimated to be no more than 400 m (Table 1 page 8). For an odontocete closer to the surface, the maximum radius with greater than or equal to 190 dB re 1 µPa (rms) would be smaller. A higher level of sound is necessary to cause PTS. On an SEL basis, Southall et al. (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB for there to be risk of PTS. Thus, for cetaceans they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of ~198 dB re 1 µPa2 s (15 dB higher than the TTS threshold for an impulse), where the SEL value is cumulated over the sequence of pulses. A cetacean would need to received one or more pulses with peak pressure exceeding 230 or 218 dB re 1 µPa (0-peak), respectively. A peak pressure of 230 dB re 1 µPa (3.2 bar m, 0-pk) would only be found within a few meters of the largest (360-in3) airguns in the planned airgun array (Caldwell and Dragoset 2000).

For baleen whales, there are no studies to indicate the levels or properties of sound required to induce TTS. LGL, Ltd (2011) concluded that the frequencies to which baleen whales are most sensitive are assumed to be lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004 as cited in LGL, Ltd 2011). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales (Southall et al. 2007).

We do not expect that sperm whales or blue whales are likely to experience TTS or PTS from the proposed activities. Levels adjacent to the airguns may not be sufficient to induce PTS in whales, especially because an individual would not be exposed to more than one pulse at this received level unless it swam alongside the airgun for longer than the inter-pulse period.

Although sea turtles detect low frequency sound, the potential effects on sea turtle biology remain largely unknown (Samuel 2005). TTS in loggerhead sea turtles is reported to have been observed during studies by Moein *et al.* (1994). Turtle hearing was tested before, within 24 hours after, and two weeks after exposure to pulses of airgun sound. Moein *et al.* (1994) used an

evoked potential method to test sea turtle hearing and concluded that the turtles exhibited some change in their hearing when tested within 24 hours after exposure (relative to pre-exposure hearing). The authors found that hearing had reverted to normal when tested two weeks after exposure. The size of the airgun used or the received sounds levels were not provided; therefore, the levels of airgun sounds that apparently elicited TTS are not known (NMFS 2006c). These findings indicate that TTS may occur in sea turtles exposed to seismic sources; however, turtles in the study were confined. Sea turtles at sea might exhibit avoidance behavior and, thus, reduced exposure to seismic pulses. For any sea turtles that exhibit little or no behavioural avoidance, or if turtles habituate to seismic noise such that avoidance reactions cease, these individuals could sustain hearing loss if exposed to high enough sound levels from seismic airguns (LGL Ltd. 2008). Mitigation measures mentioned above for whales would also apply to sea turtles and would help reduce the received level of any exposures that may occur and further minimize the risk of PTS or TTS.

Auditory Interference (Masking)
Interference, or masking, generally occurs when the interfering noise is of a similar frequency and louder than the auditory signal received by an animal processing echolocation signals or listening for acoustic information from other individuals. Generally, noise will only mask a signal if it is sufficiently close to the signal in frequency. Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h). It is probable that masking would be more likely to result from a continuous noise rather than short pulses (Richardson *et al.* 1995).

Limited data exist on the masking effects of pulsed sounds. Seismic sources emit short pulses lasting less than a second every 20 seconds or longer (e.g., 22 and 66 seconds for the proposed survey activities). The short duration and discontinuous nature of seismic pulses present a limited probability of masking natural sounds with low frequencies. Any masking that might occur would likely be temporary because seismic sources are discontinuous and the seismic vessel would continue to transit. The proposed seismic surveys could mask whale calls at some of the lower frequencies, in particular for baleen whales but also for sperm whales. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Madsen *et al.* (2006) reported that, when oceanographic conditions were appropriate, sperm whales at the surface appeared to receive seismic pulses containing higher frequencies (between 300 Hz to 3 kHz), although at much lower received levels. Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, and though the findings by Madsen *et al.* (2006) suggest frequencies of seismic pulses can overlap this range, the strongest spectrum levels of airguns are below 200 Hz (0-188 Hz for the *Langseth* airguns). Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls would be expected to pose a greater risk of effects due to masking. However, even for those frequencies that may overlap, the low duty cycle of airguns indicates that pulses are not likely to pose a significant masking problem for communication or echolocation in whales (Madsen *et al.* 2002; 2006).

For sea turtles, hearing capabilities are centered in the low frequency range, as are the dominant frequencies of seismic pulses. Given the overlap, it would not be unreasonable to anticipate some masking may result from the proposed seismic activities. Limited information is available on the potential for masking with respect to sea turtles; however, given that seismic pulses would last a fraction of a second at intervals of 66 or 300 ms, any masking that may occur would be temporary as the seismic vessel transits through an area.

Behavioral Responses of Whales

Marine mammals may briefly respond to underwater sound by slightly changing their behavior or relocating a small distance, in which case the effects of these changes are unlikely to be significant to the individual, or by being displaced from important feeding or breeding areas over a prolonged period, in which case impacts on the individual could be significant. Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors.

For blue and sperm whales that may be present in the action area and exposed to seismic airgun sounds at levels of 160 dB re 1µPa or higher, several field studies of the behavioral responses of these species, or lack of responses, have been conducted. Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, systematic data on their reactions to airgun sound are generally lacking. One study for blue whales off Oregon reported that whales continued vocalizing at the same rate as before exposure to airgun pulses, suggesting that at least their vocalization behavior was undisturbed by the sound (McDonald *et al.* 1993). Sightings by observers on seismic vessels off the U.K. suggest that during times of good sightability, the numbers of Balaenopterids (such as blue, fin, and humpback whales) seen are similar between times when airguns are firing as well as silent (Stone 1997, 1998, 2000, 2001 *as cited in* NMFS 2006d). However, fin and sei whale sighting rates were higher when airguns were shooting, perhaps due to whales remaining at the surface at times of airgun operations (Stone 2003). The analysis of combined data from all years by Stone (2003 *as cited in* NMFS 2006d) indicated that baleen whales stayed farther from airguns, altered their course more often, and were headed away from the vessel more frequently during periods of shooting, suggesting some level of localized avoidance of seismic activity. Although information for blue and fin whales is limited, studies of other baleen whales are consistent (e.g., bowhead whales, see Miller 2005; Yazvenko *et al.* 2007) and indicate these species generally tend to avoid operating airguns, with avoidance radii being quite variable.

McCauley *et al.* (1998; 2000b) studied the responses of humpback whales off western Australia to a full-scale seismic survey with a 16-gun 2,678-in^3 array, as well as to a single 20-in^3 airgun with a source level of 227 db re 1µPa·m (pk-pk). The authors found the overall distribution of humpback whales migrating through the study area was unaffected by the full-scale seismic program, but that localized avoidance of the array and, to a lesser extent, the single airgun did occur. Avoidance reactions began at 5–8 km from the array and 2 km from the single airgun. Mean avoidance distance from the airgun corresponded to a received sound level of 140 db re 1µPa (rms), the level at which humpbacks started to show avoidance reactions to an approaching airgun. However, some humpback whales, especially males, approached within distances 100 to 400 m where the maximum received level was 179 db re 1µPa (rms). Potter *et al.* (2007) also reported localized avoidance of seismic airguns off Nova Scotia, but that whales did not move

outside the detection range. Humpback whales summering in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 100-in^3 airgun (Malme *et al.* 1985 *as cited in* NMFS 2006d). Some humpbacks appeared to exhibit a startle response at received levels of 150-169 db re 1μPa. Despite the possibility of subtle effects, the author concluded there was no clear evidence of avoidance at received levels up to 172 db re 1μPa. These studies indicate that humpback whales could begin avoiding the proposed seismic survey at received lower received levels, but that some individuals may not avoid the airgun operations at levels up to 180 db re 1μPa.

Data on the short-term responses or lack of response by these whales to impulsive noise do not necessarily provide information about the long-term effects of such exposure. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. For other baleen whales, reports indicate that habitat use is not significantly altered in the long-term. Gray whales continue to migrate annually along the west coast of North America despite intermittent seismic exploration in that area for decades (Malme *et al.* 1984). Johnson *et al.* (2007) reported that gray whales exposed to seismic airguns off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002–2005. Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years. This species was often seen in summering areas where seismic exploration occurred during preceding summers (Richardson *et al.* 1986). Bowhead whales have also been observed over periods of days or weeks in areas repeatedly ensonified by seismic pulses. However, it is not known whether the same individuals were involved in these repeated observations in strongly ensonified areas, or whether individuals that tolerate repeat exposures may still experience a stress response (see *Non-Auditory Physical or Physiological Effects* section below).

For sperm whales, available studies for a variety of anthropogenic sounds indicate these whales may or may not exhibit responses to such sounds, and that responses that do occur are variable. Based on available information, it appears sperm whales may react strongly to a novel acoustic stimulus but may habituate to the presence of some anthropogenic sounds (NMFS 2006b). Sperm whale responses to various anthropogenic sounds include disruptions of sperm whale clicking and behavior from sonars (Watkins and Schevill 1975; Watkins *et al.* 1985; Goold 1999), pingers (Watkins and Schevill 1975), the Heard Island Feasibility Test (Bowles *et al.* 1994), and the Acoustic Thermometry of Ocean Climate or ATOC (Calambokidis *et al.* 1998; Costa *et al.* 1998). Sperm whales have been observed to temporarily stop clicking in response to pinger sounds in the frequency range 6-13 kHz (Watkins and Schevill 1975); however, this response is thought to be one of listening, rather than of fear (NMFS 2006b). For example, sperm whales 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). Goold (1999) reported distinct changes in vocalizations of six sperm whales off Scotland during a shepherding operation by vessels driving the whales through a narrow channel using ship noise and echosounder/fishfinder emissions. A recent preliminary analysis of acoustic data from the northern Gulf of Mexico also indicates that sperm whales are, in some cases, affected by the passing of vessels, with fewer clicks and fewer whales detected afterwards (Ioup *et al.* 2005 *as cited in* NMFS 2006b). It is not known if this reflects a change in sound-

producing behavior, or the physical movement of whales away from the source. Similar changes were also observed when the data were analyzed for the effects of a passing tropical storm (Newcomb *et al.* 2004 *as cited in* NMFS 2006b).

In contrast, other studies have shown a lack of response by sperm whales to anthropogenic sounds. Madsen and Møhl (2000) found that sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 µPa (rms) from detonators. Sperm whales in the Mediterranean Sea were reported to continue calling when exposed to frequent and strong military sonar signals (J. Gordon pers. comm. *as cited in* Richardson *et al.* 1995). When André *et al.* (1997) exposed sperm whales to a variety of sounds to determine which sounds would scare whales away from paths of vessels, sperm whales were not observed to exhibit startle reactions to sources other than 10 kHz pulses (180 dB re 1 µPa at the source).

These studies demonstrate that sperm whales can be susceptible to certain anthropogenic sounds, though responses vary. As for a response by sperm whales to seismic surveys, limited systematic information is available regarding the reactions of any toothed whale to impulsive noises. However, information that is available indicates that for small and medium-sized toothed whales, the predominantly low-frequency seismic pulses (< 188 Hz) of the seismic airguns represent part of the spectrum where auditory systems are not very sensitive (i.e., higher hearing thresholds) (Richardson *et al.* 1995). Nonetheless, available information indicates seismic pulses are strong enough to be detectable to these small-to-moderate sized odontocetes, although avoidance reactions may be limited to considerably shorter ranges (Richardson and Würsig 1997; Goold and Fish 1998). In addition, reactions to impulse noise likely vary depending on the activity at time of exposure – e.g., in the presence of abundant food or during sexual encounters toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2006b).

Sperm whales are reported to show avoidance reactions to standard vessels not emitting airgun sounds (e.g., Richardson *et al.* 1995; Würsig *et al.* 1998), and it is reasonable to assume these whales may avoid an operating seismic survey vessel as well (L-DEO 2006). Accounts of possible avoidance of seismic vessels exist for sperm whales in the Gulf of Mexico (Mate *et al.* 1994; Jochens and Biggs 2004).

Some information indicates possible responses by sperm whales after exposure to seismic sources, such as an opportunistic observation by Mate *et al.* (1994), who reported a decrease in the number of sperm whales in a given area after the initiation of airgun seismic testing, and Johnson and Miller (2002 *as cited in* NMFS 2006g) who reported one tagged whale moving away from an operating seismic vessel in the northern Gulf of Mexico in July 2001 once received seismic pulses reached approximately 137 dB re 1 µPa. Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array more than 300 km away (Bowles *et al.* 1994).

Contrary to the observations mentioned above, results of other studies indicate there is considerable tolerance of seismic surveys by at least some sperm whales. Davis *et al.* (2000) noted that sighting frequency for sperm whales did not differ significantly between different acoustic levels used in the northern Gulf of Mexico. A recent study off northern Norway reported that sperm whales continued to call and remained in the area for at least 13 days when

exposed to pulses from a distant seismic vessel, involving received levels up to 146 dB re 1 μPa pk-pk (i.e., 130 dB (rms) (Madsen *et al.* 2002). Similarly, a study conducted off Nova Scotia analyzing 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 *as cited in* NMFS 2006h). Recent data from vessel-based monitoring programs in the United Kingdom (U.K.) also suggested that sperm whales showed no noticeable avoidance response. Compilation and analysis of data on responses of marine mammals to seismic surveys off the U.K. did not result in statistically significant evidence of avoidance by sperm whales (Stone and Tasker 2006). One interpretation is that sperm whales have a high tolerance for certain types of noise (e.g., André *et al.* 1997).

