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

Biological Opinion

Agencies: National Science Foundation-Division of Ocean Sciences and NOAA's National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division

Activities Considered: Seismic survey by the Lamont-Doherty Earth Observatory in the west-central Pacific Ocean off the Marianas Islands and Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA)

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

Approved by: Helen Golde for J. H. Lecky

Date: February 1, 2012

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 *et seq.*) requires that each federal agency shall insure 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 designated for them, that agency is required to consult with either the NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. For the actions described in this document, the action agencies are the National Science Foundation (NSF), which proposes to fund the Lamont-Doherty Earth Observatory (L-DEO) to conduct a seismic survey in the west-central Pacific Ocean east of the Northern Marianas Islands from February to March of 2012 and the NMFS' Office of Protected Resources-Permits and Conservation Division (Permits Division), which proposes to authorize the NSF and L-DEO to "take" marine mammals incidental to the seismic survey. The consulting agency for these proposals is the NMFS' Office of Protected Resources – Endangered Species Act Interagency Cooperation Division.

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(IHA) application, draft IHA, environmental assessment, monitoring reports from similar activities, published and unpublished scientific information on endangered and threatened species and their surrogates, scientific and commercial information such as reports from government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

Consultation history

On October 4, 2011, NMFS' Endangered Species Act Interagency Cooperation Division received a request for formal consultation from the NSF to incidentally harass marine mammal and sea turtle species during a seismic survey cruise east of the Marianas Islands. Information was sufficient to initiate consultation with the NSF on this date. On the same day NMFS' Permits Division received an application from L-DEO to incidentally harass marine mammal and sea turtle species during a seismic survey cruise east of the Marianas Islands.

On December 8, 2011, the Endangered Species Act Interagency Cooperation Division received a request for formal consultation from the Permits Division to authorize incidental harassment of marine mammals during a seismic survey cruise east of the Marianas Islands. Information was sufficient to initiate consultation with the Permits Division on this date.

On December 14, 2011, the Permits Division sent the application out to reviewers and published a notice in the Federal Register soliciting public comment on their intent to issue an IHA.

Description of the proposed actions

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 *et seq*.) requires that each federal agency shall insure 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.

The NSF proposes to fund the L-DEO to conduct a seismic survey in the west-central Pacific Ocean east of the Northern Marianas Islands from roughly 5 February through 21 March 2012. However, it is possible that temporary delays could occur due to weather, equipment malfunctions, or other unforeseen circumstances. The *R/V Marcus G. Langseth* (*Langseth*) would conduct the survey. The *Langseth* would deploy an array of 36 airguns as an energy source and a receiving system consisting of 85 ocean bottom seismometers. In addition, a multibeam echosounder and a sub-bottom profiler would continuously operate from the *Langseth*. The *Langseth* would also deploy a hydrophone streamer. The Permits Division proposes to issue an IHA for "takes" of marine mammals that would occur incidental to these studies, pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. §1371 (a)(5)(D).

The purpose of the proposed activities is to understand the water cycle within subduction-zone systems.

The survey would occur exclusively in the Exclusive Economic Zone (EEZ) of the U.S. All planned geophysical data acquisition activities would be conducted by L-DEO with on-board assistance of the scientists who have proposed the study.

The planned seismic survey would consist of ~2,800 km of survey lines, all in water >2,000 m.

Schedule

The *Langseth* is scheduled to depart Guam on or about 5 February 2012 for the study area and return between March 2-5 (Figure 1). Once there, the *Langseth* would deploy about 85 ocean bottom seismometers. The *Langseth* would recover roughly 60 of the ocean bottom seismometers following the seismic survey, leaving about 25 in place for a period of one year. Seismic surveys should take about 16 days, with an additional 25 days of ocean bottom seismometer deployment, retrieval, and maintenance.

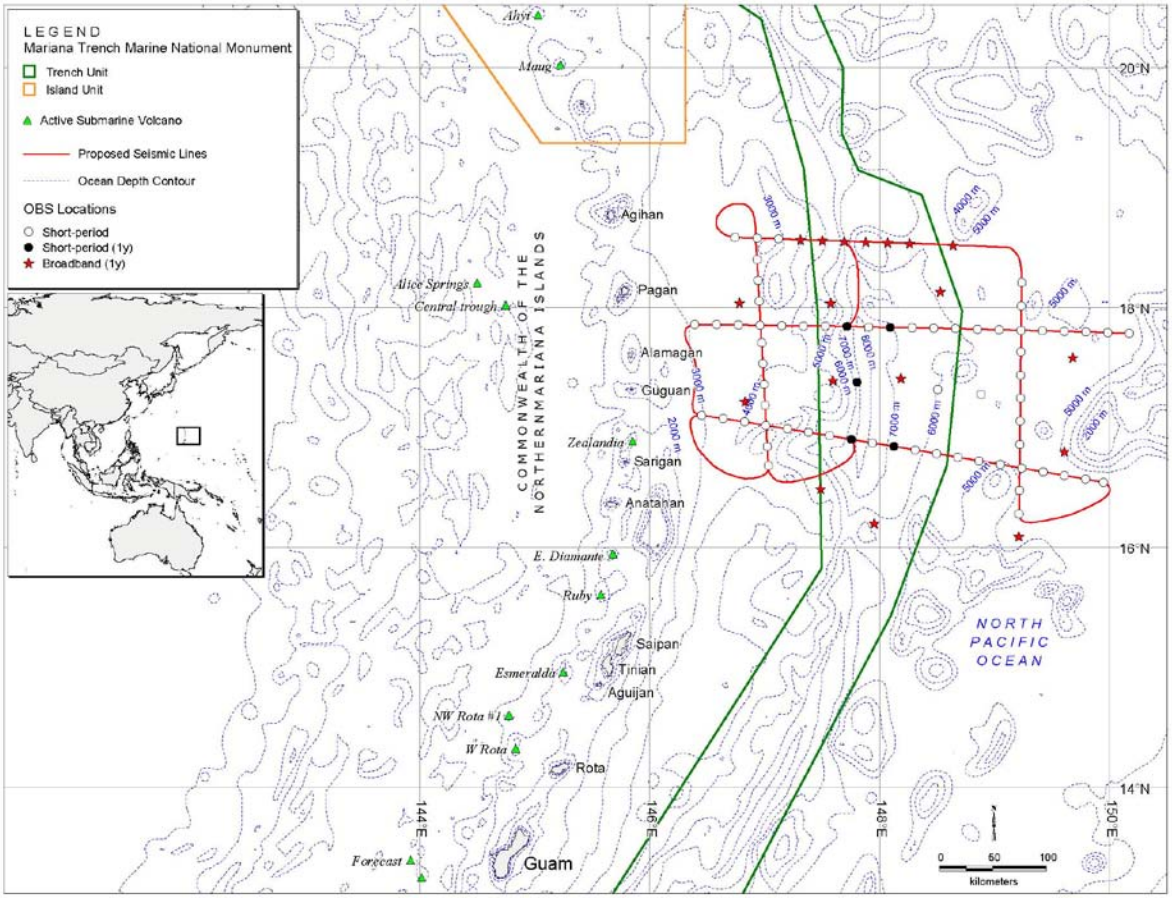


Figure 1. Study area and proposed seismic transect lines in the Commonwealth of the Northern Mariana Islands for the L-DEO survey planned for February-March 2012.

Source vessel specifications

The *Langseth* would tow the 36-airgun array along predetermined lines (Figure 1) and deploy and retrieve the ocean bottom seismometers. The *Langseth's* design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic acquisition is typically 7.4–9.3 km/h. When not towing seismic survey gear, the *Langseth* can cruise at 20–24 km/h. The *Langseth* would also serve as the platform from which marine mammal and sea turtle observers (MMOs) would watch for animals.

Airgun description

The airgun array would consist of 36 airguns, with a total volume of ~6,600 in^3, including Bolt 1500LL and Bolt 1900LLX airguns. The airgun configuration includes four identical linear arrays or "strings" (Figure 2). Each string would have ten airguns. Nine airguns in each string would fire simultaneously, with the tenth kept in reserve as a spare. The four airgun strings would be towed ~140 m behind the vessel. The tow depth of the array would be 9 m. The airgun array would fire about every 37.5 m while conducting multichannel seismic surveys with a hydrophone streamer or 500 m (shots every 15-18 s) or every 150 m while surveying with ocean bottom seismometers (shots every 58-73 s). During firing, a brief (~0.1 s) pulse of sound would be emitted, but be silent during the intervening periods.

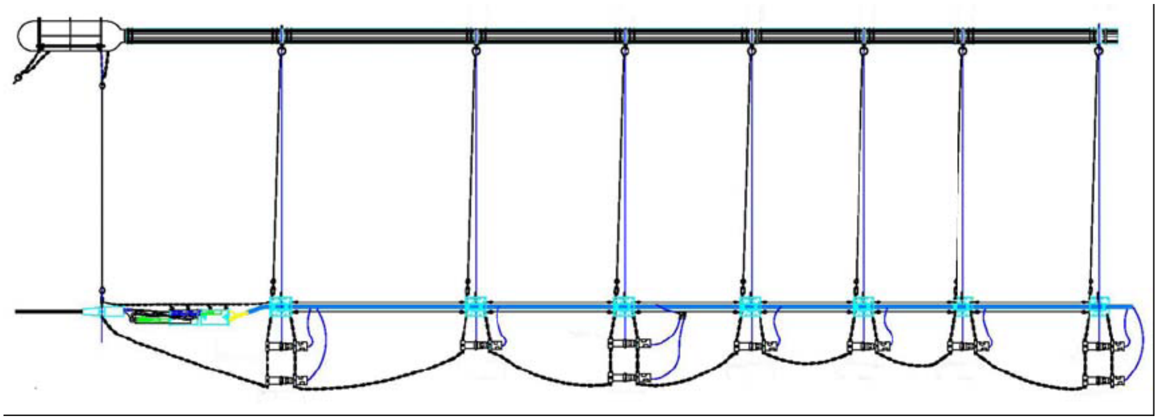


Figure 2. One linear airgun array or string with ten airguns, nine of which would be operating.

<u>36-airgun array specifications</u>

• Energy source	36-1,900 psi bolt airguns of 40–360 in^3 each, in four strings of nine operating airguns per string
• Source output (downward)	0-pk is 84 bar-m (259 dB re 1 μPa·m); pk-pk is 177 bar·m (265 dB)
• Air discharge volume	~6,600 in^3
• Dominant frequency components	2–188 Hz

Because the actual source originates from 36 airguns rather than a single point source, the highest sound levels measurable at any location in the water is less than the nominal source level. In addition, the effective source level for sound propagating in near-horizontal directions (near the ocean surface) would be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of the sound from the airgun array.

Ocean bottom seismometer retrieval

Deployment of three different types of ocean bottom seismometers would occur during the course of the seismic survey. Roughly 60 ocean bottom seismometers deployed on the seafloor would be recovered following the survey. An additional 20 broad-band ocean bottom seismometers would be placed on the seafloor and remain there for a period of one year before retrieval. Five ocean bottom seismometers would be tethered from the bottom over the Marianas Trench at a depth of 5,500-6,000 m and remain in place for one year before being retrieved. Once ocean bottom seismometers separate at retrieval, tethers would fall to the ocean floor.

Once ready for retrieval, an acoustic release transponder would interrogate the ocean bottom seismometer at a frequency of 9–11 kHz, and the *Langseth* would receive a response at a frequency of 9–13 kHz. The burn wire release assembly would then activate, and the instrument would release from the anchor and float to the surface.

Multibeam echosounder and sub-bottom profiler

Along with airgun operations, two additional acoustical data acquisition systems would operate during the survey. The multibeam echosounder and sub-bottom profiler systems would map the ocean floor during the survey. These sound sources would operate from the *Langseth* simultaneously with the airgun array.

The multibeam echosounder is a hull-mounted system operating at 10.5-13 kHz. The beamwidth is 1 or 2° fore–aft and 150° perpendicular to the ship's line of travel. The maximum source level is 242 dB re 1 μPa·m$_{\text{rms}}$. For deepwater operation, each "ping" consists of eight successive fan-shaped transmissions, each 2 to 15 ms in duration and each ensonifying a sector that extends 1° fore–aft. The eight successive transmissions span an overall cross-track angular extent of about 150°, with 2 ms gaps between the pulses for successive sectors (Maritime 2005).