An experimental study of sperm whale reactions to seismic surveys in the Gulf of Mexico was conducted, along with a study of the movements of sperm whales with satellite-linked tags in relation to seismic surveys (see Jochens and Biggs 2003; 2004; Jochens *et al.* 2006; Jochens 2008). Data show that during two controlled exposure experiments with exposure to seismic pulses at received levels up to 148 dB re 1 μPa (rms) over the octave band with most energy, there was no indication of avoidance of the vessel or changes in diving behavior (Jochens *et al.* 2006; Jochens 2008). In addition, Madsen *et al.* (2006) report that seven of eight tagged sperm whales continued to perform foraging dives throughout exposure to seismic airguns at levels up to 147 dB (rms) (the eighth whale remained at the surface during exposure). Although the sample sizes for these findings are small, the results are consistent with those off northern Norway by Madsen *et al.* (2002). Jochens *et al.* (2006) report that visual observations of sperm whale clusters during seismic studies in the Gulf indicated no significant responses in terms of (1) heading relative to seismic surveys, (2) time spent at the surface during surveys, and (3) surfacing rate from two hours before and after seismic survey lines within 100, 50, or 25 miles. Although these studies suggest that sperm whales did not exhibit horizontal avoidance of seismic activity, few exposures occurred above 160 dB pk-pk (or approximately 144 dB rms), and further research is needed to examine avoidance at higher received levels (Jochens *et al.* 2006). Jochens *et al.* (2006) also speculate that sperm whales in that area may have some level of habituation to airgun sounds.

These studies suggest that sperm whales exhibit considerable tolerance of seismic sources (e.g., no apparent disruption of behaviors such as foraging or calling), or possibly some degree of habituation. Information on distance from airguns and received levels are not always provided in these studies; distance from airguns, which can determine the received level, has been found to be an important factor affecting other large whales species such as humpback (McCauley *et al.* 2000a; 2000b), gray, and bowhead whales (see Richardson *et al.* 1995).

Particular whales might not respond to the vessels, while in other circumstances, they may change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). For the ESA-listed whale species exposed to seismic airguns during the proposed activities, any alterations of normal behavior that result in avoidance of biologically important habitat or reductions in foraging opportunities could be biologically significant. The proposed activities would overlap

with foraging and possibly migrating whales in the action area. If repeated displacement or disruption of animals occurred, the reproduction and recruitment rates could be reduced. However, as mentioned previously, the maximum repeat exposure of individuals expected during the proposed activities would be once, assuming whales do not alter their location between subsequent seismic firing of that transect. Although the proposed activities could overlap with foraging whales, given the limited duration of the proposed seismic activities (11 days), the vastness of the survey site, the limited risk for repeat exposure to airguns and the mitigation measures to minimize the risk of exposure at received levels of concern, we do not anticipate that behavioral responses to the proposed activities would significantly result in reduced foraging opportunities. Because of these reasons, we do not expect these responses to reduce the fitness of the blue and sperm whales that occur within the Action Area.

Behavioral Responses of Sea Turtles
Sea turtle hearing thresholds appear to be higher than those for mammals (DFO 2004; NMFS 2006h), and DFO (2004) concluded it is unlikely that sea turtles would be more sensitive to seismic operations than cetaceans, based on available studies. Sea turtles are expected to be less sensitive to sounds; however, behavioral responses to environmental sounds are documented in several controlled experiments. As mentioned previously, studies on sea turtle hearing indicate sensitivity to low frequency sounds (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Moein Bartol *et al.* 1999), and it has been suggested that sea turtles use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt *et al.* 1983). Some possible reactions to low frequency sounds include startle responses and rapid swimming (Lenhardt 2002; McCauley 2001 *as cited in* NMFS 2006h), as well as swimming towards the surface at the onset of the sound (Lenhardt 1994).

Available studies suggest some sea turtles exhibit an avoidance reaction to airgun-generated sounds. McCauley *et al.* (2000a; 2000b) investigated the effects of airguns on sea turtle behavior. The authors found that green and loggerhead sea turtles show avoidance to airgun arrays at 2 km (1.1 nm) and at 1 km (0.54 nm) with received levels of 166 dB re 1 µPa and 175 dB re 1 µPa, respectively. Individual sea turtles responded consistently by noticeably increasing swimming activity above a level of approximately 166 dB re 1 µPa (rms), as compared to swimming during non-airgun operation periods. The increase in swimming behavior tracked the received airgun level, by increasing at increasing levels. Above 175 dB re 1 µPa, turtle behavior became more erratic, possibly indicating the turtles were in an agitated state. In studies by Lenhardt (1994) and Lenhardt *et al.* (1983), loggerhead and Kemp's ridley turtles responded to airgun pulses and low-frequency sound – e.g., by becoming active and swimming to the surface upon exposure. Moein *et al.* (1994) used an evoked potential method to test sea turtle hearing and reported avoidance behavior in loggerhead sea turtles at the beginning of airgun exposure trials; however, repeated airgun exposures days after the initial tests did not elicit a statistically significant avoidance response. The authors concluded this may be due to either habituation or temporary threshold shift in the turtles hearing capability. And based on a review of sea turtle data from 11 L-DEO seismic surveys since 2003, Holst *et al.* (2006) concluded that turtles exhibited localized avoidance during both large- and small-source seismic surveys.

Although studies suggest sea turtles are most likely to avoid seismic airgun pulses, monitoring reports from seismic surveys indicate occasions when sea turtles were likely exposed to seismic

airgun pulses – e.g., green, leatherback, and olive ridley turtles during surveys in the Hess Deep area of the eastern tropical Pacific Ocean (Smultea and Holst 2003 *as cited in* NMFS 2006h). Of six sea turtles that were sighted during those surveys, five were seen while airguns were active. In at least one instance, an olive ridley sea turtle was sighted within ten meters of the array while active. This turtle was reported to exhibit visible responses to either exposure to the seismic pulses or to the physical presence of the array and floats (NMFS 2006h). Although the turtle swam away from the vessel and was not reported to suffer physical injury, it is assumed the turtle experienced a stress response to its exposure that may have risen to the level of harassment. Similarly, Holst *et al.* (2005b) report during seismic operations in the southern Gulf of Mexico off the Yucatán Peninsula, that seven sea turtles were sighted within the 180 dB safety radius in shallow water (< 40 m). One of these turtles was reported to be actively swimming away from the seismic source. Six of these turtles were seen < 200 m from the operating airguns before the airguns were powered- or shut-down (Holst *et al.* 2005b).

In summary, available evidence indicates avoidance of seismic sources by sea turtles is likely, but that some turtles may not avoid the source vessel and may be exposed to seismic sound at levels of concern. Based on available information on captive turtles, avoidance may begin at received levels above 166 dB re 1 µPa. Avoidance behavior may shorten the exposure period, and the ramping-up of airguns during the proposed study would provide opportunity for avoidance by sea turtles, thereby minimizing exposure to received levels of concern. Avoidance or any disruptions in sea turtle behavior are expected to be temporary and are not expected to cause any injury. For those turtles that might be exposed to seismic pulses at levels above 166 dB re 1 µPa during the proposed study, we expect this could result in a stress response that rises to the level of harassment (see below).

Non-Auditory Physical or Physiological Effects
Non-auditory physical or physiological effects are possible in marine mammals and turtles exposed to strong underwater pulsed sound, such as from airguns (LGL, Ltd 2011); however, studies of such effects are limited. Possible types of effects or injuries could include stress, neurological effects, and other types of organ or tissue damage (LGL, Ltd 2011).

Stress responses by animals involve the autonomic nervous system, producing changes in heart rate, blood pressure, and gastrointestinal activity that are typically of short duration. Such responses may or may not have significant long-term effects on an individual's welfare (NMFS 2006g). Stress responses may also involve the neuroendocrine system and hormones associated with the HPA-axis (hypothalamus-pituitary-adrenal system) in mammals or the hypothalamus-pituitary-interrenal axis in some reptiles. Functions affected by stress include immune competence, reproduction, metabolism, and behavior (NMFS 2006g). Stress is an adaptive response and does not normally place an animal at risk; however, *distress* (allostatic loading) involves a stress response resulting in a biological consequence to the individual and lasts until the animal replenishes its energy reserve sufficient to restore normal function. Minimal information is available on the physiological responses of marine mammals and sea turtles upon exposure to anthropogenic sounds. Given studies of other marine and terrestrial animals, it would be reasonable to assume that some marine mammals might experience physiological stress responses that would be classified as "distress" upon exposure to mid- and low-frequency sounds. As whales use hearing as a primary way to gather information about their environment

and for communication, we assume that limiting these abilities could be stressful for some individuals. Therefore, exposure to levels sufficient to trigger onset of PTS or TTS might be accompanied by physiological stress responses, as terrestrial animals are known to exhibit such responses under similar conditions (NRC 2003; NMFS 2006g). Stress responses may also occur at levels lower than those required for onset of TTS (NMFS 2006g). Although the magnitude and biological significance of any stress responses that might occur remain unknown, exposure to seismic sources would be limited in duration and some whales may exhibit some avoidance of seismic sources. Mitigation measures and monitoring are expected to help reduce the likelihood of exposure at levels of concern, further minimizing risk to blue and sperm whales.

It is possible that some marine mammal species may be susceptible to injury or stranding after exposure to seismic pulses; however there is no definitive evidence that these effects occur, even in close proximity to large airgun arrays (see discussion below under *Strandings*) (LGL, Ltd 2011). Available information indicates that gas and fat embolisms may potentially occur if cetaceans ascend too quickly when exposed to aversive sounds or if sounds in the environment cause the destabilization of existing bubble nuclei (see Potter 2004; Arbelo *et al.* 2005; Fernández *et al.* 2005a). There is speculation that gas and fat embolisms can occur during exposure to mid-frequency sonar; however, no available evidence indicates these effects occur in response to airgun sounds (LGL, Ltd 2011).

Sea turtles exposed to seismic sound may possibly experience a physiological stress response, but available studies are inconclusive (DFO 2004), and the magnitude or effects of any response remain largely unknown. Given evidence suggesting sea turtles likely avoid seismic sources, and those that are known to be exposed are not reported to have suffered a detectable physical injury, we assume that sea turtles exposed to seismic pulses during the proposed activities would not experience physical effects beyond a possible stress response. A stranding event involving sea turtles was reported coincident with seismic surveys (see *Strandings* section below); however, no available evidence definitively links seismic airgun testing with sea turtle mortality.

Although data are limited, we assume that some whales, and sea turtles may experience a stress response if exposed to seismic pulses in the proposed activities. Other non-auditory physical or physiological effects are unlikely to occur during the proposed activities given the limited duration of any exposures experienced by animals, the likelihood of at least some behavioral avoidance of seismic pulses, as well as efforts to minimize exposure via monitoring and mitigation measures. Such effects might only occur in unusual situations when individuals are exposed at close range for unusually long periods of time (LGL, Ltd 2011); this is not anticipated to occur during the proposed activities.

Strandings
Available information indicates that marine mammals close to underwater detonations can be killed or severely injured, with auditory organs especially susceptible to injury (Ketten *et al.* 1993; Ketten 1995 *as cited in* LGL, Ltd 2008). However, seismic airgun pulses are less energetic and have slower rise times, and there is no evidence available conclusively linking airguns to serious injury, death, or stranding even in the case of large airgun arrays (Gordon *et al.* 2003; L-DEO 2006). Evidence implicating seismic airguns in the stranding of marine mammals does exist for two beaked whales in the Gulf of California (*Ziphius cavirostris* – not listed under

the ESA nor currently considered a candidate for such listing), and possibly for four *Z. cavirostris* in the Galápagos Islands (Gentry 2002; Gordon *et al.* 2003). There appeared to be a temporal correlation between these events and seismic operations by the vessel *R/V Maurice Ewing* in the vicinity; however, a causal link could not be established for either event. Other strandings of beaked whales have also occurred, associated with military mid-frequency sonar transmissions – e.g., in the Bahamas, Canary Islands, and eastern Mediterranean Sea (Frantzis 1998). These other strandings were associated with military mid-frequency sonar (generally 2-10 kHz and relatively narrow bandwidth), which differs from the sound produced by seismic arrays (broadband and below 1 kHz). However, evidence that sonar pulses can lead to physical damage or mortality (even if indirectly) (U.S. Department of Commerce and U.S. Department of the Navy 2001; Jepson *et al.* 2003; Fernández *et al.* 2005) suggests that caution is still warranted when considering the effects on marine mammals from any high-intensity pulsed sound, such as from seismic airguns (LGL, Ltd 2008).

For sea turtles, no available information definitively links seismic airgun activities with any sea turtle mortalities (e.g., see 60 FR 21745; May 3, 1995) and strandings, although studies are limited. Anecdotal evidence from early 2004 indicates that more than 30 sea turtles stranded dead in Yucatán, Mexico (Jaszy and Horowitz 2005). Guzman-Hernandez (pers. comm. in NMFS 2006c) stated that one of the sea turtles had burst lungs, internal bleeding, and auditory damage. This event occurred during a time when seismic testing had been conducted nearby in very shallow waters. However, no definitive causal link is noted and seismic activity during the proposed study would be conducted mostly at deeper depths with monitoring to allow an opportunity to keep sea turtles from exposures to the highest received levels.

Given the available evidence on strandings, serious injury or mortality of blue or sperm whales or sea turtles due to the proposed seismic activities is not anticipated. First, marine mammal strandings involved beaked whales, which exhibit a distinct ear anatomy compared to other cetaceans. In addition, published information suggests listed taxa would not be lethally affected by exposure to the proposed seismic surveys. Lastly, the mitigation measures to be used during the proposed seismic activities should help minimize or avoid exposure.

Effects on Prey
In addition to the responses discussed above, seismic surveys could have indirect, adverse effects on whales and sea turtles by reducing the abundance or availability of prey or changing the structure or composition of the fish community. These indirect effects could occur if fish or invertebrates experience lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution in response to acoustic energy produced by seismic surveys. Because fish and invertebrate species such as squid and jellyfish are pelagic prey for whales, and leatherback and green sea turtles, such effects might have adverse consequences for individuals foraging in the action area.

Several studies have shown that short, sharp sounds can cause overt or subtle changes in fish behavior and distribution. Chapman and Hawkins (1969) tested the reactions of whiting (hake) in the field to an airgun. When the airgun was fired, the fish showed a sudden downward movement, changing their distribution from being dispersed between 25 m (80 ft) and 55 m (180 ft) depth, to forming a compact layer below 55 m (180 ft). Toward the end of an hour-long

exposure to the airgun pulses the fish had habituated to the sound and risen back upward in the water column, despite the continued presence of sound pulses. However, when the airgun resumed firing after a dormant period, the fish exhibited another downward response. Pearson *et al.* (1992) conducted a controlled experiment to determine the effects of strong sound pulses on several species of rockfish off California. Exposing rockfish to an airgun with a source level of 223 dB re 1 µPa, the authors reported startle and alarm responses in these fish. Popper *et al.* (2005) report the occurrence of threshold shifts in some fish after exposure to airguns, with recovery in 24 hours. In other airgun experiments, catch-per-unit-effort (CPUE) of demersal fish was reported to decline when airgun pulses were emitted (Skalski *et al.* 1992; Dalen and Knutsen 1986, Dalen and Raknes 1985, both *as cited in* NMFS 2006h). Reductions in the catch may have resulted from a change in the behavior of the fish. Fish schools descended to near the bottom when the airgun was firing, and the fish may have changed their swimming and schooling behavior. Fish behavior returned to normal minutes after the sounds ceased. In the Barents Sea, abundance of cod and haddock measured acoustically was reduced by 44 percent within 9.2 km (5 nm) of an area where airguns operated (Engås *et al.* 1993 *as cited in* NMFS 2006h). Actual catches declined by 50 percent throughout the trial area and 70 percent within the shooting area. This reduction in catch decreased with increasing distance until 30-33 km (16-18 nm), where catches were unchanged.

McCauley *et al.* (2003) also conducted an experiment on the effects of airgun sounds on fish. Several fish were exposed to an operating airgun, over 1.5 hours at 10-second intervals with received levels varying from less than 100 dB to over 160 dB re 1 µPa. The exposure resulted in apparent permanent, extensive damage to their sensory epithelia. Although this study demonstrates fish can be injured from repeated exposure to airgun sounds, fish in the wild are likely to move away from a seismic source and are not expected to be exposed in such a manner. Other studies of the behavioral responses of fish and fishing success to seismic sources report similar responses – e.g., see Dalen and Knutsen (1986), Turnpenny and Nedwell (1994), LaBella *et al.* (1996), Kenchington (1999), Santulli *et al.* (1999), Hirst and Rodhouse (2000), Thomson *et al.* (2001), Wardle *et al.* (2001), and Engås and Løkkeborg (2002). Egg and larval stages would not be able to escape such exposures, and Gausland (2000) reported that seismic signal levels of 230-240 dB re 1µPa pk-pk (or 16 dB lower: 214-224 dB rms) are sufficient for harm to occur to fish eggs and larvae (see also Kostyuchenko 1973).

Limited information is available on the effects of seismic pulses on invertebrates such as squid or jellyfish. A range of invertebrates are reported to be sensitive to low-frequency (10–150 Hz) hydroacoustic disturbances induced by sound waves or other sources – e.g., jelly fish, crustaceans, arrow worms, octopus, and squid (Western Australian Department of Industry and Resources 2002). This sensitivity overlaps the dominant frequency range of seismic pulses, indicating that invertebrates could likely perceive seismic activity (Western Australian Department of Industry and Resources 2002). Available studies report responses to airgun shots as being limited to transient alarm responses such as tail-flicks (lobsters) or siphon closing (ascidians) (Western Australian Department of Industry and Resources 2002), although mortality of giant squid in the Bay of Biscay may possibly have been linked to seismic airgun activity in the area (Guerra *et al.* 2004). McCauley *et al.* (2000a; 2000b) examined the effect of marine seismic surveys on captive squid and cuttlefish and reported a strong startle response or directed movement away from airguns during sudden, nearby start-ups at received levels of 174 dB re 1

μPa mean squared pressure. Alarm responses in squid were detected during gradual ramp-up of airguns once levels exceeded 156-161 dB re 1 μPa mean squared pressure. Squid in these trials appeared to make use of the sound shadow measured near the water surface. These responses for captive squid suggest that behavioral changes and avoidance of operating airguns would likely occur. The authors concluded squid significantly alter their behavior at an estimated distance of 2–5 km (1.1–2.7 nm) from an approaching large seismic source.

These studies indicate that seismic airgun activity has the potential to affect fish and invertebrates. Fish appear to exhibit startle responses and avoidance of seismic sources, recovering or habituating after a short time period. Squid also appear to exhibit alarm responses and avoidance of seismic sources. Limited data on the physiological effects of seismic sound on fish and invertebrates indicate these effects are short-term and most apparent after exposure at very close range. Disturbance of these prey species has the potential to negatively affect whale or sea turtle foraging in the action area. However, with the limited spatial and temporal scale of the proposed seismic activities, only a small fraction of available habitat would be ensonified at any one time, and prey species would be expected to return to their pre-exposure behavior once seismic firing ceased. Thus, we expect such responses would have temporary effects on the feeding ability of whales and sea turtles in the immediate survey area. Such reductions in feeding ability are not expected to reduce an individual animal's overall feeding success, and it does not appear likely that any effects on prey would pose significant risk to blue and sperm whales and sea turtles in the Action Area.

Effects of exposure to MBES and SBP
Sperm whales are presumed to be more sensitive to mid- and high-frequency sounds, and may be able to hear the mid-frequency sounds of the MBES and SBP sonar. Any exposures to these sources would be brief as the vessel passes by and individual pulses will be very short. Potential for exposure is further reduced by the fact that sounds from these sources would dissipate over an area smaller than that affected by seismic airguns, for which mitigation measures would minimize exposure within the 180dB re 1μPa isopleths for whales.

It is unlikely that a whale would be exposed to the sonar as these animals are likely to avoid the source. Sperm whales reacted to military sonar by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins *et al.* 1985). Experiments on captive odontocetes provide additional information. Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1-second pulsed sounds at frequencies similar to those emitted by multi-beam sonar (Ridgway *et al.* 1997; Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000; 2002). Behavioral changes typically involved apparent attempts at avoidance (of the sound exposure, itself, or the location of the exposure site during subsequent tests) (Finneran *et al.* 2000; Schlundt *et al.* 2000). Dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa (rms), as did belugas at received levels of 180 to 196 dB re 1 μPa and above. For shorter pulses, received levels necessary to elicit such reactions were higher (Finneran *et al.* 2000; 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002), and in some instances animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997; Schlundt *et al.* 2000). The relevance of these data to free-

ranging odontocetes is uncertain. In the wild, cetaceans sometimes avoid sound sources before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway *et al.* (1997) and Schlundt *et al.* (2000).

Recent stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals (see *Strandings* above). However, the sonars proposed for use by L-DEO differ from sonars used during Naval operations, which generally have a longer pulse duration and are often directed close to horizontal as opposed to the more downward-directed MBES and SBP. The sound energy that would be received by any individuals exposed to the MBES and SBP sources during the proposed activities is lower relative to naval sonars (LGL Ltd. 2011), as is the duration of exposure. In addition, the area of possible influence for the MBES and SBP are much smaller, consisting of a narrow zone close to and below the source vessel. Because of the unlikelihood of exposure and the brief duration for any individual that might be exposed, it is not likely MBES and SBP sonar pose a risk to sperm or blue whales during the proposed activities. In addition, Boebel *et al.* (2006) assessed the relative risk posed by various scientific acoustic instruments and concluded that multi-beam systems and sub-bottom profilers similar to those to be used during the proposed activities presented a low risk for auditory or any other injuries, and that an individual would require exposure to 250–1,000 pulses from a sub-bottom profiler to be at risk for TTS. To be susceptible to TTS, a whale would have to pass at very close range and match the vessel's speed – the probability of this occurring in the proposed survey is expected to be very small. Masking of blue or sperm whale communications is not expected to occur appreciably due to MBES or SBP signals given their directionality and the brief period when an individual mammal is likely to be within its beam.

For sea turtles and blue whales, available information indicates detection of sounds in the low-frequency range; based on this information, any individuals of these species exposed to received levels of mid-frequency (1 kHz–10 kHz) sounds or higher are not likely to detect these sounds. Therefore, blue whales and sea turtles are not likely to respond physiologically or behaviorally to received sounds from the MBES and SBP sonar to be used by the *Langseth*.

Effects of exposure to OBS and MT Instruments
The acoustic release transponder used to communicate with the OBSs and MT instruments uses frequencies of 9–13 kHz. Sperm whales could hear these signals, although blue whales and sea turtles would not. Because these signals will be used very intermittently, it is unlikely that sperm whales would respond significantly, if at all to these signals. Since these frequencies are not audible to sea turtles, we do not expect them to hear and, therefore, respond to the signals.

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 by this 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 reasonable certain to occur in the action area. We did not find any information other than what has already been described in the *Environmental Baseline* which we expect will continue into the future. The natural phenomena in the action area (e.g., climate change, natural mortality) is expected to continue to influence listed species as described in the *Environmental Baseline*. Anthropogenic effects include those from habitat degradation due to pollution, contaminants and ocean noise, vessel traffic; and commercial fishing. An increase in these activities could result in an increased effect on ESA-listed species. However, the magnitude and significance of any anticipated effects remain unknown at this time.

Integration and Synthesis of Effects
NSF and L-DEO propose to conduct a marine seismic survey on board the *R/V Langseth* in the central Pacific Ocean. NMFS' Office of Protected Resources Permits and Conservation Division proposes to issue an IHA for incidental takes that would occur during this survey, pursuant to MMPA section 101(a)(5)(D).

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. 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 population(s) those individuals represent or the species those populations comprise (Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). As a result, if the assessment indicates listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment. If possible reductions in individuals' fitness are likely to occur, the assessment considers the risk posed to population(s) and then to the species to which those individuals belong.

It is important to note that the studies available to inform our risk assessment are limited, including information on the effects of anthropogenic noise (i.e., seismic pulses and bathymetric sonar) on listed whales, and sea turtles. Information on these effects is limited and some methods to acquire acoustic information are not available. Underwater hearing abilities have been studied in a few species, and where experimental data do not exist we have made inferences based on the characteristics of sounds or from hearing physiology. Definitive statements on the effects of sound are complicated because detection of sound by species depends on acoustic properties, transmission characteristics, and hearing sensitivity. In addition, responses by an individual animal can be highly variable and depend on its activity at the time of exposure, its age, any habituation to sounds, and other factors. The narratives that follow integrate and synthesize the information contained in the *Status of the Species*, the *Environmental Baseline*, and the *Effects of the Action* sections of this Opinion to assess the risk the proposed activities pose to blue and sperm whales and green, hawksbill, olive ridley and leatherback sea turtles. We are not aware of any cumulative effects (i.e., from future state, local, tribal, or private actions) that would alter our risk assessment for these species.

Whales

Blue and sperm whales are endangered throughout their ranges, with the primary cause for depletion being historic commercial whaling of these species. Although most commercial whaling has ceased, Japan still harvests sperm whales under an IWC scientific research permit.

Available abundance estimates for these whales species indicate that current abundance appears to be significantly lower than historic levels in all ocean basins, and whales remain rare in some formerly important habitats.

In the action area, blue whales and sperm whales may occur during the proposed activities. Hearing in sperm whales is thought to include mid and high frequencies, and hearing in blue whales is thought to include low frequencies.

At present, there are several factors that may be affecting whale survival and recovery in the action area, although the significance of any effects remains largely unknown. Natural factors include circulation and productivity patterns affecting prey distribution and habitat quality; as well as natural mortality of whales, which we assume includes predation biotoxins, parasites, and disease. Anthropogenic factors include degradation of habitat resulting from pollution/ contaminants, anthropogenic noise, risk of ship strikes and entanglement or entrapment in fishing gear. Conservation and management efforts are also ongoing but any positive effect on whales in the action area will hopefully increase in the future.

After reviewing the available information, the proposed activities are likely to produce the following potential stressors for listed whales: (1) acoustic energy from the airgun array and (2) acoustic energy from the MBES and SBP sonars. We believe an individual whale would have a low probability of being exposed to acoustic energy produced by the seismic airguns that will be used during the proposed action at received levels above 180 dB re 1 μPa. Using the model prepared by L-DEO (LGL Ltd. 2011), which estimates propagation distances for given received levels, seismic airgun levels of 180 dB re 1 μPa or greater might propagate up to 940 m in the survey area for the 36 airgun array and 40 m for the 40 in³ single airgun. These represent the maximum estimated distances for received levels (rms), and all of these distances fall within the visibility (i.e., monitoring) range from the *Langseth*. Although this consultation is primarily concerned with exposure to sound levels above 180 dB re 1 μPa, the estimates for listed whale exposure consider received levels at or greater than 160 dB re 1 μPa. Using the total area that would be ensonified≥ 160 dB during th e proposed activities, it is estimated that 2 blue whales and 41 sperm whales might be exposed to seismic pulses at these levels, with individuals exposed a maximum of once. These estimates do not account for possible avoidance of seismic sounds by whales, or for mitigation measures to be used during the studies that would reduce the risk of exposure to levels above 180 dB re 1 μPa. Although seismic pulses may propagate substantial distances beyond the isopleth for 160 dB re 1 μPa, we do not expect incidental harassment of listed species at those lower received levels.

Exposure of listed whales to the MBES and SBP sonars is expected to be minimal, given the brief ping duration, the beam width of the sonars, and the fact that the vessel will be in transit. The probability of a whale swimming through an area ensonified by a MBES or SBP sonar is considered small. Any exposures that may occur are expected to be brief, and individuals are

likely to exhibit avoidance. The potential for exposure to MBES and SBP sources is further reduced by the mitigation measures for minimizing exposure to seismic airguns within the 180 dB radius. Although recent stranding events involving beaked whales have been associated with the operation of naval mid-frequency sonar, the characteristics of the MBES and SBP sonars are significantly different, including a shorter pulse duration, general downward-orientation, significantly less sound energy that would be received, shorter exposure, and much smaller zone of influence close to the vessel. The probability of TTS occurring is considered very small, and masking is not expected to occur due to the short pulse duration and low likelihood of exposure. It is not likely that the use of MBES and SBP sonars during the proposed activities poses a significant risk blue or sperm whales.