The sub-bottom profiler provides information about the sedimentary features and the bottom topography that is being mapped simultaneously by the multibeam echosounder. The output varies with water depth from 50 watts in shallow water to 1,000 (204 dB) watts in deep water. The pulse interval is 1 s, but a common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

***Langseth* sub-bottom profiler specifications**

Maximum/normal source output (downward)	204 dB re 1 μPa·m; 800 watts
Dominant frequency component	3.5 kHz
Bandwidth	1.0 kHz with pulse duration 4 ms 0.5 kHz with pulse duration 2 ms 0.25 kHz with pulse duration 1 ms
Nominal beam width	30°
Pulse duration	1, 2, or 4 ms

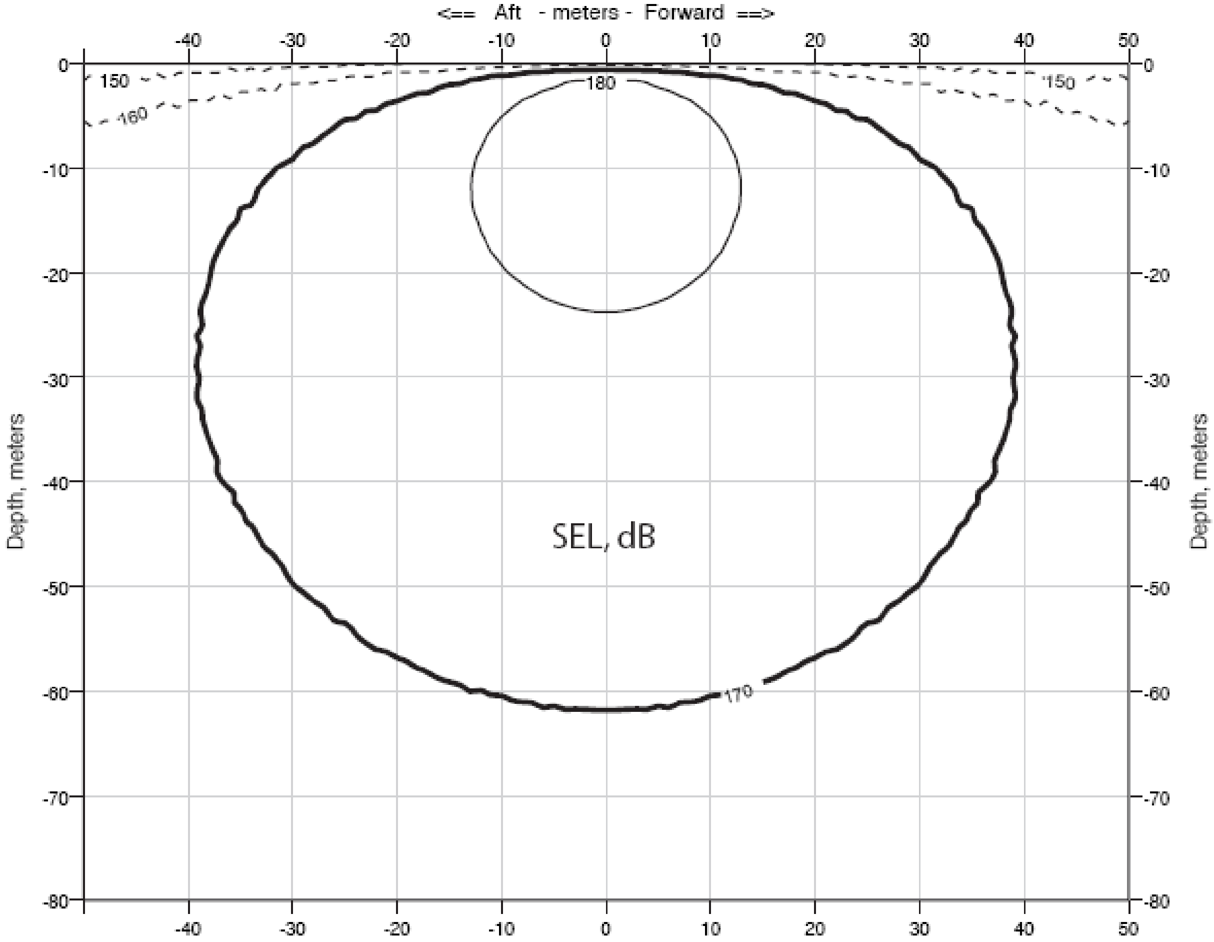
Proposed exclusion zones

Predicted sound levels vs. distance and depth. The L-DEO has predicted received sound levels, in relation to distance and direction from a single 1900LL 40-in^3 airgun used during power-downs (Figure. 3). Empirical data concerning 180and 160 dB re 1 μPa$_{\text{rms}}$ distances were acquired during the acoustic calibration study of the *Langseth*'s 36-airgun 6,600 in^3 array in 2007-2008 (Tolstoy et al. 2009). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the array was different in the Gulf of Mexico calibration study (6 m) than in the proposed survey (9 m). Because propagation varies with array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009). The correction factors used were the ratios of the 160-, 180-, and 190-dB distances from the modeled results for the 6,600-in^3 airgun array towed at 6-m and 9-m depths. The factors are 1.34–1.36 for the 180–190-dB distances, and 1.29 for the 160-dB distance.

Table 1 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the 36-airgun array and a single airgun. The 180 and 190 dB re 1 μPa$_{\text{rms}}$ distances are the safety criteria as specified by NMFS (1995) and are applicable to cetaceans and pinnipeds, respectively.

Table 1. Predicted distances to which sound levels ≥190, 180, and 160 dB re 1 µPa$_{rms}$ could be received in deep water (>1,000 m) from the 36-airgun array, as well as a single airgun.

Source and volume	Tow depth (m)	190 dB	180 dB	160 dB
Single bolt airgun 40 in^3	9	12	40	385
4 strings 36 airguns 6,600 in^3	9	400	940	3850



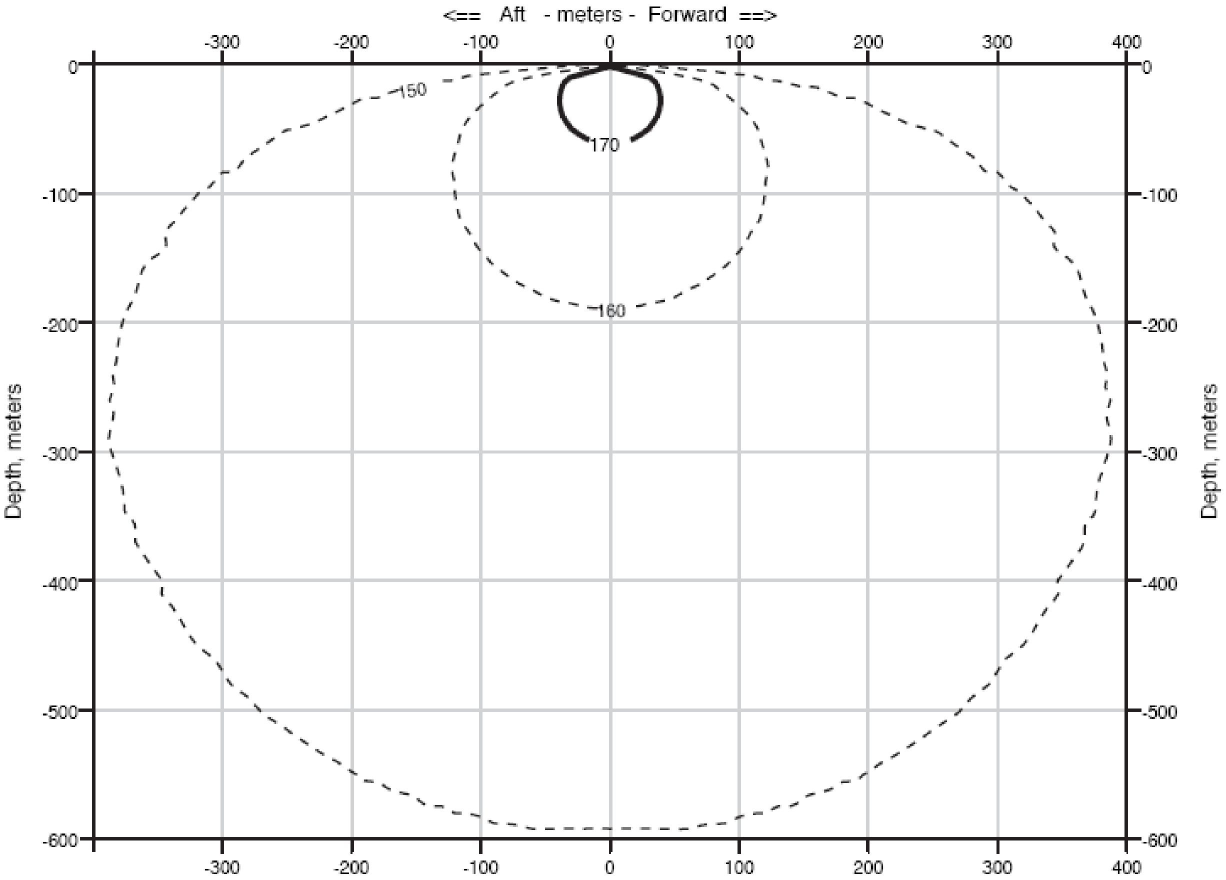


Figure 3. Modeled received sound levels (SELs) from a single 40-in^3 airgun operating in deep water at a 9-m tow depth. Received rms levels (SPLs) are likely ~10 dB higher.

Incidental Harassment Authorization

The NMFS' Permits Division is proposing to issue an IHA authorizing harassment of marine mammals incidental to the planned seismic survey, pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a)(5)(D). The IHA would be valid from February 5, 2012 through May 2, 2010, and would authorize the incidental harassment of the following endangered species (among other species): sei whales (*Balaenoptera borealis*), humpback whales (*Megaptera novaeangliae*), and sperm whales (*Physeter macrocephalus*). The proposed IHA identifies the following requirements that L-DEO must comply with as part of its authorization.

A. Establish a safety radius corresponding to the anticipated 180-dB isopleth for full (6,600 in^3) and single (40 in^3) airgun operations.

B. Use at least one, and when practical two, NMFS-approved, vessel-based MMOs to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations, start-ups of airguns at night, and while the seismic array is being deployed and retrieved. Vessel crew will also assist in detecting marine mammals, when practical. Observers will have access to reticle binoculars (7 X 50 Fujinon), big-eye binoculars (25 X 150), and night vision devices. MMOs shifts will last no longer than 4 hours at a time. MMOs will also observe during daytime periods when the seismic system is not operating for comparisons of animal abundance and behavior, when feasible.

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.
>
> ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), sea state, visibility, cloud cover, and sun glare.
>
> iii. The data listed under ii. would 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. Visually observe the entire extent of the safety radius using MMOs, for at least 30 min prior to starting the airgun (day or night). If the MMO finds a marine mammal within the safety zone, L-DEO must delay the seismic survey until the marine mammal has left the area. If the MMO sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the MMO sees no marine mammals during that time, they should assume that the animal has moved beyond the safety zone. If for any reason the entire radius cannot be seen for the entire 30 min (i.e. rough seas, fog, darkness), or if marine mammals are near, approaching, or in the safety radius, the airguns may not be started up. If one airgun is already running at a source level of at least 180 dB, L-DEO may start subsequent guns without observing the entire safety radius for 30 min prior, provided no marine mammals are known to be near the safety radius.

E. Use the passive acoustic monitoring system (PAM) to detect marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One MMO and/or bioacoustician will monitor the PAM at all times in shifts of 1-6 h. 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.

F. Do and record the following information when an animal is detected by the PAM:

> i. contact the MMO immediately (and initiate power or shut-down, 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, types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

G. Apply 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 will increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the

MMOs will monitor the safety radius, and if marine mammals are sighted, a course/speed alteration, power-down, or shut-down will occur as though the full array were operational.

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

I. Shut-down or power-down the airguns upon marine mammal detection within, approaching, or entering the safety radius. A power-down means shutting down one or more airguns and reducing the safety radius to the degree that the animal is outside of it. Following a power-down, if the marine mammal approaches the smaller designated safety radius, the airguns must completely shut down. Airgun activity will not resume until the marine mammal has cleared the safety radius, which means it was visually observed to have left the safety radius, or has not been seen within the radius for 15 min (small odontocetes) or 30 min (mysticetes and large odontocetes). If a North Pacific right whale is sighted, airguns will be shutdown immediately.