Although we cannot estimate the age, gender, or reproductive condition of any blue whales that might be exposed to these potential stressors, we assume these whales could represent any age class or either gender. Sperm whales in the Action Area would be juveniles and adult of both sexes. Based on the best available abundance information and population designations, whales exposed would represent a very small fraction of the regional abundance in the action area. The 2 blue whales represent less than 0.01 percent of the regional abundance. The 41 sperm whales would represent 0.17 percent of their regional population abundance.

Possible effects of exposure to stressors described above could include hearing threshold shifts (TTS, PTS), masking or auditory interference, behavioral responses, or non-auditory physical or physiological effects. There is no evidence that exposures to airgun pulses can cause PTS, and we do not expect PTS to occur. Available data indicate that TTS is unlikely to occur unless whales are exposed to levels over 180 dB re 1 μPa (rms). Given the measures in the IHA, any exposures that may occur are more likely to be less than 180 dB re 1 μPa, and we consider TTS unlikely to occur as a result of the proposed survey. If an individual were to experience TTS, it is expected to be temporary and reversible, and even if repeated is not expected to cause permanent auditory damage.

The proposed seismic activities might mask whale calls at some of the lower frequencies, which could affect communication or echolocation, particularly for the baleen whales. However, for any frequencies that may overlap, given the low duty cycle of airguns and the fact that the source vessel will be in transit, it is not expected that exposure to seismic activities would pose a risk to individual whales due to masking.

Exposure to seismic activities may result in behavioral responses by listed whales, but responses are variable. Available information indicates that baleen whales generally tend to avoid operating airguns, with variable avoidance distances. However, some individual humpback whales are noted to approach airguns to distances where the received level was 179 dB re 1μPa (rms). Some sperm whales appear to tolerate seismic sound. Sperm whales are also reported to avoid standard, non-seismic vessels, and we expect individuals may also show some avoidance of seismic vessels, given accounts of possible avoidance of seismic vessels in other locations. A few observations indicate possible behavioral responses including avoidance or cessation of calling by sperm whales. However, studies indicate considerable tolerance of seismic activity, with whales continuing to call and maintaining their distribution and pre-exposure behavior. This suggests variable responses, with some sperm whales exhibiting considerable tolerance and

others avoidance behavior. Although the proposed activities could overlap with foraging whales, given the limited duration of the proposed seismic activities (11 days), the vastness of the survey site, the limited risk for repeat exposure to airguns and the mitigation measures to minimize the risk of exposure at received levels of concern, we do not anticipate that behavioral responses to the proposed activities would significantly result in reduced foraging opportunities. Because of these reasons, we do not expect these responses to reduce the fitness of the blue and sperm whales that occur Action Area.

Stress responses may occur as a result of exposure, given the importance of sound and hearing to listed whales. Although the magnitude and biological significance of any stress responses that might occur remain unknown, we assume that stress responses would be minimized because exposure to seismic sources would be limited in duration and whales may show some avoidance of seismic sources. In addition, mitigation measures and monitoring would help minimize the risk to listed whales. Other non-auditory physical or physiological effects are considered unlikely to occur, given the limited duration of any exposure and the possibility of at least some avoidance of seismic pulses. Although two stranding events involving beaked whales are known to have occurred concurrent with seismic surveys (Gentry 2002; Gordon *et al.* 2003), no causal link is established for those events and no such records exist for listed whale species. The low occurrence of strandings concurrent with seismic studies is important to note, given the substantial amount of seismic activity that occurs in the marine environment. Underwater detonations are known to cause physical injury; however, seismic pulses are less energetic and have slower rise times, and no evidence links airguns to serious injury, death, or strandings of these whales.

Indirect effects on blue and sperm whales from exposure to seismic pulses are not likely to be significant. Effects from seismic airguns on the main prey items for whales would be short-term and affect a small fraction of available habitat and prey. Any prey that would be exposed are expected to recover quickly after exposure.

In summary, we do not expect injury or mortality to result from the proposed actions, and mitigation measures would help avoid exposure of whales at higher received levels. We expect that any individuals exposed to the proposed activities may be incidentally harassed, and as a result experience stress responses or exhibit behavioral responses to that exposure. The evidence available leads us to conclude that exposure to seismic pulse energy from the proposed seismic activities is not likely to cause a reduction in an individual whale's growth, survival, annual reproductive success, or lifetime reproductive success (i.e., fitness). As a result, we do not expect the proposed action to have an effect on the extinction risk of the population(s) these individuals represent or the whale species these population(s) comprise.

Sea Turtles
The primary causes for depletion sea turtles were overexploitation and incidental capture in fishing gear. Reliable estimates of overall historic and current abundance for sea turtles are not available; however, information on nesting trends is available from many locations. Declines in abundance are reported rangewide for all sea turtle species covered in this Opinion, however, a few exceptions include increases reported for leatherback nesting in some locations of the Atlantic. The population structure of sea turtles is complex both spatially and genetically, with

individuals exhibiting natal homing to nesting beaches and mixing of nesting aggregations on foraging grounds.

At present, there are several factors that may be affecting sea turtle survival and recovery in the action area. Natural factors include circulation and productivity patterns affecting prey distribution and habitat quality; as well as natural mortality of sea turtles, which we assume includes predation, parasites, diseases, and exposure to biotoxins. Anthropogenic factors include degradation of habitat resulting from pollution/contaminants, anthropogenic noise, and entanglement or entrapment in fishing gear.

After reviewing the available information, the proposed activities would produce the same two potential stressors for sea turtles, as noted above for listed whales: (1) acoustic energy from the airgun array and (2) acoustic energy from the MBES and SBP sonars. However, given that sea turtles are expected to detect and respond to sounds in the low-frequency range, any exposure to the mid-frequency or higher sounds such as MBES and SBP sonars is not likely to generate a response in leatherback sea turtles during the proposed activities.

Hearing in sea turtles is thought to include low frequencies, therefore we expect sea turtles to hear the acoustic signals from firing airguns. We expect sea turtles may be present during the proposed activities and that some may be exposed to received levels at or above 160 dB re 1 µPa. Similar to listed whales, mitigation measures to be used during the studies are expected to reduce the risk of sea turtle exposure to levels above 180 dB re 1 µPa, and we expect exposures that might occur for sea turtles would more likely involve received levels less than 180 dB re 1 µPa. Although seismic pulses may propagate substantial distances beyond the isopleth for 160 dB re 1 µPa, we do not expect incidental harassment of listed sea turtles at received levels below 166 dB re 1 µPa. Given the sparsity of sea turtles abundance information in the Action Area we cannot estimate how many sea turtles may be exposed to airgun noise at received level≥ 160 dB during the proposed activities. We also cannot estimate the proportions each sea turtle subpopulations will occur within the action area.

Possible effects on sea turtles from exposure to the seismic airguns could include hearing threshold shifts (TTS, PTS), masking or auditory interference, behavioral responses, or non-auditory physical or physiological effects. Available information indicates that TTS may occur in sea turtles exposed to seismic sources, although the received levels that may have elicited TTS are not known and experiments involved confined turtles. Sea turtles at sea would be expected to exhibit some avoidance behavior, and thus reduced exposure to seismic pulses. In addition, mitigation measures and monitoring are expected to reduce the risk of exposure at higher received levels. Given that sea turtle hearing capabilities are centered in the low-frequency range, exposure to the low-frequency seismic pulses may lead to masking. However, the seismic pulse would last a fraction of a second at intervals of 66 or 300 ms, thus any masking that may occur would be temporary and is not likely to present a significant risk for sea turtles that may be exposed.

Exposure may result in behavioral responses by sea turtles, since studies indicate some turtles exhibit avoidance reactions to airgun noises. Some accounts suggest sea turtles have been exposed to seismic sound resulting in a stress response that may have risen to the level of

harassment. No injury or mortality of sea turtles is expected; the lack of strandings associated with seismic studies is important to note, particularly with the substantial amount of seismic activity in the marine environment. Evidence suggests that sea turtles exhibit behavioral responses, but no sea turtles have been reported to have suffered detectable physical injuries because of these exposures. Also, based on the evidence, sea turtles are likely to avoid seismic sources at harmful levels. Given this, we expect any exposed sea turtles would experience physical effects such as behavioral responses and possible stress responses that rise to the level of harassment, but no sea turtles are expected to be injured or killed from exposure to seismic sources.

The proposed activities are anticipated to occur during migration and foraging activities, however, exposure to airgun sounds are not expected to reduce foraging opportunities to levels that would reduce the fitness of individual sea turtles.

Indirect effects are not likely for leatherback sea turtles resulting from effects of airguns on prey. Any effects from airguns on prey would affect a small fraction of available habitat and prey. Any prey that would be exposed are expected to recover quickly after exposure.

In summary, TTS and PTS are considered not likely to occur as a result of the proposed activities, because of avoidance behavior of other sea turtle species and reduced exposure risk at higher received levels resulting from the mitigation measures and monitoring. Masking is not expected to pose a significant risk to sea turtles. We do not expect injury or mortality. We expect that individuals exposed to the proposed activities may be incidentally harassed, and as a result experience stress responses or exhibit behavioral responses to exposure. However, available information indicates some sea turtles would likely avoid seismic pulses. In addition, any exposures that may occur would be of short duration. The evidence available leads us to conclude that exposure to seismic pulse energy in the proposed survey is not likely to cause a reduction in an individual turtle's growth, survival, annual reproductive success, or lifetime reproductive success (i.e., fitness). As a result, we do not expect the proposed action to have an effect on the extinction risk of the populations these individuals represent or the sea turtle species those populations comprise.

Conclusion
After reviewing the current status of blue and sperm whales and green, hawksbill, olive ridley and leatherback, sea turtles; the environmental baseline for the action area; the anticipated effects of the proposed activities; and the cumulative effects, it is NMFS' biological opinion that the proposed actions, as described in this Opinion, are not likely to jeopardize the continued existence of these species. Similarly, it is NMFS' biological opinion that the issuance of an IHA by NMFS' Office of Protected Resources Permits and Conservation Division for harassment that would occur incidental to the proposed action is not likely to jeopardize the continued existence of these species. Critical habitat will not be adversely affected by the proposed actions.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit 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 sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the Lamont-Doherty Earth Observatory and NMFS' Office of Protected Resources Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Section 7(b)(4)(C) of the ESA specifies that in order to provide an incidental take statement for an endangered or threatened species of marine mammal, the taking must be authorized under section 101(a)(5) of the MMPA. One of the federal actions considered in this Opinion is NMFS' Permits and Conservation Division's proposed authorization of the incidental taking of blue whales and sperm whales pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act. With this authorization, the incidental take of listed whales is exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

NMFS anticipates the incidental harassment of the blue whales (*Balaenoptera musculus*), and sperm whales (*Physeter macrocephalus*), as well as green sea turtles (*Chelonia mydas*). hawksbill sea turtles (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and leatherback sea turtles (*Dermochelys coriacea*) during the proposed survey activities.

Amount or Extent of Take
NMFS anticipates the proposed action to conduct a seismic survey in the central North Pacific Ocean might result in the incidental take of listed species. Blue and sperm whales as well as green, hawksbill, olive ridley and leatherback sea turtles may be exposed to seismic sounds at received levels above 160 dB re 1 µPa. The proposed action might take 2 blue whales and 41 sperm whales by exposing individuals to received levels greater than 160 dB re 1 µPa. These

estimates are based on the best available information on whale densities in the area to be ensonified above 160 dB re 1 μPa during the proposed activities. This incidental take would result from exposure to acoustic energy during seismic operations, would be in the form of harassment, and is not expected to result in the death or injury of any individuals that are exposed.

We also expect the proposed action might also take individual green, hawksbill, olive ridley and leatherback sea turtles as a result of exposure to acoustic energy during seismic surveying, and we expect this take would also be in the form of harassment, with no death or injury expected for individuals exposed. Harassment of these sea turtles is expected to occur at received levels of seismic sounds above 166 dB re 1 μPa. Because density estimates of sea turtles in the survey area are unknown, we estimate take as the number of turtles exposed to seismic operations above 166 dB re 1 μPa during the proposed activities. These turtles could be of all ages and life stages in the survey area.

Harassment of blue and sperm whales exposed to seismic surveys at levels less than 160 dB re 1 μPa, or of green, hawksbill, olive ridley or leatherback sea turtles at levels less than 166 dB re 1 μPa, is not expected. We do not expect listed species to be taken by operation of the multibeam echosounder or the sub-bottom profiler. However, if overt adverse reactions (for example, dive reactions, or rapid departures from the area) by listed whales or listed sea turtles are observed outside of the 160 dB re 1 μPa, or 166 dB re 1 μPa isopleths, respectively, while airguns are operating, incidental take may be exceeded. Additionally, if such reactions by listed species are observed while the multibeam echosounder or the sub-bottom profiler are in operation, this may constitute take that is not covered in this Incidental Take Statement. If such overt adverse reactions are observed the Lamont-Doherty Earth Observatory and NMFS' Permits and Conservation Division must contact the Endangered Species Act Interagency Cooperation Division within 48 hours of the incident at 301-427-8403 and/or by email to kellie.foster-taylor@noaa.gov to determine whether reinitation of consultation is required.

Any incidental take of blue whales, sperm whales, or green, hawksbill, olive ridley and leatherback sea turtles is restricted to the permitted action as proposed. If the actual incidental take meets or exceeds the predicted level, the Lamont-Doherty Earth Observatory and NMFS' Permits and Conservation Division must reinitiate consultation. All anticipated takes would be "takes by harassment", as described previously, involving temporary changes in behavior.