J. Emergency shutdown. In the unanticipated event that any taking of a marine mammal in a manner prohibited by the proposed Authorization occurs, such as an injury, serious injury or mortality, and is judged to result from these activities, L-DEO will immediately cease operating all authorized sound sources and report the incident to the Chief of the Permits, Conservation, and Education Division, Office of Protected Resources, NMFS, at 301-713-2289. L-DEO will postpone the research activities until NMFS is able to review the circumstances of the take. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate and necessary, and notify L-DEO that they may resume the seismic survey operations.

K. If concentrations of sei or sperm whales are observed (by visual observers or passive acoustic detection) at a continental slope site just prior to or during the airgun operations, those operations will be moved to another location along the slope based on recommendations by the on-duty MMO aboard the *Langseth*. If a North Pacific right (*Eubalaena japonica*) is visually sighted, the airgun array shall be shut-down regardless of the distance of the animal(s) to the sound source.

L. In the unanticipated event that any cases of marine mammal injury or mortality are judged to result from these activities, L-DEO will cease operating seismic airguns and report the incident to the Office of Protected Resources, NMFS, immediately. Airgun operation will then be postponed until NMFS is able to review the circumstances and work with L-DEO to determine whether modifications in the activities are appropriate and necessary.

M. Conduct seismic operations during daylight hours where possible.

N. L-DEO is required to comply with the Terms and Conditions of the Opinion’s Incidental Take Statement issued to both the NSF and the NMFS’ Office of Protected Resources.

In addition, the proposed IHA requires L-DEO to adhere to the following reporting requirements:

A. The Holder of this Authorization is required to submit a report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days after the expiration of the IHA. This report must contain and summarize the following information:

i. Dates, times, locations, heading, speed, weather, and associated activities during all seismic operations;

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 shutdowns), 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 (visual observation) at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 180 dB re 1 microPa (rms) with a discussion of any specific behaviors those individuals exhibited and

  b. may have been exposed (modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 180 dB re 1 microPa (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 Opinion's Incidental Take Statement, and

  b. mitigation measures of the IHA. For the Opinion, the report will confirm the implementation of each term and condition and describe the effectiveness, as well as any conservation measures, for minimizing the adverse effects of the action on listed whales.

Approach to the assessment

The NMFS approaches its Section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and 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 are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our *risk analyses*). 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. The continued existence of these "species" depends on the fate of the populations that comprise them. 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, the populations that comprise that species, 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 individual 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 individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during 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., Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

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.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of listed resources* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the evidence available to us. This evidence consists of monitoring reports submitted by past and present permit holders, reports from NMFS Science Centers; reports prepared by natural resource agencies in States and other countries, reports from non-governmental organizations involved in marine conservation issues, the information provided by the Permits 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 state agencies like the Minerals Management Service, U.S. Coast Guard, and U.S. Navy whose operations extend into the marine environment.

During the consultation, we conducted electronic searches of the general scientific literature using search engines, including Agricola, Ingenta Connect, Aquatic Sciences and Fisheries Abstracts, JSTOR, Conference Papers Index, First Search (Article First, ECO, WorldCat), Web of Science, Oceanic Abstracts, Google Scholar, and Science Direct.

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 will exhibit a particular response to acoustic exposure or close vessel approach) as well as data that do not support that conclusion. When data were equivocal or when faced with substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

In this particular assessment, we identified the stressors associated with the action and evaluated which had a significant possibility of occurring based upon previous seismic surveys. Of the probable stressors, we identified the species that were expected to co-occur with the effects of the action, particularly the acoustic isopleths of the airgun and other sound sources. Utilizing survey data from previous years, density estimates per unit area of listed whales were multiplied by the area to be ensonified where effects were expected.

In the process of this assessment, we were required to make several assumptions where data were insufficient to support conclusions regarding the specific species and actions at hand. These included:

- Baleen whales can generally hear low-frequency sound better than high frequencies, as the former is the primarily the range in which they vocalize. However, humpback whales frequently vocalize with mid-frequency sound and are likely to hear at these frequencies as well. Because of this, we can partition baleen whales into two groups: those that are specialists at hearing low frequencies (ex: sei whales) and those that hear at low- to mid-frequencies (ex.: humpback whales). Toothed whales (such as sperm whales) are better adapted to hear mid- and high-frequency sound for the same reason (although this species also responds to low-frequency sound and is considered to hear at low-, mid-, and high frequencies). Sperm whales are also assumed to have similar hearing qualities as other, better studied, toothed whales.

- Species for which little or no information on response to sound will respond similarly to their close taxonomic or ecological relatives (i.e., baleen whales respond similarly to each other).

Action area

The proposed seismic survey should occur east of the Northern Marianas Islands between 5 February and 21 March 2012 (Figure 1 on page 3). The survey would encompass deep water in an area from 16.5–19°N and 146.5–150°E in the west-central Pacific Ocean. However, responses to seismic sound sources by listed species occur within the 160 dB isopleths (modeled to be 3.85 km from the *Langseth*). This expands the action area beyond the seismic survey track lines (2,800 km) to an ensonified region of 15,685 km^2, or 19,607 km^2 to account for repeated exposure of the same area.

Status of listed resources

The NMFS has determined that the actions considered in this Opinion may affect species listed in Table 2, which are provided protection under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.).

Table 2. Listed cetaceans and sea turtles potentially occurring in the action area.

Common name	**Scientific name**	**Status**
Cetaceans		
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
North Pacific right whale	*Eubalaena japonica*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Marine turtles		
Green sea turtle	*Chelonia mydas*	Endangered/ Threatened
Hawksbill sea turtle	*Eretmochelys imbricate*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle-North Pacific DPS	*Caretta caretta*	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered/ Threatened

Species not considered further in this Opinion

North Pacific right whales have not been sighted in the action area despite some survey effort. Japanese surveys well to the north support infrequent occurrence as low as 37˚ N, but general occurrence is north of this (Fujise et al. 2003; Matsuoka et al. 2009; Tamura et al. 2005; Tamura et al. 2007; Tamura et al. 2006; Zenitani et al. 1999). North Pacific right whales have also not been observed in marine mammal surveys from other parts of the North Pacific (offshore Hawaii and eastern tropical Pacific) during similar seasonal periods (Barlow 2006; Ferguson and Barlow

2001). It is therefore highly unlikely that an individual will be in the action area. Even if one were, the individual is further unlikely to be in proximity to seismic operations, as the action area consists of a small fraction of a large marine area; the probability of encountering a single individual is remote. Finally, a shut-down will occur if a North Pacific right whale is sighted. Therefore, the possibility of North Pacific right whale exposure is discountable. For these reasons, we conclude that the proposed activities may affect, but are not likely to adversely affect North Pacific right whales, and this species will not be considered in greater detail in the remainder of this Opinion.

No data exist to support fin whale occurrence in the action area, either, although some effort has been conducted during a period when they would likely be present, if at all (SRS-Parsons et al. 2007). Fin whales occur well to the north (Fujise et al. 2003; Matsuoka et al. 2009; Tamura et al. 2005; Tamura et al. 2007; Tamura et al. 2006; Zenitani et al. 1999). Even within the region between 35- 45˚ N (well to the north of the action area), there is a clear increase in sightings with increasing latitude after the proposed action time frame (Fujise et al. 2003; Matsuoka et al. 2009; Tamura et al. 2005; Tamura et al. 2007; Tamura et al. 2006; Zenitani et al. 1999). This is what one would predict based upon fin whale life history, which generally involves a higher-latitude distribution in the Pacific Ocean (Clark 1995; Gambell 1985a; Mizroch et al. 1999). No fin whales were detected visually or acoustically during a 2007 survey throughout the Northern Marianas Islands region. A single acoustic detection was made 900 miles to the east of the action area during a recent NOAA high seas survey, but none were detected in the area around the Northern Marianas Islands; several other acoustic detections were made to the north and far east of the action area during this cruise (DoN 2011). We do not expect fin whale occurrence in the action area during the timeframe of the proposed seismic survey. As with North Pacific right whales, fin whales have also not been observed in marine mammal surveys from other parts of the North Pacific (offshore Hawaii and eastern tropical Pacific) during similar seasonal periods (Barlow 2006; Ferguson and Barlow 2001). Therefore, is unlikely that an individual fin whale will be in the action area and the possibility is discountable. For these reasons, we conclude that the proposed activities may affect, but are not likely to adversely affect fin whales and are not considered further in this Opinion.

No data exist to support blue whales occurring in or near the action area during the proposed survey. The presence of blue whales in the Soloman Islands (south of the Equator) is more likely from southern hemisphere populations, individuals from which are not expected to occur in or near the action area (Reeves et al. 1999a). These data also stem from surveys now over 50 years old and subsequent surveys have not found blue whales in nearly the same numbers, possibly due to late-season surveys or further exploitation of populations from whaling. Blue whale presence is expected well to the north (>15˚ to the north)(Fujise et al. 2003; Matsuoka et al. 2009; Tamura et al. 2005; Tamura et al. 2007; Tamura et al. 2006; Zenitani et al. 1999). Blue whales have also not been observed in marine mammal surveys from other lower-latitude parts of the North Pacific (offshore Hawaii and eastern tropical Pacific) during similar seasonal periods (Barlow 2006; Ferguson and Barlow 2001). Based upon available information, blue whales should not occur in the action area and the possibility of exposure is discountable and are not considered further in this Opinion.

Olive ridley sea turtles occur in the Northern Marianas only rarely and loggerheads not at all (Eckert 1993b; Eldredge 2003; Michael 2004; NMFS and USFWS 1998b; Pritchard 1977; Pritchard 1995; Wiles et al. 1995). None of these species nest in the vicinity. Several surveys in waters surrounding the Marianas Islands have failed to detect any individual of these sea turtle species (Grimm and Farley 2008; Kolinski 2001; Kolinski et al. 1999; Pultz et al. 1999; Randall et al. 1975; SRS-Parsons et al. 2007; Stojkovich 1977; Vogt 2009). We considered that these species are known to be wide-ranging and it is possible that currents can push individuals out of their normal range into local waters (Pickard and Emery 1982; Polovina et al. 2000) and that these species tend to travel or forage in deep oceanic waters (Eckert 1993b; Kolinski 2001). However, given the lack of sightings, strandings, bycatch, or other detections, the probability of individual occurrence is low and leads us to discount the possibility of loggerheads or olive ridleys being exposed to actions associated with the proposed seismic survey. For these reasons, we conclude that the proposed activities may affect, but are not likely to adversely affect loggerhead and olive ridley sea turtles, and these species will not be considered in greater detail in the remainder of this Opinion.

Green and hawksbill sea turtles are regular inhabitants of nearshore waters of the Marianas Islands (Davis ; DON 2004; DON 2005b; Gutierrez 2004; Kolinski 2001; Kolinski et al. 2004; Michael 2004; NMFS 1998; Randall et al. 1975; Wiles et al. 1989; Wiles et al. 1995; Wiles et al. 1990). Green sea turtle nesting also occurs in some Marianas locations, but hawksbill nesting is rare (Davis ; DON 2005a; Franko's Maps 2005; Gutierrez 2004; Kolinski et al. 1999; NMFS 1998; NMFS and USFWS 1998a; Pritchard 1995; Pultz et al. 1999; Wiles et al. 1995). Both species forage in shallow, nearshore waters well outside the action area (Abraham et al. 2004; DON 2003b; Franko's Maps 2005; Wiles et al. 1995). This is consistent with life history trends found in other areas; both species feed in mangrove, seagrass, or coral reef habitats as juveniles and adults (Bjorndal and Bolten 2000; Bjorndal and Bolten 2010; Boyle and Limpus 2008; Cardona et al. 2009; Godley et al. 1998; Hatase et al. 2006; Hazel 2009; Heithaus et al. 2002; Musick and Limpus 1997; Parker and Balazs in press; Seminoff et al. 2002). Younger age classes (hatchlings to juveniles) do undergo an oceanic stage, but do so by associating with weedlines, *Sargassum* concentrations, or flotsam where they can be sheltered (Hornell 1927; Mellgren and Mann 1996; Mellgren et al. 1994; Musick and Limpus 1997; NMFS and USFWS 1998a). These features, frequently associated with frontal or current boundaries or gyre systems, are not a characteristic of the action area (Irene Kelly-NOAA, personal communication 2010). A recent survey through offshore regions failed to find either species, although nearshore surveys routinely identify green and hawksbill sea turtles (SRS-Parsons et al. 2007). We considered that both species are wide-ranging (Musick and Limpus 1997; Plotkin 2003), but ultimately the action area is not habitat in which one would expect green or hawksbill sea turtles to occur. Therefore, we find that the probability of green or hawksbill sea turtle exposure to actions associated with the proposed seismic survey is discountable and they are not considered further in this Opinion.