Reasonable and Prudent Measures
NMFS believes the reasonable and prudent measure described below is necessary and appropriate to minimize the amount of incidental take of listed blue and sperm whales and green, hawksbill, olive ridley and leatherback sea turtles resulting from the proposed action. This measure is non-discretionary and must be a binding condition of the Lamont-Doherty Earth Obsevatory and NMFS' authorization for the exemption in section 7(o)(2) to apply. If the Lamont-Doherty Earth Obsevatory or NMFS fail to ensure compliance with this term and conditions and its implementing terms and conditions, the protective coverage of section 7(o)(2) may lapse.

The Lamont-Doherty Earth Observatory must implement and monitor the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of blue and sperm whales pursuant to section 101(a)(5)(D) of the MMPA.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, NMFS' Permits and Conservation Division and the Lamont-Doherty Earth Observatory must comply with the following terms and conditions, which implement the Reasonable and Prudent Measure described above. These terms and conditions are non-discretionary.

To implement the Reasonable and Prudent Measure, Lamont-Doherty Earth Observatory and NMFS' Permits and Conservation Division shall ensure that:

1. Mitigation and Monitoring Requirements

    The Lamont-Doherty Earth Observatory is required to implement the following mitigation and monitoring requirements when conducting this survey to achieve the least practicable adverse impact on affected marine mammal species or stocks:

    (a) Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (PSVOs) (except during meal times and restroom breaks, when at least one PSVO will be on watch) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from civil twilight-dawn to civil twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew shall also assist in detecting marine mammals, when practicable. PSVOs will have access to reticle binoculars (7x50 Fujinon), big-eye binoculars (25x150), and night vision devices. PSVO shifts shall last no longer than 4 hours at a time. PSVOs will also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

    (b) PSVOs will conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water.

    (c) Record the following information when a marine mammal is sighted:

    > (i) species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

    > (ii) time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, and sun glare; and

(iii) the data listed under Condition 1(c)(ii) will also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

(d) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One PSVO) and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

(e) Do and record the following when an animal is detected by the PAM:

(i) notify the on-duty PSVO(s) immediately of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;

(ii) enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

(f) Visually observe the entire extent of the exclusion zone (EZ) (180 dB re 1 μPa [rms] for cetaceans using NMFS-qualified PSVOs, for at least 30 minutes (min) prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the EZ, the Lamont-Doherty Earth Observatory must delay the seismic survey until the marine mammal(s) has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the PSVO shall wait 30 min. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), the Lamont-Doherty Earth Observatory may start the second airgun without observing the entire EZ for 30 min prior, provided no marine mammals are known to be near the EZ (in accordance with Condition 1[h] below).

(g) Establish a 180 dB re 1 μPa (rms) EZ for marine mammals before the 36 airgun array (6,600 in^3) is in operation; and a 180 dB re 1 μPa (rms) EZ before a single airgun (40 in^3) is in operation, respectively. See Table 1 in the Incidental Hararrsment Authorization for distances and EZs.

(h) Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shutdown for more than 8 min, which means start the smallest gun first and add airguns in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs shall monitor the EZ, and if marine mammals are sighted, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from shut-down requires that the PSVOs be able to view the full EZ as described in Condition 1(f) (above).

(i) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant EZ. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the EZ, further mitigation measures, such as a power-down or shut-down, will be taken.

(j) Power-down or shut-down the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant EZ. A shut-down means all operating airguns are shut-down (i.e., turned off). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun, which reduces the EZ to the degree that the animal(s) is no longer in or about to enter it.

(k) Following a power-down, if the marine mammal approaches the smaller designated EZ, the airguns must then be completely shut-down. Airgun activity will not resume until the PSVO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 min for species with shorter dive durations (small odontocetes) or 30 min for species with longer dive durations (mysticetes and large odontocetes, including sperm whales).

(l) Following a power-down or shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described in Condition 1(h).

(m) Marine geophysical surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant EZs are visible and can be effectively monitored.

(n) No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant EZ cannot be effectively monitored by the PSVO(s) on duty.

2.   Reporting Requirements
The Lamont-Doherty Earth Observatory is required to:

(a) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the *Langseth*'s central North Pacific cruise. This report must contain and summarize the following information:

(i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;

(ii) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shut-downs), observed throughout all monitoring activities.

(iii) An estimate of the number (by species) of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

(iv) A description of any overt adverse reactions (for example, dive reactions, or rapid departures from the area) by listed whales or listed sea turtles observed outside of the 160 dB re 1 μPa or 166 dB re 1 μPa isopleths, respectively, while airguns and/or the multibeam echosounder and sub-bottom profiler are operating.

(v) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (ITS); and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act-listed marine mammals.

(b) Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, within 30 days after receiving comments from NMFS on the draft report. If NMFS decides that the draft report needs no comments, the draft report shall be considered to be the final report.

3.   Reporting Prohibited Take
In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA (if issued), such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), the Lamont-Doherty Earth Observatory shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov).

The report must include the following information:
- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Activities will not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with the Lamont-Doherty Earth Observatory to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. the Lamont-Doherty Earth Observatory may not resume their activities until notified by NMFS via letter, email, or telephone.

4. <u>Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death</u>
    In the event that the Lamont-Doherty Earth Observatory discovers an injured or dead marine mammal, and the lead PSVO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), the Lamont-Doherty Earth Observatory will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov).

    The report must include the same information identified in the paragraph above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with the Lamont-Doherty Earth Observatory to determine whether modifications in the activities are appropriate.

5. <u>Reporting an Injured or Dead Marine Mammal not Related to the Lamont-Doherty Earth Observatory Activities</u>
    In the event that the Lamont-Doherty Earth Observatory discovers an injured or dead marine mammal, and the lead PSVO determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the Lamont-Doherty Earth Observatory will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands

Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov), within 24 hours of the discovery. The Lamont-Doherty Earth Observatory will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.

6. The Lamont-Doherty Earth Observatory is required to comply with the Terms and Conditions of the Incidental Take Statement (ITS) corresponding to NMFS' Biological Opinion issued to both the National Science Foundation and NMFS' Office of Protected Resources Permits and Conservation Division.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

We recommend the following conservation recommendations, which would provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect endangered large whales and endangered or threatened sea turtles:

1. *Improve estimates of levels and forms of "take" and responses to seismic sounds.* The Permits and Conservation Division should review reports submitted for this and other prior geophysical research surveys funded by the National Science Foundation and compile and analyze information to improve agency estimates of the number of the different species of marine mammals and sea turtles that are likely to be exposed to sounds from seismic surveys, the response of those species to this exposure, and the probable consequences of those responses on the life history of individual animals. The results should be provided to the Endangered Species Act Interagency Cooperation Division as part of requests for consultation on future proposals to authorize incidental harassment.

In order for NMFS' Office of Protected Resources Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their habitats, NMFS' Office of Protected Resources Permits and Conservation Division should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

REINITIATION NOTICE

This concludes formal consultation on the proposed marine seismic survey conducted by the Lamont-Doherty Earth Observatory on board the *R/V Langseth* in the central Pacific Ocean, and the issuance of an incidental harassment authorization for the proposed survey pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA). As provided in 50 CFR §402.16, 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 authorized take is exceeded, section 7 consultation must be reinitiated immediately.

REFERENCES

Aguayo, A. L. 1974. Baleen whales off continental Chile. Pp.209-217 *In:* The Whale Problem: A Status Report. W.E. Schevill (Ed), Harvard University Press, Cambridge, Massachusetts.

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

Aguilar, R., J. Mas and X. Pastor 1995. Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the western Mediterranean.Pp. 1-9 *In:* Richardson, J.I. and T.H. Richardson (compilers), Proceedings of the Twelfth Annual Workshop on Sea Turtle Biology and Conservation. 25-29 February 1992, Jekyll Island, Georgia. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-361.

Allen, B.M. and R.P. Angliss. 2010. Draft Alaska Marine Mammal Stock Assessments 2010. April 2010. National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way, NE, Seattle, WA 98115.

Allen, K. R. 1970. A note on baleen whale stocks of the North West Atlantic. Report of the International Whaling Commission Annex I, 20:112-113.

Allen, K. R. 1980. Conservation and Management of Whales.Division of Marine Resources, University of Washington. 107p.

Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs 70(3):445-470.

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

Angliss, R. P. and K. L. Lodge 2004. Alaska Marine Mammal Stock Assessments - 2003. NOAA Technical Memorandum NMFS-AFSC-144:U.S. Department of Commerce, 230p.

Angliss, R. P. and R. B. Outlaw 2007. Alaska Marine Mammal Stock Assessments, 2006. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-168, 244 p.

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

Baillie, J. and G. Groombridge (eds.). 1996. 1996 IUCN red list of threatened animals. International Union for the Conservation of Nature; Gland, Switzerland.

Balcomb, K. and G. Nichols 1978. Western North Atlantic humpback whales. Report of the International Whaling Commission 28:159-164.

Bannister, J. and E. Mitchell 1990. North Pacific sperm whale stock identity: distributional evidence from Maury and Townsend charts. Report of the International Whaling Commission, (Special Issue 12):219-230.

Barlow, J. and P. J. Clapham 1997. A new birth-interval approach to estimating demographic parameters of humpback whales. Ecology 78(2):535-546.

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

Bartol, S.M. and D.R. Ketten. 2006. Turtle and tuna hearing. In: Sea turtle and pelagic fish sensory biology: developing techniques to reduce sea turtle bycatch in longline fisheries.

Edited by Y. Swimmer and R. Brill. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center; Honolulu, Hawai'i.

Bérubé, M., A. Aguilar, D. Dendanto, F. Larsen, G. N. d. Sciara, R. Sears, J. Sigurjónsson, J. Urban-R. and P. J. Palsbøll. 1998. Population genetic structure of North Atlantic, Mediterranean and Sea of Cortez fin whales, *Balaenoptera physalus* (Linnaeus 1758): analysis of mitochondrial and nuclear loci. Molecular Ecology 7:585-599.

Berzin, A. A. 1971. The sperm whale. Pacific Sci. Res. Inst. Fisheries Oceanography. Translation 1972, Israel Program for Scientific Translation No. 600707, Jerusalem: 1-394.

Berzin, A.A., and A.A. Rovnin. 1966. The distribution and migrations of whales in the northeastern part of the Pacific, Chukchi and Bering Seas. Izvestia TINRO 58:179-207.

Boebel, O., E. Burkhardt and H. Bornemann 2006. Risk assessment of Atlas hydrosweep and Parasound scientific echosounders. EOS, Transactions, American Geophysical Union 87(36):suppl., [np].

Bolten, A. B., K.A. Bjorndal and H. R. Martins 1994. Life history model for the loggerhead sea turtle (*Caretta caretta*) populations in the Atlantic: Potential impacts of a longline fishery. . Pp.48-55 *In:* Balazs, G.J. and S.G. Pooley (eds), Research Plan to Assess Marine Turtle Hooking Mortality: Results of an Expert Workshop Held in Honolulu, Hawaii, November 16-18, 1993. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-201, pp.48-55.

Bowles, A. E., M. Smultea, B. Würsig, D. P. DeMaster and D. Palka 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustic Society of America 96(4):2469–2484.

Braham, H. W. 1991. Endangered Whales: A Status Update. A report on the 5-year status of stocks review under the 1978 amendments to the U.S. Endangered Species Act.:National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service. Seattle, Washington. 56p.

Brandon, R. 1978. Adaptation and evolutionary theory. Studies in the History and Philosophy of Science 9:181-206.

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

Calambokidis, J., T. E. Chandler, D. P. Costa, C. W. Clark and H. Whitehead 1998. Effects of the ATOC sound source on the distribution of marine mammals observed from aerial surveys off central California. Abstracts - World Marine Mammal Science Conference, Monaco, 20-24 January 1998.

Calambokidis, J., E.A. Falcone, T.J. Quinn II, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R.G. LeDuc, D.K. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R, D.W. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K.R. Flynn, A. Havron, J. Huggins and N. Maloney. 2008. SPLASH: Structure of populations, levels of abundance, and status of humpback whales in the North Pacific. Final report prepared by Cascadia Research for U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; Seattle, Washington.

Calambokidis, J., G. H. Steiger, J. C. Cubbage, K. C. Balcomb, C. Ewald, S. Kruse, R. Wells and R. Sears 1990. Sightings and movements of blue whales off central California 1986-88 from photo-identification of individuals. Report of the International Whaling Commission(Special Issue 12):343-348.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. R. Urban, J. K. Jacobsen, O. Von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. M. Ellis, Y. Miyamura, P. Ladrón de Guevara, M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow and T. J. I. Quinn 2001a. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science 17(4):769-794.

Calambokidis, J., G. H. Steiger, J. M. Straley, T. Quinn, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. R. Urban, J. Jacobson, O. von Zeigesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. Ladrón de Guevara, S. A. Mizroch, L. Schlender and K. Rasmussen 1997. Abundance and population structure of humpback whales in the North Pacific basin. Final Report under contract No. 5ABNF500113. NMFS Southwest Fisheries Science Center; La Jolla, California.

Caldwell, J. and W. Dragoset 2000. A brief overview of seismic air-gun arrays. The Leading Edge 19(8):898-902.

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

Caretta, JV, KA. Forney, E. Oleson, K. Martien, MM. Muto, MS. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, RL. Brownell Jr., J. Robbins, DK. Mattila, K. Ralls and MC. Hill. 2011. U.S. Pacific Marine Mammal Stock Assessments: 2010. NOAA-TM-NMFS-SWFSC-476. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Cetaceanhabitat.org. 2009. Accessed 3/31/2009 via the INTERNET at: 222.cetaceanhabitat.org.

Chapman, C. J. and A. D. Hawkins 1969. The importance of sound in fish behaviour in relation to capture by trawls. FAO Fisheries Report 62(3):717-729.

Cherfas, J. 1989. The hunting of the whale. Viking Penguin Inc., N.Y., 248p.