Critical habitat has not been established in the region of the proposed action area. We conclude that critical habitat will not be impacted by the proposed actions.

The biology and ecology of species with anticipated exposure below informs the effects analysis for this Opinion. Summaries of the global status and trends of each species presented provide a foundation for the analysis of species as a whole.

Sei whale

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

Population designations. The population structure of sei whales is unknown and populations herein assume (based upon migratory patterns) population structuring is discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

North Atlantic. In the western North Atlantic, a major portion of the sei whale population occurs in northern waters, potentially including the Scotian Shelf, along Labrador and Nova Scotia, south into the U.S. EEZ, including the Gulf of Maine and Georges Bank (Mitchell and Chapman 1977; Waring et al. 2004). These whales summer in northern areas before migrating south to waters along Florida, the Gulf of Mexico, and the northern Caribbean Sea (Gambell 1985b; Mead 1977). Sei whales may range as far south as North Carolina. In the U.S. EEZ, the greatest abundance occurs during spring, with most sightings on the eastern edge of Georges Bank, in the Northeast Channel, and along the southwestern edge of Georges Bank in Hydrographer Canyon (CETAP 1982). In 1999, 2000, and 2001, NMFS aerial surveys found sei whales concentrated along the northern edge of Georges Bank during spring (Waring et al. 2004). Surveys in 2001 found sei whales south of Nantucket along the continental shelf edge (Waring et al. 2004). During years of greater prey (e.g., copepods) abundance, sei whales are found in more inshore waters, such as the Great South Channel (in 1987 and 1989), Stellwagen Bank (in 1986), and the Gulf of Maine (Payne et al. 1990a; Schilling et al. 1992). In the eastern Atlantic, sei whales occur in the Norwegian Sea, occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b; Jonsgård and Darling 1977; Olsen et al. 2009).

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

Southern Hemisphere. Sei whales occur throughout the Southern Ocean during the austral summer, generally between 40°-50° S (Gambell 1985b). During the austral winter, sei whales occur off Brazil and the western and eastern coasts of southern Africa and Australia, although all of the 20 sightings off Argentina occurred in August or September (Iniguez et al. 2010). However, sei whales generally do not occur north of 30º S in the Southern Hemisphere (Reeves et al. 1999b). However, confirmed sighting records exist for Papua New Guinea and New Caledonia, with unconfirmed sightings in the Cook Islands (Programme) 2007).

In the Southern Hemisphere, the IWC has divided the Southern Ocean into six baleen whale feeding areas – designated at 60° S latitude and longitude as: 60°-120° W (Area I), 0°-60° W (Area II), 0° to 70° E (Area III), 70°-130° E (Area IV), 130°-170° W (Area V), and 170°-120°W (Area VI).

There is little information on the population structure of sei whales in the Antarctic, although some degree of isolation appears to exist between IWC Areas I-VI; sei whale movements are dynamic and individuals move between stock designation areas (Donovan 1991; IWC 1980a).

In the North Pacific, sei whales appear to prefer feeding along the cold eastern currents (Perry et al. 1999).

Reproduction. Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months, calves are weaned at 6-9 months, and the calving interval is about 2-3 years (Gambell 1985b; Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977).

Feeding. Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2006). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Konishi et al. 2009; Mizroch et al. 1984; Rice 1977). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95% of their diets (Calkins 1986). The dominant food for sei whales off California during June-August is northern anchovy, while in September-October whales feed primarily on krill (Rice 1977). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollack, capelin, and Atka mackerel (Nemoto and Kawamura 1977). In the Southern Ocean, analysis of stomach contents indicates sei whales consume *Calanus* spp. and small-sized euphasiids with prey composition showing latitudinal trends (Kawamura 1974). Sei whales in the Southern Hemisphere may reduce direct interspecific competition with blue and fin whales by consuming a wider variety of prey and by arriving later to feeding grounds (Kirkwood 1992). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries. In the North Pacific, sei whales appear to prefer feeding along the cold eastern currents (Perry et al. 1999). Sei whales have the flexibility to skim or engulf prey (Brodie and Vikingsson 2009).

Vocalization and hearing. Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 s duration and tonal and upsweep calls in the 200-600 Hz range of 1-3 s durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 msec) FM sweeps between 1.5-3.5 kHz (Thomson and Richardson 1995).

Status and trends. The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. Table 3 provides estimates of historic and current abundance for ocean regions.

Table 3. Summary of past and present sei whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	>105,000	--	25,000	--	(Braham 1991)
North Atlantic	Basinwide	--	--	>4000	--	(Braham 1991)
	NMFS - Nova Scotia stock	--	--	207	--	(NMFS 2008)
	IWC - Iceland-Denmark stock	--	--	1,290	0-2,815*	(Cattanach et al. 1993)
	IWC - Iceland-Denmark stock	--	--	1,590	343-2,837*	(Cattanach et al. 1993)
North Pacific	Basinwide	42,000	--	7,260-12,620*	--	(Tillman 1977); *circa 1974
	NMFS - eastern North Pacific stock	--	--	46	CV=0.61	(Carretta et al. 2008)
	NMFS - Hawaii stock	--	--	77	0-237*	(Carretta et al. 2008)
Southern Hemisphere	Basinwide	63,100	--	--	--	(Mizroch et al. 1984)
	Basinwide	65,000	--	--	--	(Braham 1991)
	South of 60°S	--	--	626	553-699	(IWC 1996)
	South of 30°S	--	--	9,718	--	(IWC 1996)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. No information on sei whale abundance exists prior to commercial whaling (Perry et al. 1999). Between 1966 and 1972, whalers from land stations on the east coast of Nova Scotia engaged in extensive hunts of sei whales on the Nova Scotia shelf, killing about 825 sei whales (Mitchell and Chapman 1977). In 1974, the North Atlantic stock was estimated to number about 2,078 individuals, including 965 whales in the Labrador Sea group and 870 whales in the Nova Scotia group (Mitchell and Chapman 1977). In the northwest Atlantic, Mitchell and Chapman (1977) estimated the Nova Scotia stock to contain between 1,393-2,248 whales; an aerial survey program conducted from 1978-1982 on the continental shelf and edge between Cape Hatteras, North Carolina, and Nova Scotia generated an estimate of 280 sei whales (CETAP 1982). These two estimates are more than 20 years out of date and likely do not reflect the current abundance; the Cetacean and Turtle Assessment Program estimate has a high degree of uncertainty and is considered statistically unreliable (Perry et al. 1999; Waring et al. 2004; Waring et al. 1999). The total number of sei whales in the U.S. Atlantic EEZ remains unknown (Waring et al. 2006). Rice (1977) estimated total annual mortality for adult females as 0.088 and adult males as 0.103.

North Pacific. Ohsumi and Fukuda (1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973. From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987; Perry et al. 1999). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales, killing 300-600 sei whales per year from 1911-1955. The sei whale catch peaked in 1959, when 1,340 sei whales died. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). There have been no direct estimates of sei whale populations for the eastern Pacific Ocean (or the entire Pacific).

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

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

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast during 1975-1996, two showed evidence of collisions (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada’s Maritime Provinces (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in death. New rules for seasonal (June through December) slowing of vessel traffic in the Bay of Fundy to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to reduce sei whale ship strike mortality by 17%.

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

Critical habitat. The NMFS has not designated critical habitat for sei whales.

Humpback whale

Description of the species. Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed) (Gendron and Urban 1993). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985).

Population designations. Populations have been relatively well defined for humpback whales

North Atlantic. Humpback whales range from the mid-Atlantic bight and the Gulf of Maine across the southern coast of Greenland and Iceland to Norway in the Barents Sea. Whales migrate to the western coast of Africa and the Caribbean Sea during the winter. Humpback whales aggregate in four summer feeding areas: Gulf of Maine and eastern Canada, west Greenland, Iceland, and Norway (Boye et al. 2010; Katona and Beard 1990; Smith et al. 1999).

Increasing range and occurrence in the Mediterranean Sea coincides with population growth and may represent reclaimed habitat from pre-commercial whaling (Frantzis et al. 2004; Genov et al. 2009). The principal breeding range for Atlantic humpback whales lies from the Antilles and northern Venezuela to Cuba (Balcomb III and Nichols 1982; Whitehead and Moore 1982; Winn et al. 1975). The largest breeding aggregations occur off the Greater Antilles where humpback whales from all North Atlantic feeding areas have been photo-identified (Clapham et al. 1993; Katona and Beard 1990; Mattila et al. 1994; Palsbøll et al. 1997; Smith et al. 1999; Stevick et al. 2003b). However, the possibility of historic and present breeding further north remains enigmatic but plausible (Smith and G.Pike 2009). Winter aggregations also occur at the Cape Verde Islands in the eastern North Atlantic and along Angola (Reeves et al. 2002; Reiner et al. 1996; Weir 2007). Accessory and historical aggregations also occur in the eastern Caribbean (Levenson and Leapley 1978; Mitchell and Reeves 1983; Reeves et al. 2001a; Reeves et al. 2001b; Schwartz 2003; Smith and Reeves 2003; Swartz et al. 2003; Winn et al. 1975). To further highlight the "open" structure of humpback whales, a humpback whale migrated from the Indian Ocean to the South Atlantic Ocean, demonstrating that interoceanic movements can occur (Pomilla and Rosenbaum 2005). Genetic exchange at low-latitude breeding groups between Northern and Southern Hemisphere individuals and wider-range movements by males has been suggested to explain observed global gene flow (Rizzo and Schulte 2009). However, there is little genetic support for wide-scale interchange of individuals between ocean basins or across the equator.

North Pacific. Based on genetic and photo-identification studies, the NMFS currently recognizes four stocks, likely corresponding to populations, of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific (Hill and DeMaster 1998). Gene flow between them may exist. Humpback whales summer in coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during winter. However, more northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in the waters around Hawaii while the eastern North Pacific population (also called the California-Oregon-Washington-Mexico stock) winters along Central America and Mexico. However, Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure. Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawaii and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawaii may have emigrated from

Mexican wintering areas. A "population" of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in the Mariana Islands, Guam, Rota, and Saipan from January-March (Darling and Mori 1993; Eldredge 1991; Eldredge 2003; Rice 1998). During summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2007; Calambokidis 1997; Calambokidis et al. 2001).

Southern Hemisphere. Eight proposed stocks, or populations, of humpback whales occur in waters off Antarctica (Figure 4). Individuals from these stocks winter and breed in separate areas and are known to return to the same areas. However, the degree (if any) of gene flow (i.e., adult individuals wintering in different breeding locations) is uncertain. Based upon recent satellite telemetry, a revision of stocks A and G may be warranted to reflect stock movements within and between feeding areas separated east of 50º W (Dalla Rosa et al. 2008). A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India and movements of this group are poorly known (Mikhalev 1997; Rasmussen et al. 2007). Areas of the Mozambique Channel appear to be significant calving and wintering areas for humpback whales (Kiszka et al. 2010). In addition to being a breeding area, the west coast of South Africa also appears to serve as a foraging ground due to upwelling of the Benguela Current (Barendse et al. 2010). Females appear in this area in large numbers well before their male counterparts, frequently accompanied by calves (Barendse et al. 2010).

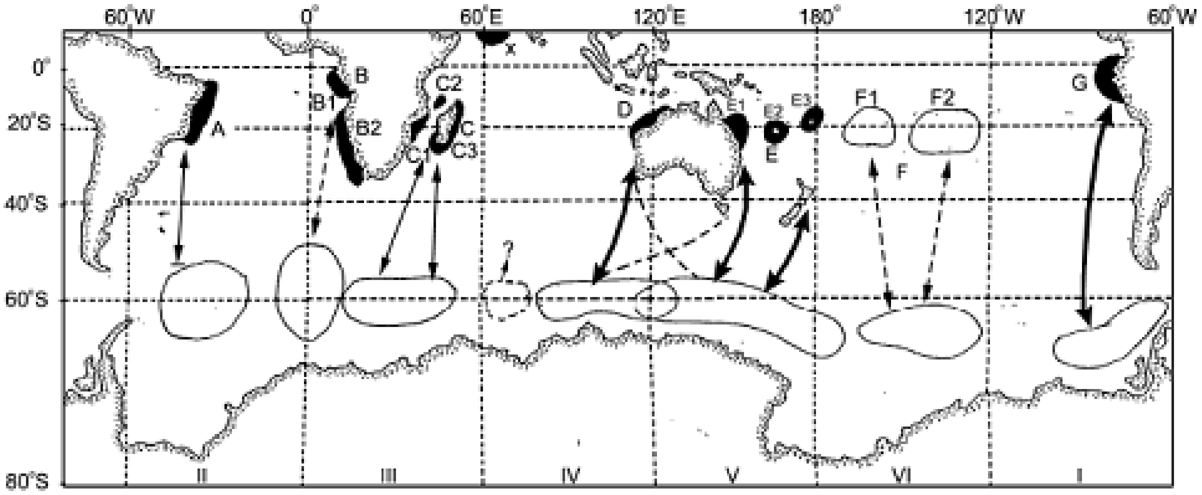


Figure 4. Southern Hemisphere humpback stocks (populations) (IWC 2005).

Reproduction. Humpback whale calving and breeding generally occurs during winter at lower latitudes. Gestation takes about 11 months, followed by a nursing period of up to 1 year (Baraff and Weinrich 1993). Sexual maturity is reached at between 5-7 years of age in the western North Atlantic, but may take as long as 11 years in the North Pacific, and perhaps over 11 years (e.g., southeast Alaska, Gabriele et al. 2007). Females usually breed every 2-3 years, although consecutive calving is not unheard of (Clapham and Mayo 1987; 1990; Glockner-Ferrari and Ferrari 1985 as cited in NMFS 2005b; Weinrich et al. 1993). Larger females tend to produce larger calves that may have a greater chance of survival (Pack et al. 2009). In some Atlantic areas, females tend to prefer shallow nearshore waters for calving and rearing, even when these areas are extensively trafficked by humans (Picanco et al. 2009).

In calving areas, males sing long complex songs directed towards females, other males, or both. The breeding season can best be described as a floating lek or male dominance polygamy (Clapham 1996). Calving occurs in the shallow coastal waters of continental shelves and oceanic islands worldwide (Perry et al. 1999). Males "court" females in escort groups and compete for proximity and presumably access to reproduce females (particularly larger females) (Pack et al. 2009). Although long-term relationships do not appear to exist between males and females, mature females do pair with other females; those individuals with the longest standing relationships also have the highest reproductive output, possibly as a result of improved feeding cooperation (Ramp et al. 2010).

Diving. In Hawaiian waters, humpback whales remain almost exclusively within the 1,800 m isobath and usually within water depths of less than 182 m. Maximum diving depths are approximately 170 m (but usually <60 m), with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1-5.1 min in the North Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). In the Gulf of California, humpback whale dive durations averaged 3.5 min (Strong 1990). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

Feeding. During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992). The principal fish prey in the western North Atlantic are sand lance, herring, and capelin (Kenney et al. 1985). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best. 1995). Additional evidence, such as songs sung in northern latitudes during winter, provide additional support to plastic seasonal distribution (Smith and G.Pike 2009). Relatively high rates of resighting in foraging sites in Greenland suggest whales return to the same areas year after year (Kragh Boye et al. 2010).

Vocalization and hearing. Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (Au 2000; Au et al. 2006; Frazer and Mercado 2000; Payne 1970; Richardson et al. 1995c; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack and Whitehead 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995c; Tyack and Whitehead 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m; (Au 2000; Erbe 2002; Payne and Payne 1985; Richardson et al. 1995c; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

Status and trends. Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA. (Winn and Reichley 1985) argued that the global humpback whale population consisted of at least 150,000 whales in the early 1900s, mostly in the Southern Ocean. In 1987, the global population of humpback whales was estimated at about 10,000 (NMFS 1987). Although this estimate is outdated, it appears that humpback whale numbers are increasing. Table 4 provides estimates of historic and current abundance for ocean regions.

Table 4. Summary of past and present humpback whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	1,000,000	--	--	--	(Roman and Palumbi 2003)
North Atlantic	Basinwide	240,000	156,000-401,000*	11,570	10,005-13,135*	(Roman and Palumbi 2003) (Stevick et al. 2001) *in* (Waring et al. 2004)
	Basinwide - Females	--	--	2,804	1,776-4,463	(Palsbøll et al. 1997)
	Basinwide - Males	--	--	4,894	3,374-7,123	(Palsbøll et al. 1997)
	Western North Atlantic from Davis Strait, Iceland to the West Indies	>4,685*	--	--	--	*circa 1865; (Mitchell and Reeves 1983)
	NMFS - Gulf of Maine stock	--	--	845	CV=0.55	(NMFS 2008)
	NMFS - Gulf of Maine stock, including a portion of Scotian Shelf	--	--	902	177-1,627*	(Clapham et al. 2003)
	Northeast Atlantic - Barents and Norwegian Seas	--	--	889	331-1,447*	(Øien 2001) *in* (Waring et al. 2004)
North Pacific	Basinwide	15,000	--	6,000-8,000	--	(Calambokidis et al. 1997)
	NMFS - Western North Pacific stock	--	--	394	329-459*	(Angliss and Allen 2007)
	NMFS - Central North Pacific stock	--	--	4,005	3,259-4,751*	(Angliss and Allen 2007)
	NMFS - Eastern North Pacific stock	--	--	1,391	1,331-1,451*	(Carretta et al. 2008)
Indian Ocean	Arabian Sea	--	--	56	35-255	Minton et al. (Minton et al. 2003) *in* (Bannister 2005)
Southern Hemisphere	Basinwide	100,000	--	19,851	--	(Gambell 1976; IWC 1996)
	South of 60°S	--	--	4,660	2,897-6,423	(IWC 1996)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. The best available estimate of North Atlantic abundance comes from 1992-1993 mark-recapture data, which generated an estimate of 11,570 humpback whales (Stevick et al. 2003a). Historical estimates have ranged from 40,000-250,000 (Smith and G.Pike 2009). Estimates of animals on Caribbean breeding grounds exceed 2,000 individuals (Balcomb III and Nichols 1982). Several researchers report an increasing trend in abundance for the North

Atlantic population, which is supported by increased sightings within the Gulf of Maine feeding aggregation (Barlow 1997; Katona and Beard 1990; Smith et al. 1999; Waring et al. 2001). The rate of increase varies from 3.2-9.4%, with rates of increase slowing over the past two decades (Barlow 1997; Katona and Beard 1990; Stevick et al. 2003a). If the North Atlantic population has grown according to the estimated instantaneous rate of increase ($r = 0.0311$), this would lead to an estimated 18,400 individual whales in 2008 (Stevick et al. 2003a). Pike et al. (2009) suggested that the eastern and northeastern waters off Iceland are areas of significant humpback utilization for feeding, estimating nearly 5,000 whales in 2001 and proposing an annual growth rate of 12% for the area. The authors suggest that humpback whales in the area had probably recovered from whaling.

North Pacific. The pre-exploitation population size may have been as many as 15,000 humpback whales, and current estimates are 6,000-8,000 whales (Calambokidis et al. 1997; Rice 1978a). It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978a). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999). Estimates have risen over time from 1,407-2,100 in the 1980s to 6,010 in 1997 (Baker 1985; Baker and Herman 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). Because estimates vary by methodology, they are not directly comparable and it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,010 is the result of a real increase or an artifact of model assumptions. Tentative estimates of the eastern North Pacific stock suggest an increase of 6-7% annually, but fluctuations have included negative growth in the recent past (Angliss and Outlaw 2005). However, based upon surveys between 2004 and 2006, Calambokidis et al. (2008) estimated that the number of humpback whales in the North Pacific consisted of about 18,300 whales, not counting calves (Barlow et al. (2009) provided a bias-corrected estimate of 20,800 individuals) and the population was growing at 4.9% annually. Almost half of these whales likely occur in wintering areas around the Hawaiian Islands.

Southern Hemisphere. The IWC recently compiled population data on humpback whales in the Southern Hemisphere. Approximately 42,000 Southern Hemisphere humpbacks can be found south of 60° S during the austral summer feeding season (IWC 2007). However, humpback whales in this region experienced severe whaling pressure. Based upon whaling logs, particularly by Soviet vessels, at least 75,542 humpback whales were harvested from Antarctic waters from 1946 through 1973, largely from management areas IV, V, and VI (Clapham et al. 2009). One-third of these catches occurred from 1959-1961 in Area V. These numbers support Southern Hemisphere humpbacks being well below their carrying capacities (Clapham et al. 2009). Recent surveys off the Brazilian breeding grounds suggests a population of 6,404 individuals in this area (Andriolo et al. 2010).

Natural threats. Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008). Predation on humpback whales in the action area have been noted, although events appear to be bunched, with several incidents in a given year and none in others(Neilson and Gabriele 2007).

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

Anthropogenic threats. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Fisheries interactions are a significant problem for several marine mammal species and particularly so for humpback whales. Aside from the potential of entrapment and entanglement, there is also concern that many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to accurately determine the frequency of such mortalities. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed.

Between 1998 and 2005, observers identified 12 humpback whales injured or killed by fisheries off the U.S. west coast (NMFS, unpublished data). An estimated 78 rorquals were killed annually in the offshore southern California drift gillnet fishery during the 1980s (Heyning and Lewis. 1990). From 1996-2000, 22 humpback whales of the Central North Pacific stock were found entangled in fishing gear (Angliss and Lodge. 2004). In 1996, a vessel from the Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crabpot floats from the whale. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. The first estimate of population-level effects of entanglement were recently produced, with over 12% of the Gulf of Maine population of humpbacks acquiring new scars from entanglement interactions annually (Wade and Baker 2010).

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

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

Oil spills could have a significant deleterious effect on marine mammals that are exposed to them. Exposure can occur via skin contact, ingestion of oil directly or through contaminated prey, or inspired while at the surface (Geraci 1990). This exposure could result in displacement of marine mammals from an impacted area or produce toxic effects. Perhaps the most famous shipwreck of all time occurred in the Gulf of Alaska when, in 1989, the *Exxon Valdez* released at least 11 million gallons of Alaskan crude oil into one of the largest and most productive estuaries in North America. The spill was the worst in U.S. history until the *Deepwater Horizon* event in 2010. The Alaska Department of Environmental Conservation estimated that 149 km of shoreline was heavily oiled and 459 km were at least lightly oiled. Oil spills, both small and large, occur widely along U.S. shores at refining and transfer facilities and extraction sites.

Whale watching, particularly of humpback whales, is extensive in Hawaiian waters during winter. The interactions that individuals experience in these waters likely influence how they react to approaches by vessels in the future (Herman 1979).

Critical habitat. The NMFS has not designated critical habitat for humpback whales.

Sperm whale

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

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

North Atlantic. In the western North Atlantic, sperm whales range from Greenland south into the Gulf of Mexico and the Caribbean, where they are common, especially in deep basins north of the continental shelf (Romero et al. 2001; Wardle et al. 2001). The northern distributional limit of female/immature pods is probably around Georges Bank or the Nova Scotian shelf (Whitehead et al. 1991). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico in all seasons (Hansen et al. 1996; Mullin et al. 1994). Sperm whales distribution follows a distinct seasonal cycle, concentrating east-northeast of Cape Hatteras in winter and shifting northward in spring when whales occur 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, mature male sperm whales have been recorded as far north as Spitsbergen (Øien 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature males predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Christensen et al. 1992a; Christensen et al. 1992b; Gunnlaugsson and Sigurjónsson 1990; Øien 1990).

North Pacific. Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin in summer, and occur south of 40^{o} N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974). Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl et al. 1983; Forney et al. 1995; Lee 1993; Mobley Jr . et al. 2000; Rice 1960; Shallenberger 1981), but they reach peak abundance from April to mid-June and from the end of August through mid-November (Rice 1974). They are seen in every season except winter (December-February) in Washington and Oregon (Green et al. 1992). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly towards the middle of the tropical Pacific and northward towards the tip of Baja California (Carretta et al. 2006).

Mediterranean. Sperm whales occur from the Alboran Sea to the Levant Basin, primarily over steep slope and deep offshore waters. Sperm whales are rarely sighted in the Sicilian Channel, and are vagrants to the northern Adriatic and Aegean Seas (Notarbartolo di Sciara and Demma 1997). In 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.

Southern Hemisphere. All sperm whales of the Southern Hemisphere are treated as a single stock with nine divisions, although this designation has little biological basis and is more in line with whaling records (Donovan 1991). Sperm whales that occur off the Galapagos Islands, mainland Ecuador, and northern Peru may be distinct from other sperm whales in the Southern Hemisphere (Dufault and Whitehead 1995; Rice 1977; Wade and Gerrodette 1993).