Christensen, I., T. Haug and N. Øien 1992. Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. ICES Journal of Marine Science 49:341-355.

Clapham, P.J. 1994. Maturational changes in patterns of association among male and female humpback whales. Journal of Zoology 71: 440-443.

Clapham, P. J. 1996. The social and reproductive biology of humpback whales: an ecological perspective. Mammal Review 26:27-49.

Clapham, P. J. B., L.S., C. A. Carlson, M. A. Christian, D. K. Mattila, C. A. Mayo, M. A. Murphy and S. Pittman 1993a. Seasonal occurrence and annual return of humpback

whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71:440-443.

Clark, C. W. 1995. Matters arising out of the discussion of blue whales. Annex M1. Application of U.S. Navy underwater hydrophone arrays for scientific research on whales. Report of the International Whaling Commission, Annex M 45:210-212.

Clark, C. W. and W. T. Ellison 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: evidence from models and empirical measurements. Pp.564-582 In: J.A. Thomas, C.F. Moss, and M. Vater (Editors), Echolocation in Bats and Dolphins. University of Chicago Press, Chicago, Illinois.

Clarke, C. W. and R. A. Charif 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997. JNCC Report No. 281.

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

Cliffton, K., D. O. Cornejo and R. S. Felger 1982. Sea turtles of the Pacific Coast of Mexico. Pp. 199-209 *In:* K.A. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, DC. 583 pp.

Colborn, T. and M. J. Smolen 1996. Epidemiological analysis of persistent organochlorine contaminants in cetaceans.Pp. 92-172 *In*: Ware, G.W. (Ed), Reviews of Environmental Contamination and Toxicology, Volume 146. Springer, New York.

Continental Shelf Associates 2004. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf - Final Programmatic Environmental Assessment. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS EIS/EA, MMS 2004-054. 487p.

Cooke, J., Weller, DW, Bradford, AL, Burdin, AM and Brownell RL, Jr. 2008. Population assessment of western gray whales in 2008. Paper SC/60/BRG11 presented to the IWC Scientific Committee. Paper SC/60/BRG11 presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 10pp.

Costa, D. P., D. E. Crocker, D. M. Waples, P. M. Webb, J. Gedamke, D. Houser, P. D. Goley, B. J. LeBoeuf and J. Calambokidis 1998. The California Marine Mammal Research Program of the Acoustic Thermometry of Ocean Climate experiment. Pp.1542-1553 *In:* Magoon, O.T. et al. (eds), Conference Proceedings of California and the World Ocean '97: Taking a look at California's ocean resources: an agenda for the future. American Society of Civil Engineers, Reston, VA. .

Crouse, D. T. 1999. The consequences of delayed maturity in a human-dominated world. American Fisheries Society Symposium 23:195-202.

Cruz, R. Turtle distribution in the Philippines. */In/*: Kinan, I. (ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop, February 5-8, 2002, Honolulu, Hawaii.

Cummings, W. C. and P. O. Thompson 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. Journal of the Acoustical Society of America 50(4 pt.2):1193-1198.

Davis, R. W., W. E. Evans and B. Würsig 2000. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume I: Executive Summary. Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-02. 40p.

DFO 2004. Review of scientific information on impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. Department of Fisheries and Oceans, Canada. Habitat Status Report 2004/002. 15p.

Dolphin, W. F. 1987. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology 65(1):83-90.

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

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

Eckert, K. L. 1993. The biology and population status of marine turtles in the North Pacific Ocean. Final Report to NOAA, NMFS, SWFSC. Honolulu, HI.

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

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

Erhart, L. M., D.A. Bagley and W. E. Redfoot 2003. Loggerhead Turtles in the Atlantic Ocean : Geographic Distribution, Abundance, and Population Status. Pp.157-174 *In:* Bolten, A.B. and B.E. Witherington (eds), Loggerhead Sea Turtles. Smithsonian Books, Washington D.C.

Evans, P. G. H. 1998. Biology of cetaceans of the North-east Atlantic (in relation to seismic energy).Chapter 5 *In:* Tasker, M.L. and C. Weir (eds), Proceedings of the Seismic and Marine Mammals Workshop, London 23-25 June 1998. Sponsored by the Atlantic Margin Joint Industry Group (AMJIG) and endorsed by the UK Department of Trade and Industry and the UK's Joint Nature Conservation Committee (JNCC).

Finneran, J. J., C. R. Schlundt, D. A. Carder, J. A. Clark, J. A. Young, J. B. Gaspin and S. H. Ridgway 2000. Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whales (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. Journal of the Acoustical Society of America 108(1):417-431.

Finneran, J. J., C. R. Schlundt, R. Dear, D. A. Carder and S. H. Ridgway 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111(6):2929-2940.

Frantzis, A. 1998. Does acoustic testing strand whales? Nature 392(6671):29.

Fretey, J., A. Billes and M. Tiwari 2007. Leatherback, *Dermochelys coriacea*, nesting along the Atlantic coast of Africa. Chelonian Conservation and Biology 6(1):126-129.

FWRI 2006. Fish and Wildlife Research Institute (FWRI), Florida Fish and Wildlife Conservation Commission. Data from the Florida Index Nesting Beach Survey Program (1989-2005). Available at http://www.floridamarine.org.

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

Gambell, R. 1976b. The blue whale. Biologist 26(5):209-215.

Gambell, R. 1985a. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). In: Ridgway SH, Harrison R, editors. Handbook of Marine Mammals, vol. 3: The Sirenians and Baleen Whales.:London: Academic Press. p 171-192.

Gausland, I. 2000. Impact of seismic surveys on marine life. The Leading Edge 19(8):903-905.

Gentry, R. L. 2002. Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000. Dated November 4, 2002. National Marine Fisheries Service, Silver Spring Maryland. 4p. Available online at: http://www.nmfs.noaa.gov/pr/health/publications.htm

Geraci, J. R. 1990. Physiological and toxic effects on cetaceans.Pp. 167-197 *In:* Geraci, J.R. and D.J. St. Aubin (eds), Sea Mammals and Oil: Confronting the Risks. Academic Press, Inc.

Goold, J. C. 1999. Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. Journal of the Marine Biological Association of the U.K. 79:541-550.

Goold, J. C. and P. J. Fish 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. Journal of the Acoustical Society of America 103(4):2177-2184.

Goold, J. C. and S. E. Jones 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98(3):1279-1291.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M. P. Simmonds, R. Swift and D. Thompson 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16-34.

Gordon, J. C. D. 1987. Sperm whale groups and social behaviour observed off Sri Lanka. Report of the International Whaling Commission 37:205-217.

Gosho, M. E., D. W. Rice and J. M. Breiwick 1984. The sperm whale, *Physeter macrocephalus*. Marine Fisheries Review 46(4):54-64.

Govan, H. 1998. Community turtle conservation at Río Oro on the Pacific Coast of Costa Rica. Marine Turtle Newsletter 80:10-11.

Greene, C. R., Jr and W. J. Richardson 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. Journal of the Acoustical Society of America 83(6):2246-2254.

Groombridge, B. and R. Luxmoore 1989. The Green Turtle and Hawksbill (Reptiliia:Cheloniidae): World Status, Exploitation and Trade. CITES Secretariat, Lausanne, Switzerland. 601p.

Guerra, A., A. F. Gonzalez and F. Rocha 2004. A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations. International Council for the Exploration of the Seas (ICES) Annual Science Conference, 22-25 September 2004, Vigo, Spain. ICES CM 2004/CC:29.

Hamilton, P. K., G. S. Stone and S. M. Martin 1997. Note on a deep humpback whale (*Megaptera novaeangliae*) dive near Bermuda. Bulletin of Marine Science 61:491-494.

Hatase, H., M. Kinoshita, T. Bando, N. Kamezaki, K. Sato, Y. Matsuzawa, K. Goto, K. Omuta, Y. Nakashima, H. Takeshita and W. Sakamoto 2002. Population structure of loggerhead turtles, *Caretta caretta,* nesting in Japan: bottlenecks on the Pacific population. Marine Biology 141:299-305.

Herman, L. M., P. H. Forestell and R. C. Antinoja 1980. The 1976/1977 migration of humpback whales into Hawaiian waters: composite description. . Marine Mammal Commission Report No. MMC 77-19.:Washington, D.C.

Hirst, A. G. and P. G. Rodhouse 2000. Impacts of geophysical seismic surveying on fishing success. Reviews in Fish Biology and Fisheries 10:113-118.

Holsbeek, L., C. R. Joiris, V. Debacker, I. B. Ali, P. Roose, J.-P. Nellissen, S. Gobert, J.-M. Bouquegneau and M. Bossicart 1999. Heavy metals, organochlorines and polycyclic aromatic hydrocarbons in sperm whales stranded in the southern North Sea during the 1994/1995 winter. Marine Pollution Bulletin 38(4):304-313.

Holst, M., W. J. Richardson, W. R. Koski, M. A. Smultea, B. Haley, M. W. Fitzgerald and M. Rawson 2006. Effects of large and small-source seismic surveys on marine mammals and sea turtles. EOS Trans. AGU 87(36):Joint Assembly Supplement, Abstract OS42A-01.

Holst, M., M. A. Smultea, W. R. Koski and B. Haley 2005b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off the northern Yucatán Peninsula in the southern Gulf of Mexico, January-February 2005. Prepared by LGL, Ltd. for the Lamont-Doherty Earth Observatory of Columbia University and the National Marine Fisheries Service, Office of Protected Resources. LGL Report TA2822-31. 110p.

IWC 1979. Report of the Sub-committee on Protected Species. Annex G, Appendix I. Report of the International Whaling Commission 29:84-86.

IWC 1990. Report of the Scientific Committee. Report of the International Whaling Commission 40:39-179.

IWC 2005. Chair's Report of the 56th Annual Meeting. International Whaling Commission. Available online at: http://www.iwcoffice.org/_documents/meetings/ulsan/CRREP57.pdf Accessed 7/26/2006.

IWC 2008b. Report of the Sub-Committee on Bowhead, Right and Gray whales. Report of the Scientific Committee Annex F. Accessed 2/20/2009 via the INTERNET at: www.icwoffice.org.

Jaszy, M. and C. Horowitz 2005. The costs of seismic exploration. TerraNature, 2 March 2005. Available online at: http://www.terranature.org/oceanNoise.htm. Accessed: 10/20/2006.

Jepson, P. D., M. Arbelo, R. Deaville, I. A. P. Patterson, P. Castro, J. R. Baker, E. Degollada, H. M. Ross, P. Herraez, A. M. Pocknell, F. Rodriguez, R. E. Howie, A. Espinosa, R. J. Reid, J. R. Jaber, V. Martin, A. A. Cunningham and A. Fernandez 2003. Gas-bubble lesions in stranded cetaceans. Nature 425:575-576.

Jessop, T. S. 2001. Modulation of the adrenocortical stress response in marine turtles (Cheloniidae): Evidence for a hormonal tactic maximizing maternal reproductive investment. Journal of Zoology 254(1):57-65.

Jessop, T. S., M. Hamann, M. A. Read and C. J. Limpus 2000. Evidence for a hormonal tactic maximizing green turtle reproduction in response to a pervasive ecological stressor. General and Comparative Endocrinology 118:407-417.

Jessop, T. S., J. Sumner, V. Lance and C. Limpus 2004. Reproduction in shark-attacked sea turtles is supported by stress-reduction mechanisms. Proceedings of the Royal Society Biological Sciences Series B 271 (Suppl).S91-S94.

Jochens, A., D. C. Biggs, D. Engelhaupt, J. Gordon, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. M. Thode, P. Tyack, J. Wormuth and B. Würsig 2006. Sperm whale seismic study in the Gulf of Mexico; Summary Report 2002-2004. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-034. 352p.

Jochens, A. E. and D. C. Biggs 2003. Sperm whale seismic study in the Gulf of Mexico: Annual report: Year 1. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-069. 139p.

Jochens, A. E. and D. C. Biggs 2004. Sperm whale seismic study in the Gulf of Mexico: Annual report: Year 2. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-067, 167p.

Jones, M.L. and S.L. Swartz. Gray whale. In: Perrin, WF, Wursig, B, Thewissen, JG, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA 92101-4495. p524-536.

Johnson, J. H. and A. A. Wolman 1984. The humpback whale, *Megaptera novaeangliae*. Marine Fisheries Review 46(4):30-37.

Johnson, S. R., W. J. Richardson, S. B. Yazvenko, S. A. Blokhin, G. Gailey, M. R. Jenkerson, S. K. Meier, H. R. Melton, M. W. Newcomer, A. S. Perlov, S. A. Rutenko, B. Würsig, C. R. Martin and D. E. Egging 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9813-0. 19p.

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

Katona, S. K. and J. A. Beard 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Report of the International Whaling Commission(Special Issue 12):295-306.

Keller, J. M., P. D. McClellan-Green, J. R. Kucklick, D. E. Keil and M. M. Peden-Adams 2006. Effects of organochlorine contaminants on loggerhead sea turtle immunity: comparison of a correlative field study and *in vitro* exposure experiments. Environmental Health Perspectives 114(1):70-76.

Kenchington, T. J. 1999. Impacts of seismic surveys on fish behaviour and fisheries catch rates on Georges Bank. Prepared by Gadus Associates for Norigs 2000. Georges Bank Review Panel, Halifax, Nova Scotia. 24p.

Ketten, D. R. 1994. Functional analyses of whale ears: Adaptations for underwater hearing. IEEE Proceedings in Underwater Acoustics (Oceans 94) 1:264-270.

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

Ketten, D. R., J. Lien and S. Todd 1993. Blast injury in humpback whale ears: evidence and implications. Journal of the Acoustical Society of America 94(3 Pt.2):1849-1850.

Kintisch, E. 2006. As the seas warm: Researchers have a long way to go before they can pinpoint climate-change effects on oceangoing species. Science 313:776-779.

Kostyuchenko, L. P. 1973. Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. Hydrobiological Journal 9(5):45-48.