Gaskin (1973) found females to be absent in waters south of 50º and decrease in proportion to males south of 46-47º.

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

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

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

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet and Whitehead 1996; Jaquet et al. 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000a; Davis et al. 2000b; Davis et al. 2000c; Davis et al. 2002; Wormuth et al. 2000). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet et al. 1996; Waring et al. 1993). Sperm whale over George's Bank were associated with surface temperatures of 23.2-24.9°C (Waring et al. 2003).

Reproduction. Female sperm whales become sexually mature at an average of 9 years or 8.25-8.8 m (Kasuya 1991). Males reach a length of 10 to 12 m at sexual maturity and take 9-20 years to become sexually mature, but require another 10 years to become large enough to successfully breed (Kasuya 1991; Würsig et al. 2000). Mean age at physical maturity is 45 years for males and 30 years for females (Waring et al. 2004). Adult females give birth after roughly 15 months of gestation and nurse their calves for 2-3 years (Waring et al. 2004). The calving interval is estimated to be every 4-6 years between the ages of 12 and 40 (Kasuya 1991; Whitehead et al.

2008). In the North Pacific, female sperm whales and their calves are usually found in tropical and temperate waters year round, while it is generally understood that males move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters off of the Aleutian Islands (Kasuya and Miyashita 1988). It has been suggested that some mature males may not migrate to breeding grounds annually during winter, and instead may remain in higher latitude feeding grounds for more than 1 year at a time (Whitehead and Arnbom 1987).

Sperm whale age distribution is unknown, but sperm whales are believed to live at least 60 years (Rice 1978b). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rates for juveniles and adults are now considered unreliable (IWC 1980b). In addition to anthropogenic threats, there is evidence that sperm whale age classes are subject to predation by killer whales (Arnbom et al. 1987; Pitman et al. 2001).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals) versus the Pacific (25-30 individuals) (Jaquet and Gendron 2009). Groups may be stable for long periods, such as for 80 days in the Gulf of California (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in “bachelor schools,” but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Diving. Sperm whales are probably the deepest and longest diving mammalian species, with dives to 3 km and durations in excess of 2 hours (Clarke 1976; Watkins et al. 1993; Watkins et al. 1985). However, dives are generally shorter (25- 45 min) and shallower (400-1,000 m). Dives are separated by 8-11 min rests at the surface (Gordon 1987; Jochens et al. 2006; Papastavrou et al. 1989; Watwood et al. 2006; Würsig et al. 2000). Sperm whales typically travel ~3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Feeding. Sperm whales appear to feed regularly throughout the year (NMFS 2006). It is estimated they consume about 3-3.5% of their body weight daily (Lockyer 1981). They seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Rice 1989a). A large proportion of a sperm whale’s diet consists of low-fat, ammoniacal, or luminescent squids (Clarke 1996; Clarke 1980b; Martin and Clarke 1986). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopi, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Angliss and Lodge 2004; Berzin 1972; Clarke 1977; Clarke 1980a; Rice 1989a). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989a). In some areas of the North Atlantic, however, males prey heavily on the oil-rich squid *Gonatus fabricii*, a species also frequently eaten by northern bottlenose whales (Clarke 1997).

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

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

Status and trends. Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is unknown, several studies and estimates of abundance are available. Table 5 contains historic and current estimates of sperm whales by region. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead 2003).

North Atlantic. 190,000 sperm whales were estimated to have been in the entire North Atlantic, but CPUE data from which this estimate is derived are unreliable according to the IWC (Perry et al. 1999). The total number of sperm whales in the western North Atlantic is unknown (Waring et al. 2008). The best available current abundance estimate for western North Atlantic sperm whales is 4,804 based on 2004 data. The best available estimate for Northern Gulf of Mexico sperm whales is 1,665, based on 2003-2004 data, which are insufficient to determine population trends (Waring et al. 2008). Sperm whales were widely harvested from the northeastern Caribbean (Romero et al. 2001) and the Gulf of Mexico where a sperm whale fishery operated during the late 1700s to the early 1900s (NMFS 2006; Townsend 1935).

Table 5. Summary of past and present sperm whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	--	--	900,000	--	(Würsig et al. 2000)
	--	1,110,000	672,000-1,512,000	360,000	105,984-614,016*	(Whitehead 2002)
North Atlantic	Basinwide	224,800	--	22,000	--	(Gosho et al. 1984; Würsig et al. 2000)
	Northeast Atlantic, Faroes-Iceland, and U.S. East Coast (combined)	--	--	13,190	--	(Whitehead 2002)
	NMFS - North Atlantic stock (Western North Atlantic)	--	--	4,804	1,226-8,382*	(NMFS 2008)
	Eastern North Atlantic - Iceland	--	--	1,234	823-1,645*	(Gunnlaugsson and Sigurjónsson 1990)
	Eastern North Atlantic - Faroe Islands	--	--	308	79-537*	(Gunnlaugsson and Sigurjónsson 1990)
	Eastern North Atlantic - Norwegian Sea	--	--	5,231	2,053-8,409*	(Christensen et al. 1992b)
	Eastern North Atlantic - Northern Norway to Spitsbergen	--	--	2,548	1,200-3,896*	(Øien 1990)
Gulf of Mexico	NMFS - Gulf of Mexico stock	--	--	1,665	CV=0.2	(NMFS 2008)
	Northern Gulf of Mexico - off the Mississippi River Delta between 86° and 91°W	--	--	398	253-607	(Jochens et al. 2006)
	North-central and Northwestern Gulf of Mexico	--	--	87	52-146	(Mullin et al. 2004)
North Pacific	Basinwide	620,400	--	472,100	--	(Gosho et al. 1984)
				930,000	--	(Rice 1989a)
	Eastern Tropical Pacific	--	--	26,053	13,797-38,309*	(Whitehead 2003)
	Off Costa Rica	--	--	1,360	823-2,248*	(Gerrodette and Palacios 1996)
	Off Central America north of Costa Rica	--	--	333	125-890*	(Gerrodette and Palacios 1996)
	Eastern Temperate North Pacific	--	--	26,300	0-68,054*	(Barlow and Taylor 2005)
				32,100	9,450-54,750*	(Barlow and Taylor 2005)
	NMFS - North Pacific stock	--	--	--	--	(Angliss and Allen 2007)
	NMFS - California/Oregon/ Washington stock	--	--	2,853	CV=0.25*	(Carretta et al. 2008)
	NMFS - Hawaii stock	--	--	7,082	2,918-11,246*	(Carretta et al. 2008)
Southern Hemisphere	Basinwide	547,600	--	299,400	--	(Gosho et al. 1984; IWC 1988; Perry et al. 1999)
	South of 60 °S	--	--	14,000	8,786-19,214*	(Butterworth et al. 1995) as cited in (Perry et al. 1999)
	South of 30 °S	--	--	128,000	17,613-238,387*	(Butterworth et al. 1995) as cited in (Perry et al. 1999)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

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

Southern Hemisphere. Whaling in the Southern Hemisphere averaged roughly 20,000 whales between 1956-1976 (Perry et al. 1999). Population size appears to be stable (Whitehead 2003). Whitehead (2002b) estimated 12,069 sperm whales south of 60° S.

Natural threats. Sperm whales are known to be occasionally predated upon by killer whales (Jefferson and Baird 1991; Pitman et al. 2001) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989b; Weller et al. 1996; Whitehead 1995). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

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

Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). In 2000, the Japanese Whaling Association announced plans to kill 10 sperm whales in the Pacific Ocean for research. Although consequences of these deaths are unclear, the paucity of population data, uncertainly regarding recovery from whaling, and re-establishment of active programs for whale harvesting pose risks for the recovery and survival of this species. Sperm whales are also hunted for subsistence purposes by whalers from Lamalera, Indonesia, where a traditional whaling industry has been reported to take up to 56 sperm whales per year. Japan also kills up to 101 sei whales annually (IWC 2008).

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

Sperm whales are known to have been incidentally taken in drift gillnet operations, which killed or seriously injured an average of nine sperm whales annually from 1991-1995 (Barlow et al. 1997). Sperm whales have been bycaught in pelagic drift gillnets along the U.S. east coast and in artisanal gillnets targeting sharks and large pelagic fishes off the Pacific coasts of northwestern South America, Central America, and Mexico (Palacios and Gerrodette 1996; Waring et al. 1997). Interactions between longline fisheries and sperm whales have been common over the past decade (Rice 1989; Hill and DeMaster 1999). One sperm whale was observed entangled within the Hawaiian Islands EEZ in the Hawaii-based longline fishery and was able to free itself without injury (Forney 2004). An individual was caught and released from gillnetting, although injured, on Georges Bank during 1990. A second individual was freed, but injured, from gillnetting on George's Bank in 1995. In 1994, a sperm whale was disentangled from gillnet along the coast of Maine. In August 1993, a dead sperm whale, with longline gear wound tightly around the jaw, was found floating ~32 km off Maine.

There have not been any recent documented ship strikes involving sperm whales in the North Pacific, although there are a few records of ship strikes in the 1990s. Two whales described as "possibly sperm whales" are known to have died in U.S. Pacific waters in 1990 after being struck by vessels (Barlow et al. 1997). There is an anecdotal record from 1997 of a fishing vessel that struck a sperm whale in southern Prince William Sound in Alaska, although the whale did not appear to be injured (Laist et al. 2001). More recently in the Pacific, two sperm whales were struck by a ship, but it is not known if these ship strikes resulted in injury or mortality (NMFS 2009). Worldwide, sperm whales are known to have been struck 17 times out of a total record of 292 strikes of all large whales, 13 of which resulted in mortality (Jensen and Silber 2003; Laist et al. 2001). Given the current number of reported cases of injury and mortality, it does not appear that ship strikes are a significant threat to sperm whales (Whitehead 2003).

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and HCHs in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 µg Cr/g tissue, with the mean (8.8 µg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals do not appear to accumulate chromium at higher levels.

Critical habitat. The NMFS has not designated critical habitat for sperm whales.

Leatherback sea turtle

Distribution. Leatherbacks range farther than any other sea turtle species, having evolved physiological and anatomical adaptations that allow them to exploit cold waters (Frair et al. 1972; Greer et al. 1973; USFWS 1995). High-latitude leatherback range includes in the Atlantic includes the North and Barents Seas, Newfoundland and Labrador , Argentina, and South Africa (Goff and Lien 1988; Hughes et al. 1998; Luschi et al. 2003; Luschi et al. 2006; Márquez 1990; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998; Gill 1997; Hodge and Wing 2000).

Leatherbacks also occur in Mediterranean and Indian Ocean waters (Casale et al. 2003; Hamann et al. 2006). Associations exist with continental shelf and pelagic environments and sightings occur in offshore waters of 7-27˚ C (CETAP 1982). Juvenile leatherbacks usually stay in warmer, tropical waters >21˚ C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James et al. 2005).

Population designations. Leatherbacks break into four nesting aggregations: Pacific, Atlantic, and Indian oceans, and the Caribbean Sea. Detailed population structure is unknown, but is likely dependent upon nesting beach location.

Atlantic Ocean. Nesting aggregations occur along Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida (Bräutigam and Eckert 2006; Márquez 1990; Spotila et al. 1996). Widely dispersed but fairly regular African nesting also occurs between Mauritania and Angola (Fretey et al. 2007). Many sizeable populations (perhaps up to 20,000 females annually) of leatherbacks are known to nest in West Africa (Fretey 2001). The population of leatherbacks nesting on Gabon beaches has been suggested as being the world's largest, with 36,185-126,480 clutches being laid by 5,865-20,499 females annually from 2002-2007 (Witt et al. 2009). The total number of females utilizing Gabon nesting beaches is estimated to be 15,730- 41,373 (Witt et al. 2009). Genetic analyses support distinct subpopulations within the Atlantic basin, including the St. Croix (U.S.V.I.), Trinidad, and mainland Caribbean (Florida, Costa Rica, Suriname/French Guiana) nesting aggregations (Dutton et al. 1999). Recent analysis suggests seven Atlantic stocks including Florida, northern Caribbean, western Caribbean, southern Caribbean-Guyana Shield-Trinidad, West Africa, South Africa, and Brazil (TEWG 2007). North Atlantic leatherbacks likely number 34,000-94,000 individuals, with females numbering 18,800 and the eastern Atlantic segment numbering 4,700 (TEWG 2007). Trends and numbers include only nesting females and are not a complete demographic or geographic cross-section. The largest nesting aggregation in the western North Atlantic occurs in French Guiana and Suriname, likely belongs to a metapopulation whose limits remain unknown (Rivalan et al. 2006). Heppell et al. (2003) concluded that leatherbacks generally show less genetic structuring than green and hawksbill sea turtles. The French Guiana nesting aggregation has declined ~15% annually since 1987 (NMFS 2001b). However, from 1979-1986, the number of nests increased ~15% annually, possibly indicating the current decline may be linked with the erosion cycle of Guiana beaches (NMFS 2006e). Guiana nesting may have increased again in the early 2000s (NMFS 2006e). Suriname nesting numbers have recently increased from more than 10,000 nests annually since 1999 and a peak of 30,000 nests in 2001. Overall, Suriname and French Guiana nesting trends towards an increase (Girondot et al. 2007; Hilterman and Goverse 2003). Florida (March-July) and U.S. Caribbean nesting since the early 1980s has increased ~0.3% and 7.5% per year, respectively, but lags behind the French Guiana coast and elsewhere in magnitude (NMFS/SEFSC 2001).

Caribbean Sea. Nesting occurs in Puerto Rico, St. Croix, Costa Rica, Panama, Colombia, Trinidad and Tobago, Guyana, Suriname, and French Guiana (Bräutigam and Eckert 2006; Márquez 1990; Spotila et al. 1996).

Indian Ocean. Nesting is reported in South Africa, India, Sri Lanka, and the Andaman and Nicobar islands(Hamann et al. 2006).

Pacific Ocean. Leatherbacks are found from tropical waters north to Alaska within the North Pacific and is the most common sea turtle in the eastern Pacific north of Mexico (Eckert

1993a; Stinson 1984; Wing and Hodge 2002). The west coast of Central America and Mexico hosts nesting from September-March, although Costa Rican nesting peaks during April-May (Chacón-Chaverri and Eckert 2007; LGL Ltd. 2007). Leatherback nesting aggregations occur widely in the Pacific, including China, Malaysia, Papua New Guinea, Indonesia, Thailand, Australia, Fiji, the Solomon Islands, and Central America (Dutton et al. 2007; Limpus 2002). Significant nesting also occurs along the Central American coast (Márquez 1990). Although not generally known to nest on Japanese shores, two nests were identified in the central Ryukyu Islands in 2002 (Kamezaki et al. 2002).

In the Pacific, nesting beaches in Mexico and Costa Rica (nesting occurs October through March) are a separate population from the western Pacific beaches (Benson et al. 2007a; summary in NMFS and USFWS 2007d; Spotila 2004a). In Costa Rica, leatherbacks nest at Playa Naranjo in Santa Rosa National Park, the second-most important nesting beach on the Pacific coast (Yañez et al. 2010), Rio Oro on the Osa Peninsula, and at various beaches in Las Baulas National Park, which includes Playa Langosta and Playa Grande and contains the largest colony of leatherbacks in the Pacific (Spotila 2004a). Females typically lay six clutches per season (average nine days between nests), which incubate for 58–65 days (Lux et al. 2003). Limited nesting also occurs along Nicaragua, Panama, El Salvador, and Guatemala.

Occurrence around the Marianas Islands is supported by satellite tracking of females migrating between the eastern and western Pacific. Specifically, a single individual was tracked within 100 nautical miles of the Northern Marianas Islands during December and January, supporting co-occurrence of this species with the proposed action (Scott Benson, pers. comm.).

Habitat. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Grant and Ferrell 1993; Schroeder and Thompson 1987; Shoop and Kenney 1992; Starbird et al. 1993). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011b; Collard 1990; Davenport and Balazs 1991; Frazier 2001; HDLNR 2002). Aerial surveys off the western U.S. support continental slope waters as having greater leatherback occurrence than shelf waters (Bowlby et al. 1994; Carretta and Forney 1993; Green et al. 1992; Green et al. 1993). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Areas above 30º N in the Atlantic appear to be popular foraging locations (Fossette et al. 2009b). Northern foraging areas were proposed for waters between 35º and 50º N along North American, Nova Scotia, the Gulf of Saint-Laurent, in the western and northern Gulf Stream, the Northeast Atlantic, the Azores front and northeast of the Azores Islands, north of the Canary Islands. Southern foraging was proposed to occur between 5º and 15º N in the Mauritania upwelling, south of the Cape Verde islands, over the Guinea Dome area, and off Venezuela, Guyana and Suriname.

Migration and movement. Leatherback sea turtles migrate throughout open ocean convergence zones and upwelling areas, along continental margins, and in archipelagic waters (Eckert 1998; Eckert 1999; Morreale et al. 1994). In a single year, a leatherback may swim more than 9,600 km to nesting and foraging areas throughout ocean basins (Benson et al. 2007a; Benson et al. 2007b; Eckert 1998; Eckert 2006; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; Sale et al. 2006). Much of this travel may be due to movements within current and eddy features, moving individuals along (Sale and Luschi 2009). Return to nesting beaches may be accomplished by a form of geomagnetic navigation and use of local cues (Sale and Luschi 2009). Leatherback females will either remain in nearshore waters between nesting events, or range widely, presumably to feed on available prey (Byrne et al. 2009; Fossette et al. 2009a).

Fossette et al. (2009b) identified three main migratory strategies in leatherbacks in the North Atlantic (almost all of the studied individuals were female). One involved 12 individuals traveling to northern latitudes during summer/fall and returning to waters during winter and spring. Another strategy used by six individuals was similar to this, but instead of a southward movement in fall, individuals overwintered in northern latitudes (30-40º N, 25-30º W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10º in winter, where they remained or returned to the northwest Atlantic. A third strategy, which was followed by three females remaining in tropical waters for the first year subsequent to nesting and moving to northern latitudes during summer/fall and spending winter and spring in latitudes of 40-50º N.

Satellite tracking data reveal that leatherback females leaving Mexican and Central American nesting beaches migrate towards the equator and into Southern Hemisphere waters, some passing the Galápagos Islands, and disperse south of 10ºS (Dutton et al. 2006; Shillinger et al. 2010). However, observations of leatherbacks in the Galápagos Islands are rare (Zárate et al. 2010).

Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave exposure, possibly as a means to aid hatchling dispersal (Garcon et al. 2010). Individuals nesting in Malayasia undergo migrations to tropical feeding areas, taking 5-7 months to arrive there from nesting locations (Benson et al. 2011b). Additional foraging occurs in temperate locations, including across the Pacific basin aloing the U.S. west coast; individuals take 10-12 months to migrate here (Benson et al. 2011b). Individuals nesting during the boreal summer move to feeding areas in the North China Sea, while boreal winter nesters moved across the Equator to forage in the Southern Hemisphere (Benson et al. 2011b).

Sex ratio. A significant female bias exists in all leatherback populations thus far studied. An examination of strandings and in-water sighting data from the U.S. Atlantic and Gulf of Mexico coasts indicates that 60% of individuals were female. Studies of Suriname nesting beach temperatures suggest a female bias in hatchlings, with estimated percentages of females hatched over the course of each season at 75.4, 65.8, and 92.2% in 1985, 1986, and 1987, respectively (Plotkin 1995). Binckley et al. (1998) found a heavy female bias upon examining hatchling gonad histology on the Pacific coast of Costa Rica, and estimated male to female ratios over three seasons of 0:100, 6.5:93.5, and 25.7:74.3. James et al. (2007) also found a heavy female bias (1.86:1) as well as a primarily large sub-adult and adult size distribution. Leatherback sex determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell et al. 2005).

Feeding. Leatherbacks may forage in high-invertebrate prey density areas formed by favorable features (Eckert 2006; Ferraroli et al. 2004). Although leatherbacks forage in coastal waters, they appear to remain primarily pelagic through all life stages (Heppell et al. 2003). The location and abundance of prey, including medusae, siphonophores, and salpae, in temperate and boreal latitudes likely has a strong influence on leatherback distribution in these areas (Plotkin 1995). Leatherback prey are frequently found in the deep-scattering layer in the Gulf of Alaska (Hodge and Wing 2000). North Pacific foraging grounds contain individuals from both eastern and western Pacific rookeries, although leatherbacks from the eastern Pacific generally forage in the Southern Hemisphere along Peru and Chile (Dutton 2005-2006; Dutton et al. 2000; Dutton et al. 1998). Mean primary productivity in all foraging areas of western Atlantic females is 150% greater than in eastern Pacific waters, likely resulting in twice the reproductive output of eastern Pacific females (Saba et al. 2007). Leatherbacks have been observed feeding on jellyfish in waters off Washington State and Oregon (Eisenberg and Frazier 1983; Stinson 1984).

Diving. Leatherbacks are champion deep divers among sea turtles with a maximum- recorded dive of over 4,000 m (Eckert et al. 1989; López-Mendilaharsu et al. 2009). Dives are typically 50-84 m and 75-90% of time duration is above 80 m (Standora et al. 1984). Leatherbacks off South Africa were found to spend <1% of their dive time at depths greater than 200 m (Hays et al. 2009). Dive durations are impressive, topping 86 min, but routinely 1-14 min (Eckert et al. 1989; Eckert et al. 1996; Harvey et al. 2006; López-Mendilaharsu et al. 2009). Most of this time is spent traveling to and from maximum depths (Eckert et al. 1989). Dives are continual, with only short stays at the surface (Eckert et al. 1989; Eckert et al. 1986; Southwood et al. 1999). Off Playa Grande, Costa Rica, adult females spent 57–68% of their time underwater, diving to a mean depth of 19 m for 7.4 min (Southwood et al. 1999). Off St. Croix, adult females dove to a mean depth of 61.6 m for an average of 9.9 min, and spent an average of 4.9 min at the surface (Eckert et al. 1989). During shallow dives in the South China Sea, dives averaged 6.9–14.5 min, with a maximum of 42 min (Eckert et al. 1996). Off central California, leatherbacks dove to 20–30 m with a maximum of 92 m (Harvey et al. 2006). This corresponded to the vertical distribution of their prey (Harvey et al. 2006). Leatherback prey in the Gulf of Alaska are frequently concentrated in the deep-scattering layer (Hodge and Wing 2000). Mean dive and surface durations were 2.9 and 2.2 min, respectively (Harvey et al. 2006). In a study comparing diving patterns during foraging versus travelling, leatherbacks dove shallower (mean of 53.6 m) and moved more slowly (17.2 km/day) while in foraging areas while travelling to or from these areas (81.8 m and 51.0 km/day) (Fossette et al. 2009b).

Vocalization and hearing. Information on the hearing capabilities of sea turtles is limited, but the information that is available suggests auditory capabilities are centered in the low-frequency range (< 1 kHz), with hearing thresholds at about 132-140 dB (Lenhardt 1994; Lenhardt et al. 1983; Moein Bartol and Ketten 2006; Moein Bartol et al. 1999; O'Hara and Wilcox 1990; Ridgway et al. 1969). There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz (L-DEO 2006).

Status and trends. Leatherback sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA, but declines in nesting have continued worldwide. Breeding females were initially estimated at 29,000-40,000, but were later refined to ~115,000 (Pritchard 1971; Pritchard 1982). Spotila et al. (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004b). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001a; NMFS 2001b).

Heavy declines have occurred at all major Pacific basin rookeries, as well as Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. This includes a nesting decline of 23% between 1984-1996 at Mexiquillo, Michoacán, Mexico (Sarti et al. 1996). Fewer than 1,000 females nested on the Pacific coast of Mexico from 1995-1996 and fewer than 700 females are estimated for Central America (Spotila et al. 2000). The number of leatherback turtles nesting in Las Baulas National Park declined rapidly during the 1990s, from about 1,500 females during the 1988–89 nesting season, to about 800 in 1990–91 and 1991–92 to 193 in 1993–94 (Williams et al. 1996) and 117 in 1998–99 (Spotila et al. 2000). Spotila (2004a) reported that between 59 and 435 leatherbacks nest at Las Baulas each year depending on the El Niño–La Niña cycle. Leatherbacks have rarely been observed during NSF-funded seismic surveys in the eastern tropical Pacific (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005c; Smultea and Holst 2003).

Declines in the western Pacific are equally severe. Nesting at Terengganu, Malaysia is 1% of that in the 1950s (Chan and Liew 1996). The South China Sea and East Pacific nesting colonies have undergone catastrophic collapse. Overall, Pacific populations have declined from an estimated 81,000 individuals to <3,000 total adults and subadults (Spotila et al. 2000). The number of nesting leatherbacks has declined by an estimated 95% over the past 20 years in the Pacific (Gilman 2009). Drastic overharvesting of eggs and mortality from fishing activities is likely responsible for this tremendous decline (Eckert 1997; Sarti et al. 1996).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales (Pitman and Dutton 2004). Hatchlings are preyed upon by herons, gulls, dogfish, and sharks. Leatherback hatching success is particularly sensitive to nesting site selection, as nests that are overwashed have significantly lower hatching success and leatherbacks nest closer to the high-tide line than other sea turtle species (Caut et al. 2009b).