L-DEO 2006. Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals During Seismic Testing in the Northern Gulf of Mexico, Fall 2006. Prepared by LGL, Ltd. - LGL Report TA4295-1. Submitted to the National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland, by the Lamont-Doherty Earth Observatory, Palisades, New York.149p.

L-DEO 2008. Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals During a Marine Geophysical Survey by the R/V Marcus Langseth in Southeast Asia, March-July 2009. Prepared by LGL, Ltd. - LGL Report TA4553-2. Submitted to the National Marine

Fisheries Service, Office of Protected Resources, Silver Spring, Maryland, by the Lamont-Doherty Earth Observatory, Palisades, New York.149p.

LaBella, G., S. Cannata, C. Froglia, S. Ratti and G. Rivas 1996. First assessment of effects of air-gun seismic shooting on marine resources in the central Adriatic Sea. Abstract only - The third international conference on health, safety & environment in oil & gas exploration & production : New Orleans LA, 9-12 June 1996.

Lagueux, C. J. 1998. Demography of marine turtles harvested by Miskitu indians of Atlantic Nicaragua. P. 90 *In:* Byles, R. and Y. Fernandez (compilers), Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. 28 February - 1 March 1996, Hilton Head, South Carolina. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-412.

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

Learmonth, J. A., C. D. MacLeod, M. B. Santos, G. J. Pierce, H. Q. P. Crick and R. A. Robinson 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: An Annual Review 44:431-464.

Lenhardt, M. 2002. Sea turtle auditory behavior. Journal of the Acoustical Society of America 112(5 Pt. 2):2314.

Lenhardt, M. L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pp.238-241 *In:* Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar (Eds), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum, NMFS-SEFSC-351.

Lenhardt, M. L., S. Bellmund, R. A. Byles, S. W. Harkins and J. A. Musick 1983. Marine turtle reception of bone conducted sound. The Journal of Auditory Research 23:119-125.

León, Y. M. and C. E. Diez 1999. Population structure of hawksbill turtles on a foraging ground in the Dominican Republic. Chelonian Conservation and Biology 3(2):230-236.

León, Y. M. and C. E. Diez 2000. Ecology and population biology of hawksbill turtles at a Caribbean feeding ground.Pp. 32-33 *In:* Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez-Millán, and L. Sarti-Martinez (compilers), Proceedings of the Eighteenth International Sea Turtle Symposium. 3-7 March 1998, Mazatlán, Sinaloa, México. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-436.

LGL Ltd. 2011. Environmental Assessment of a Marine Geophysical Survey by the *R/V Marcus G. Langseth* in the central Pacific Ocean, November-December 2011. Prepared for Lamont-Doherty Earth Observatory, Palisades, NY and National Science Foundation, Arlington, VA, by LGL Ltd., environmental research associates, Ontario, Canada. May 17, 2011. LGL Report TA4949-1.

Lyrholm, T. and U. Gyllensten 1998. Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. Proceedings of the Royal Society of London B 265(1406):1679-1684.

MacLeod, C. D., S. M. Bannon, G. J. Pierce, C. Schweder, J. A. Learmonth, J. S. Herman and R. J. Reid 2005. Climate change and the cetacean community of north-west Scotland. Biological Conservation 124:477-483.

Madsen, P. T., M. Johnson, P. J. O. Miller, N. Aguilar Soto, J. Lynch and P. Tyack 2006. Quantitative measurements of air-gun pulses recorded on sperm whales (*Physeter*

macrocephalus) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120(4):2366-2379.

Madsen, P. T. and B. Møhl 2000. Sperm whales (*Physeter catodon* L. 1758) do not react to sounds from detonators. Journal of the Acoustical Society of America 107(1):668-671.

Madsen, P. T., B. Møhl, B. K. Nielsen and M. Wahlberg 2002. Male sperm whale behaviour during seismic survey pulses. Aquatic Mammals 28(3):231-240.

Madsen, P. T., R. Payne, N. U. Kristiansen, M. Wahlberg, I. Kerr and B. Mohl 2002. Sperm whale sound production studied with ultrasound time/depth-recording tags. Journal of Experimental Biology 205:1899-1906.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack and J. E. Bird 1984. Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration.Report prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Office under Contract No. 14-12-0001-29033. 357p.

Margaritoulis, D., R. Argano, I. Baran, F. Bentivegna, M.N. Bradai, J.A. Camiñas, P. Casale, G. De Metrio, A. Demetropoulos, G. Gerosa, B.J. Godley, D.A. Haddoud, J. Houghton, L. Laurent and B. Lazar 2003. Loggerhead Turtles in the Mediterranean Sea : Present Knowledge and Conservation Perspectives. Pp.175-198 *In:* Bolten, A.B. and B.E. Witherington (eds), Loggerhead Sea Turtles. Smithsonian Books, Washington D.C.

Maser, C., B. R. Mate, J. F. Franklin and C. T. Dyrness 1981. Natural History of Oregon Coast Mammals.U.S. Department of Agriculture, Forest Service, General Technical Report PNW-133. 524p.

Mate, B. R., K. M. Stafford and D. K. Ljungblad 1994. A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. Journal of the Acoustic Society of America 96(5 part 2):3268–3269.

Mattila, D., P. J. Clapham, O. Vásquez and R. S. Bowman 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. Canadian Journal of Zoology 72:1898-1907.

Mayashita, T, Pastene, L and Kato, H (Compliers). 2007 Progress Report on Cetacean Research, April 2007 to March 2008, with statistical data for the Calendar year 2007 or the season 2007/2008. Report prepared for the International Whaling Commission 2008. Accessed via the INTERNET at: www.iwc.org.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch and K. McCabe 2000b. Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Prepared for the Australian Petroleum Production Exploration Association by the Centre for Marine Science and Technology, Project CMST 163, Report R99-15. 203p.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdock and K. McCabe 2000a. Marine seismic surveys - a study of environmental implications. Australian Petroleum Production & Exploration Association (APPEA) Journal 40:692-708.

McCauley, R. D., J. Fewtrell and A. N. Popper 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113:5.

McCauley, R. D., M.-N. Jenner, C. Jenner, K. A. McCabe and J. Murdoch 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise:

preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal 38:692-707.

McDonald, M. A., J. A. Hildebrand, S. Webb, L. Dorman and C. G. Fox 1993. Vocalizations of blue and fin whales during a midocean ridge airgun experiment. Journal of the Acoustic Society of America 94(3 part 2):1849.

McDonald, M. A., J. A. Hildebrand and S. C. Webb 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. Journal of the Acoustical Society of America 98(2 Part 1):712-721.

McMahon, C. R. and G. C. Hays 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12:1330-1338.

Mead, J. G. 1977. Records of sei and Bryde's whales from the Atlantic coast of the United States, the Gulf of Mexico, and the Caribbean. Report of the Special Meeting of the Scientific Committee on Sei and Bryde's Whales, International Whaling Commission, La Jolla, California. p.113-116.

Meyer-Schoene, L. and B. T. Walton 1994. Turtles as monitors of chemical contaminants in the environment. Reviews of Environmental Contamination and Toxicology 135:93-153.

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

Miller, G. W. 2005. Monitoring seismic effects on marine mammals - Southeastern Beaufort Sea, 2001-2002. Pp. 511-542 *In:* Armsworthy, S.L., P.J. Cranford, and K. Lee (Eds), Offshore Oil and Gas Environmental Effects Monitoring: Approaches and Technologies. Battelle Press, Columbus, Richmond.

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

Milton, S. L., S. Leone-Kabler, A. A. Schulman and P. L. Lutz 1994. Effects of hurricane Andrew on the sea turtle nesting beaches of South Florida. Bulletin of Marine Science 54(3):974-981.

Mitchell, E. 1974. Canada progress report on whale research, May 1972–May 1973. Report of the International Whaling Commission 24(196-213).

Mitchell, E. and D. G. Chapman 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Report of the International Whaling Commission(Special Issue 1):117-120.

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

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

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

Moein, S. E., J. A. Musick, J. A. Keinath, D. E. Barnard, M. Lenhardt and R. George 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Final Report submitted to the U.S. Army Corps of Engineers, Waterways Experiment Station. Virginia Institute of Marine Science (VIMS), College of William and Mary, Gloucester Point, Virginia. 42p.

Nasu, K. 1974. Movement of baleen whales in relation to hydrographic conditions in the northern part of the North Pacific Ocean and the Bering Sea. In: Oceanography of the

Bering Sea with Emphasis on Renewable Resources:Hood, D.W. and E.J. Kelley (eds). International Symposium for Bering Sea Study, Hakodate, Japan, 31 January - 4 February 1972. p345-361.

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

Nieukirk, S. L., K. M. Stafford, D. k. Mellinger, R. P. Dziak and C. G. Fox 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean Journal of the Acoustical Society of America 115:1832-1843.

NMFS 1991. Recovery Plan for the Humpback Whale (*Megaptera novaeangliae*).Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service. Silver Spring, Maryland. 105p.

NMFS 1998b. Recovery plan for the blue whale (*Balaenoptera musculus*).Prepared by Reeves, R.L., P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber for the National Marine Fisheries Service, Silver Spring, Maryland. 42pp.

NMFS 2005b. Biological Opinion on the Issuance of ESA Section 10(a)(1)(A) Permit No. 1451 to the National Marine Fisheries Service - Office of Sustainable Fisheries for Research on Sea Turtles.National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 48p.

NMFS 2005b. Draft environmental impact statement for amending the Atlantic Large Whale Take Reduction Plan: Broad-based gear modifications.Draft EIS prepared by Industrial Economics, Incorporated, and NOAA's National Marine Fisheries Service. .

NMFS 2006b. Biological opinion on the proposed regulatory program implementing conservation and management measures adopted by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 144p.

NMFS 2006b. Draft Recovery Plan for the Sperm Whale (*Physeter Macrocephalus*). National Marine Fisheries Service, Silver Spring, Maryland. 92p.

NMFS 2006c. Biological opinion on the issuance of an incidental harassment authorization to Scripps Institution of Oceanography for a marine seismic survey in the Southwest Pacific Ocean (Louisville Ridge) National Marine Fisheries Service, Silver Spring, Maryland. 68p.

NMFS 2006d. Biological Opinion on the issuance of an incidental harassment authorization to Scripps Institution of Oceanography for a marine seismic survey in the Eastern Tropical Pacific Ocean. National Marine Fisheries Service, Silver Spring, Maryland. 76p.

NMFS 2006e. Biological Opinion on Permitting Structure Removal Operations on the Gulf of Mexico Outer Continental Shelf and the Authorization for Take of Marine Mammals Incidental to Structure Removals on the Gulf of Mexico Outer Continental Shelf. National Marine Fisheries Service, Silver Spring, Maryland. 131p.

NMFS 2006g. Biological Opinion on the 2006 Rim-of-the-Pacific Joint Training Exercises (RIMPAC). National Marine Fisheries Service, Silver Spring, Maryland. 123p.

NMFS 2006h. Biological Opinion on the Funding and Permitting of Seismic Surveys by the National Science Foundation and the National Marine Fisheries Service in the Eastern Tropical Pacific Ocean from March to April 2006. National Marine Fisheries Service, Silver Spring, Maryland. 76p.

National Marine Fisheries Service. 2007. Recovery Plan for the Hawaiian Monk Seal (*Monachus schauinslandi*). Second Revision. National Marine Fisheries Service, Silver Spring, MD. 165 pp.

National Marine Fisheries Service, Pacific Islands Regional Office, 1601 Kapiolani Blvd Suite 1110 Honolulu, HI 96814.

NMFS and USFWS 1991a. Recovery Plan for U.S. Population of Atlantic Green Turtle *Chelonia mydas*. National Marine Fisheries Service, Washington, D.C.

NMFS and USFWS 1991b. Recovery Plan for U.S. Population of Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Washington, D.C.

NMFS and USFWS 1992b. Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.

NMFS and USFWS 1993. Recovery Plan for hawksbill turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. National Marine Fisheries Service, St. Petersburg, Florida.

NMFS and USFWS 1998a. Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, Maryland.

NMFS and USFWS 1998b. Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). National Marine Fisheries Service, Silver Spring, Maryland.

NMFS and USFWS 1998c. Recovery Plan for the U.S. Pacific Populations of the Leatherback Turtles (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, Maryland.

NMFS and USFWS 1998c. Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS 1998d. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS 1998e. Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS 2007a. Green Sea Turtle (*Chelonia mydas*) 5-Year Review: Summary and Evaluation U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland; and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, Florida. 105p.

NOS 2003. Oil and sea turtles: biology, planning, and response. G. Shigenaka (Ed). National Ocean Service, NOAA. 116p.

NRC 2003. Ocean Noise and Marine Mammals.National Research Council: Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals.

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

Øien, N. 1990. Sightings surveys in the northeast Atlantic in July 1988: distribution and abundance of cetaceans. Report of the International Whaling Commission 40:499-511.

Palsbøll, P. J., J. Allen, M. Bérubé, P. J. Clapham, T. P. Feddersen, R. R. Hudson, H. Jørgensen, S. Katona, A. H. Larsen, F. Larsen, J. Lien, D. K. Mattila, J. Sigurjónsson, R. Sears, T. Smith, R. Sponer, P. Stevick and N. Øien 1997. Genetic tagging of humpback whales. Nature 388:767-769.

Papa, A. 2009. Dynamite use eyed in dolphin stranding . Philippine Daily Inquirer. First Posted 20:31:00 02/11/2009).

Papastavrou, V., S. C. Smith and H. Whitehead 1989. Diving behaviour of the sperm whale, *Physeter macrocephalus*, off the Galápagos Islands. Canadian Journal of Zoology 67:839-846.

Parker, D. M., W. J. Cooke and G. H. Balazs 2005. Diet of oceanic loggerhead sea turtles (*Caretta caretta*) in the central North Pacific. Fishery Bulletin 103:142-152.

Pearson, W. H., J. R. Skalski and C. I. Malme 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences 49:1343-1356.

Perry, S. L., D. P. DeMaster and G. K. Silber 1999. The Great Whales: History and Status of Six Species Listed as Endangered Under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Pike, D. A. and J. C. Stiner 2007a. Fluctuating reproductive output and environmental stochasticity: do years with more reproducing females result in more offspring? Canadian Journal of Zoology 85(6):737-742.

Pomilla, C. and H. C. Rosenbaum 2005. Against the current: an inter-oceanic whale migration event. Biology Letters 1(4):476-479.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. Macgillivray, M. E. Austin and D. A. Mann 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6):3958-3971.

Potter, J. R., M. Thillet, C. Douglas, M. A. Chitre, Z. Doborzynski and P. J. Seekings 2007. Visual and passive acoustic marine mammal observations and high-frenquency seismic source characteristics recorded during a seismic survey. IEEE Journal of Oceanic Engineering 32(2):469-483.

Pritchard, P. C. H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea*, in Pacific México, with a new estimate of the world population status. Copeia 1982(4):741-747.

Putrawidjaja, M. 2000. Marine turtles in Irian Jaya, Indonesia. Marine Turtle Newsletter 90:8-10.

Reeves, R. R., B. D. Smith, E. A. Crespo and G. c. Notarbartolo di Sciara 2003. Dolphins, Whales and Porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. ix + 139p.

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

Reilly, S. B. and V. G. Thayer 1990. Blue whale (*Balaenoptera musculus*) distribution in the Eastern Tropical Pacific. Marine Mammal Science 6(4):265-277.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific.Pp.170-195 *In:* The whale problem: a status report. W.E. Schevill (ed). Harvard Univ. Press, Cambridge, Mass. 419p.

Richardson, T. H., J. I. Richardson, C. Ruckdeshel and M. W. Dix 1978. Remigration patterns of loggerhead sea turtles (*Caretta caretta*) nesting on Little Cumberland and Cumberland Islands, Georgia. Florida Marine Research Publications 33:39-44.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme and D. H. Thomson 1995. Marine mammals and noise. MMS Contr. 14-12-0001-30673. Acad. Press, San Diego, Calif., 576 p.

Richardson, W. J. and B. Würsig 1997. Influences of man-made noise and other human actions on cetacean behaviour. Marine and Freshwater Behavior and Physiology 29:183-209.

Richardson, W. J., B. Würsig and C. R. Greene, Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79(4):1117-1128.

Ridgway, S. H., D. A. Carder, R. R. Smith, T. Kamolnick, C. E. Schlunt and W. R. Elsberry 1997. Behavioural responses and temporary shift in masked hearing threshold of bottlenose dolphins, *Tursiops truncatus*, to 1-second tones of 141 to 201 dB re 1 mPa. Technical Report 1751, July 1997. Naval Command, Control and Surveillance Center, RDT&E Division, San Diego, CA.

Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin and J. H. Anderson 1969. Hearing in the giant sea turtle, *Chelonia mydas*. Proceedings of the National Academy of Sciences of the United States of America 64:884-890.

Robinson, R. A., J. A. Learmonth, A. M. Hutson, C. D. Macleod, T. H. Sparks, D. I. Leech, G. J. Pierce, M. M. Rehfisch and H. Q. P. Crick 2005. Climate change and migratory species. A Report for Defra Research Contract CR0302, August 2005. BTO Research Report 414, British Trust for Ornithology, Norfolk, U.K. 306p.

Rosenberg, D. 2005. Japan Focus. April 15, 2005. Accessed 3/3/2009 via the INTERNET at: http://japanfocus.org/products/details/1789.

Ross, J. P. 1984. Adult sex ratio in the green sea turtle. Copeia 1984(3):774-776.

Ross, J. P. 2005. Hurricane effects on nesting *Caretta caretta*. Marine Turtle Newsletter 108:13-14.

Santulli, A., A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi and V. D'Amelio 1999. Biochemical responses of European sea bass (Dicentrarchus labrax L.) to the stress induced by offshore experimental seismic prospecting. Marine Pollution Bulletin 38(12):1105-1114.

Schlundt, C. R., J. J. Finneran, D. A. Carder and S. H. Ridgway 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus,* and white whale, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107(6):3496-3508.

Scott, T. M. and S. S. Sadove 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science 13:317-321.

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

Simmonds, M. P. and S. J. Isaac 2007. The impacts of climate change on marine mammals: early signs of significant problems. Oryx 41(1):19-26.

Skalski, J. R., W. H. Pearson and C. I. Malme 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences 49:1357-1365.

Smith, T. D., J. Allen, P. J. Clapham, P. S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila and P. J. Palsbøll 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science 15(1):1-32.

Spotila, J. R. 2004. Sea turtles: A complete guide to their biology, behavior, and conservation. John Hopkins University Press, Baltimore. 227p.

Spotila, J. R., A. E. Dunham, A. J. Leslie, A. C. Steyermark, P. T. Plotkin and F. V. Paladino 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):209-222.

Spotila, J. R., R. D. Reina, A. C. Steyermark, P. T. Plotkin and F. V. Paladino 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

Stearns, S. C. 1992. The evolution of life histories.Oxford University Press, 249p.

Stevick, P., J. Allen, P. J. Clapham, N. Friday, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, J. Sigujónsson, T. D. Smith, N. Øien and P. S. Hammond 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258:263-273.

Suárez, A., P. H. Dutton and J. Bakarbessy 2000. Leatherback (*Dermochelys coriacea*) nesting on the North Vogelkop Coast of Irian Jaya, Indonesia. P.260 *In:* Kalb, H. and T. Wibbels (eds), 19th Annual Symposium on Sea Turtle Conservation and Biology. 2-6 March 1999, South Padre Island, Texas.

Tershy, B. R., J. Urbán-Ramírez, D. Breese, L. Rojas-Bracho and L. T. Findley 1993. Are fin whales resident to the Gulf of California? Revista de Investigación Científica de la Universidad Autónoma de Baja California Sur (UABCS) 1:69-71.

Thomson, D. H., J. W. Lawson and A. Muecke 2001. Proceedings of a Workshop to Develop Methodologies for Conducting Research on the Effects of Seismic Exploration on the Canadian East Coast Fishery. Halifax, Nova Scotia, 7-8 September 2000. Environmental Studies Research Funds Report No. 139. Calgary. 92 p.

Tolstoy, M., J. Diebold, S. Webb, D. Bohnenstiehl and E. Chapp 2004b. Acoustic calibration measurements. Chapter 3 *In*: Marine mammal and acoustic monitoring during Lamont-Doherty Earth Observatory's acoustic calibration study in the northern Gulf of Mexico, 2003. W.J. Richardson (ed.), Revised ed. Report from LGL Ltd., Ontario, Canada for Lamont-Doherty Earth Observatory, Palisades, New York, and the National Marine Fisheries Service, Silver Spring, Maryland. Available at: http://www.nmfs.noaa.gov/pr/pdfs/permits/lamont_report_gulf.pdf.

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, S.C. Webb, D.R. Bohenstiehl, T.J. Crone and R.C. Holmes. 2009. Broadband calibration of R/V Marcus G. Langseth four-string seismic sources. Geochem. Geophys. Geosyst., 10, Q08011, doi:10.1029/2009GC002451.

Tolstoy, M., J. B. Diebold, S. C. Webb, D. R. Bohnenstiehl, E. Chapp, R. C. Holmes and M. Rawson 2004a. Broadband calibration of *R/V Ewing* seismic sources. Geophysical Research Letters 31(L14310):4p.

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

Turnpenny, A. W. H. and J. R. Nedwell 1994. The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. Consultancy Report, Fawley Aquatic Research Laboratories, Ltd. FCR 089/94. 50p.

Tyack, P. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. Behavioral Ecology and Sociobiology 8:105-116.

U.S. Department of Commerce 1983. Draft Management Plan and Environmental Impact Statement for the Proposed Hawaii Humpback Whale National Marine Sanctuary.Prepared by the NOAA Office of Ocean and Coastal Resource Management and the State of Hawaii. 172p.

U.S. Department of Commerce and U.S. Department of the Navy 2001. Joint Interim Report Bahamas Marine Mammal Stranding Event of 15-16 March 2000.U.S. Department of

Commerce, National Oceanic and Atmospheric Administration and Department of the Navy Joint Interim Report. 59p.

Urick, R. J. 1983. Principles of underwater sound.McGraw-Hill, Inc. 423p.

Valiela, I., P. Peckol, C. D'Avanzo, J. Kremer, D. Hersh, K. Foreman, K. Lajtha, B. Seely, W. R. Geyer, T. Isaji and R. Crawford 1998. Ecological effects of major storms on coastal watersheds and coastal waters: Hurricane Bob on Cape Cod. Journal of Coastal Research 14(1):218-238.

Van Meter, R. J., J. R. Spotila and H. W. Avery 2006. Polycyclic aromatic hydrocarbons affect survival and development of common snapping turtle (*Chelydra serpentina*) embryos and hatchlings. Environmental Pollution 142:466-475.

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

Wardle, C. S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A. M. Ziolkowski, G. Hampson and D. Mackie 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21:1005-1027.

Waring, G. T., R. M. Pace, J. M. Quintal, C. P. Fairfield and K. Maze-Foley 2004. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2003. NOAA Technical Memorandum NMFS-NE-182:Woods Hole, Massachusetts, 300p.

Watkins, W. A. 1977. Acoustic behavior of sperm whales. Oceanus 20:50-58.

Watkins, W. A. 1981a. Activities and underwater sounds of fin whales. Scientific Reports of the Whales Research Institute 33:83-117.

Watkins, W. A., M. A. Daher, K. M. Fristrup, T. J. Howald and G. Notarbartolo-di-Sciara 1993. Sperm whale tagged with transponders and tracked underwater by sonar. Marine Mammal Science 9(1):55-67.

Watkins, W. A., K. E. Moore, J. Sigujónsson, D. Wartzok and G. N. di Sciara 1984. Fin Whale (*Balaenoptera physalus*) tracked by radio in the Irminger Sea. Rit Fiskideildar 8:1-14.

Watkins, W. A., K. E. Moore and P. Tyack 1985. Sperm whale acoustic behavior in the southeast Caribbean. Cetology 49:1-15.

Watkins, W. A. and W. E. Schevill 1975. Sperm whales (*Physeter catodon*) react to pingers. Deep-Sea Research 22:123-129.

Weilgart, L. and H. Whitehead 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. Canadian Journal of Zoology 71(4):744-752.

Weilgart, L. S. and H. Whitehead 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40:277-285.

Weller, DW, Bradford, AL, Lang, AR, Kim HW, Sidorenko, M, Tsidulko, A, Burdin, AM and Browness, RL, Jr. 2008. Status of western Gray whales off northeastern Sakhalin Island, Russia, in 2007. Paper SC/60/BRG3 presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 10pp.

Wenzel, F. W., D. K. Mattila and P. J. Clapham 1988. *Balaenoptera musculus* in the Gulf of Maine. Marine Mammal Science 4(2):172-175.

Western Australian Department of Industry and Resources 2002. Petroleum Information Series - Guidelines Sheet 1. Guidelines on minimising acoustic disturbance to marine fauna. Available online at: http://www.doir.wa.gov.au/documents/mineralsandpetroleum/ envsheetmar02.pdf   Accessed on: 10/19/2006.

Whitehead 1987. Updated status of the humpback whale, *Megaptera novaeangliae*, in Canada. Canadian Field-Naturalist 101(2):284-294.

Whitehead, H. 1982. Populations of humpback whales in the northwest Atlantic. Report of the International Whaling Commission 32:345-353.

Whitehead, H. 1995. Status of Pacific sperm whale stocks before modern whaling. Report of the International Whaling Commission 45:407-412.

Whitehead, H. 1996. Variation in the feeding success of sperm whales: temporal scale, spatial scale, and relationship to migrations. Journal of Animal Ecology 65:429-438.

Whitehead, H. 2003. Sperm whales: social evolution in the ocean. University of Chicago Press, Chicago, Illinois. 431p.

Whitehead, H., J. Christal and S. Dufault 1997. Past and distant whaling and the rapid decline of sperm whales off the Galápagos Islands. Conservation Biology 11(6):1387-1396.

Whitehead, H., S. Waters and T. Lyrholm 1992. Population structure of female and immature sperm whales (*Physeter macrocephalus*) off the Galapagos Islands. Canadian Journal of Fisheries and Aquatic Sciences 49(1):79-84.

Whitehead, H. P. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series 242:295-304.

Winn, H. E. and N. E. Reichley 1985. Humpback whale - *Megaptera novaeangliae*. Handbook of Marine Mammals: Vol. 3 The Sirenians and Baleen Whales:241-274.

Witherington, B. E., M. Bresette and R. Herren 2006a. *Chelonia mydas* – Green Turtle. Chelonian Research Monographs 3:90-104.

Witherington, B. E. and L. M. Ehrhart 1989. Hypothermic stunning and mortality of marine turtles in the Indian River Lagoon System, Florida. Copeia 1989(3):696-703.

Würsig, B., T. A. Jefferson and D. J. Schmidly 2000. The marine mammals of the Gulf of Mexico.Texas A&M University Press, College Station. 232p.

Yazvenko, S. B., T. L. McDonald, S. A. Blokhin, S. R. Johnson, S. K. Meier, H. R. Melton, M. W. Newcomer, R. M. Nielson, V. L. Vladimirov and P. W. Wainwright 2007. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9809-9. 29p.

Yochem, P. K. and S. Leatherwood 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). In: Ridgway SH, Harrison R, editors. Handbook of Marine Mammals, vol. 3: The Sirenians and Baleen Whales.:London: Academic Press. p 193-240.

Zug, G. R. and J. F. Parham 1996. Age and growth in leatherback turtles, *Dermochelys coriacea*: A skeletochronological analysis. Chelonian Conservation and Biology 2:244-249.