Anthropogenic threats. Leatherback nesting and marine environments are facing increasing impacts through widespread development and tourism along nesting beaches (Hamann et al. 2006; Hernandez et al. 2007; Maison 2006; Santidrián Tomillo et al. 2007). Structural impacts to beaches include building and piling construction, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). In some areas, timber and marine debris accumulation as well as sand mining reduce available nesting habitat (Bourgeois et al. 2009; Chacón Chaverri 1999; Formia et al. 2003; Laurance et al. 2008). Lights on or adjacent to nesting beaches alter nesting adult behavior and is often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Bourgeois et al. 2009; Cowan et al. 2002; Deem et al. 2007; Witherington 1992; Witherington and Bjorndal 1991). Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). Although global warming may expand foraging habitats into higher latitude waters, increasing temperatures may increase feminization of nests (Hawkes et al. 2007; James et al. 2006; McMahon and Hays 2006; Mrosovsky et al. 1984). Rising sea levels may also inundate nests on some beaches. Egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of females along nesting beaches is of concern worldwide.

Bycatch, particularly by longline fisheries, is a major source of mortality for leatherback sea turtles (Crognale et al. 2008; Fossette et al. 2009a; Gless et al. 2008; Petersen et al. 2009). Wallace et al. (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace et al. 2010); many of these turtles are expected to be leatherbacks. Donoso and Dutton (2010) found that 284 leatherbacks were bycaught between 2001 and 2005 as part of the Chilean longline fishery, with two individuals observed dead; leatherbacks were the most frequently bycaught sea turtle species. Finkbeiner et al. (2011) estimated that annual bycatch interactions total 1,400 individuals annually for U.S. Atlantic fisheries (resulting in roughly fourty mortalities) and one hundred interactions in U.S. Pacific fisheries (resulting in about ten mortalities).

We know little about the effects of contaminants on leatherback sea turtles. The metals arsenic, cadmium, copper, mercury, selenium, and zinc bioaccumulate, with cadmium in highest concentration in leatherbacks versus any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). A diet of primarily jellyfish, which have high cadmium concentrations, is likely the cause (Caurant et al. 1999). Organochlorine pesticides have also been found (Mckenzie et al. 1999). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight Davenport et al. 1990; Oros et al. 2009).

Critical habitat. On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, U.S.V.I. from the 183 m isobath to mean high tide level between 17° 42'12" N and 65°50'00" W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. However, studies do not currently support significant critical habitat deterioration.

On Janauary 26 2012, the NMFS designated critical habitat for leatherback sea turtles in waters along Washington State (Cape Flattery to Cape Blanco; 64,760 km^2) and California (Point Arena to Point Arquello; 43,798 km^2) (77 FR 4170). The primary constituent elements of these areas include (1.) the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia, Phacellophora,* and *Cyanea*) of sufficient condition, distribution, diversity, and abundance to support individual as well as population growth, reproduction, and development and (2) migratory pathway conditions to allow for safe and timely passage and access to/from/within high use foraging areas.

Environmental baseline

By regulation, environmental baselines for 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 that are contemporaneous with the consultation in process (50 CFR §402.02). The *Environmental baseline* for this Opinion includes the effects of several activities affecting the survival and recovery of ESA-listed whale and sea turtle species in the action area.

Physical and oceanographic features

The action area includes numerous hydrothermal vents, seamounts, volcanoes, and, of course, the Marianas Trench. The Marianas Islands themselves are made up of 15 volcanic islands, with other former islands now subsided, particularly to the south (Baker et al. 1996). Eruptions frequently occur, with underwater eruptions having previously caused explosions, bubbling, and fish kills (DON 2003b; Smithsonian Institute 1995; USGS 2005b). Earthquakes are also frequent, though not particularly powerful, with occasional intense magnitudes (DON 2003a; DON 2003b; EERI 1993; USGS 2004; USGS 2005a; Zhang and Lay 1992). Regional seamounts come in two forms: volcanic and mud. Volcanic seamounts frequently have hydrothermal vent communities associated with them while macrofaunal communities tend to inhabit mud seamounts (Embley et al. 2004; Fryer 1999). Productivity around seamounts tends to be higher due to physical mixing of waters that bring nutrients closer to the surface (Rogers 1994).

Although ocean circulation around the Marianas Islands is poorly understood, it is a part of the North Pacific Subtropical Gyre (NPSG), which is the largest ecosystem on Earth and the planet's largest circulation (Eldredge 1983; Karl 1999). Waters are warm (24-31˚ C, mean of 27-28˚ C), with low nutrients, chlorophyll, and subsequently low densities of organisms (Karl 1999; Miller 2007; NOAA 2004). Local surface waters in the Marianas are well mixed, with a surface layer down to 90-125 m. Below this relatively stable thermocline, waters chill rapidly. Circulation is wind-driven and anti-cyclonic, with low interchange of water from surrounding currents (Karl 1999). This relatively stable, homogenous water body can be perturbated, though, with tropical cyclones or eddies bringing nutrient-rich waters up to the surface to fuel localized primary productivity (Karl 1999; Venrick 1990).

As a whole, the west central Pacific is considered oligotrophic, lacking significant nutrient availability in surface waters for widespread primary productivity (Rodier and Borgne 1997). Phytoplankton biomass around the Marianas Island is low, reflected by low chlorophyll α concentrations >0.1 mg/m^3 and primary productivity rates of 170-182 $mgCm^{-2}d^{-1}$ (NASA 1998; Radenac and Rodier 1996; Sea Around Us 2009). Areas with such low primary productivity tend to be dominated by nano- and picoplakton; this is the case in and around the Marianas, where phytoplankton are dominated by prochlorophytes, haptophytes, and chlorophytes (Higgins and Mackey 2000; Le Bouteiller et al. 1992). El Niño events appear to have little effect on local productivity (Higgins and Mackey 2000; Mackey et al. 1997). As such, zooplankton productivity is also very low in general (Vinogradov and Parin 1973). However, seamounts can locally enhance productivity and, consequently, increase secondary productivity that supports pelagic and demersal fish (Boehlert and Genin 1987; Darnitsky 1980; Fedorov and Chistikov 1985; Greze and Kovalev 1985; Parin et al. 1985; Rogers 1994; Zaika and Kovalev 1984). Local eddies formed by current passage past the Marianas Islands can also create locally enhanced chlorophyll α (Wolanski et al. 2003).

Climate change

We primarily discuss climate change as a threat common to all species addressed in this Opinion, rather than in each of the species-specific narratives. As we better understand responses to climate change, we will address these effects in the relevant species-specific section.

In general, based on forecasts made by the Intergovernmental Panel on Climate Change, climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the near future (IPCC 2000; IPCC 2001a; IPCC 2001b; IPCC 2002). From 1906 to 2006, global surface temperatures have risen 0.74º C and continues at an accelerating pace; 11 of the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remains unknown. Species that are shorter-lived, larger body size, or generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is most likely to have its most pronounced affects on species whose populations are already in tenuous positions (Isaac 2008). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming.

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for whale calving and rearing, the distribution and abundance of prey and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated to prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). Climate change can influence reproductive success by altering prey availability, as evidenced by high-success of northern elephant seals during El Niño periods, when cooler, more productive waters are associated with higher first year pup survival (McMahon and Burton. 2005). Reduced prey availability resulting from increased sea temperatures has also been suggested to explain reductions in Antarctic fur seal pup and harbor porpoise survival (Forcada et al. 2005; Macleod et al. 2007). Polygamous marine mammal mating systems can also be perturbated by rainfall levels, with the most competitive grey seal males being more successful in wetter years than in drier ones (Twiss et al. 2007). Sperm whale females were observed to have lower rates of conception following unusually warm sea surface temperature periods (Whitehead 1997). Marine mammals with restricted distributions linked to water temperature may be particularly exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88% of cetaceans would be affected by climate change, 47% would be negatively affected, and 21% would be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters and preferences for shelf habitats (Macleod 2009). Kaschner et al. (2011)modeled marine mammal species richness, overlaid with projections of climate change and found that species in lower-latitude areas would likely be more affected than those in higher-latitude regions. Variations in the recruitment of krill and the reproductive success of krill predators correlate to variations in sea-surface temperatures and the extent of sea-ice cover age during winter months. Although the IPCC (2001b) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran et al. (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20% since the 1950s.

Roughly 50% of the Earth's marine mammal biomass occurs in the Southern Ocean, with all baleen whales feeding largely on a single krill species, *Euphausia superba*, here and feeding virtually nowhere else(Boyd 2002). However, Atkinson et al. (2004) found severe decreases in krill populations over the past several decades in some areas of the Antarctic, linked to sea ice loss. Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators (Antarctic fur seals, gentoo penguins, macaroni penguins, and black-browed albatrosses) that depend on krill for prey and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50% in the 1990s, although incidental mortalities from longline fisheries probably contributed to the decline of the albatross. However, these declines resulted, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older krill age classes, which lowered the number of predators krill could sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s. By 2055, severe reductions in fisheries catch due to climate change have been suggested to occur in the Indo-Pacific, Red Sea, Mediterranean Sea, Antarctic, and tropical areas worldwide while increased catches are expected in the Arctic, North Pacific, North Atlantic, and northern portions of the Southern Ocean (Cheung et al. 2010).

Similarly, Sims et al. (2001) found the timing of squid peak abundance in the English Channel advanced by 120-150 days in the warmest years compared with the coldest. Bottom water temperatures correlated with the extent of squid movement, and temperature increases over the 5 months before and during the month of peak squid movement did not differ between early and late years. These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which climatic changes association with the North Atlantic Oscillation mediate. Cephalopods dominate the diet of sperm whales, who would likely re-distribute following changes in the distribution and abundance of their prey. If, however, cephalopod populations collapse or decline dramatically, sperm whales would likely decline as well.

Climate change has been linked to changing ocean currents as well. Rising carbon dioxide levels have been identified as a reason for a poleward shift in the Eastern Australian Current, shifting warm waters into the Tasman Sea and altering biotic features of the area (Johnson et al. 2011; Poloczanska et al. 2009). Similarly, the Kuroshio Current in the western North Pacific (an important foraging area for juvenile sea turtles) has shifted southward as a result of altered long-term wind patterns over the Pacific Ocean (Poloczanska et al. 2009).

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world’s oceans in search of prey. If sea ice extent decreases, then larval krill may not be able to survive without access to underice algae to feed on. This may be a cause of decreased krill abundance in the northern western Antarctic Peninsula during the last decade (Fraser and Hofmann 2003). Meltwaters have also reduced surface water salinities, shifting primary production along the Antarctic Peninsula (Moline et al. 2004). Blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990b). If they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations would likely experience declines similar to those observed in other krill predators, including dramatic declines in population size and increased year-to year variation in population size and demographics. These outcomes would dramatically increase the extinction probability of baleen whales. Edwards et al. (2007) found a 70% decrease in one zooplankton species in the North Sea and an overall reduction in plankton biomass as warm-water species invade formerly cold-water areas. However, in other areas, productivity may increase, providing more resources for local species (Brown et al. 2009). In addition, reductions in sea ice may alleviate “choke points” that allow some marine mammals to exploit additional habitats (Higdon and Ferguson 2009).

Foraging is not the only potential aspect that climate change could influence. Acevedo-

Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott. 2009). It has also been suggested that increases in harmful algal blooms could be a result from increases in sea surface temperature (Simmonds and Eliott. 2009).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half degree Celsius increase in temperatures during hurricane season from 1965-2005 correlated with a 40% increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of ocean water; this rate will likely increase. Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). The loss of nesting beaches, by itself, would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperatures regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtle nests and reduce hatching success (Caut et al. 2009a). Storms may also cause direct harm to sea turtles, causing “mass” strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchling), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009b; Fuentes et al. 2010; Fuentes et al. 2009c). Smaller individuals likely experience increased predation (Fuentes et al. 2009b)Climatic anomalies influencing the Marianas Islands include El Niño/Southern Oscillation (ENSO) and La Niña events (Giese and Carton 1999; Mantua and Hare 2002a; NOAA 2005a; NOAA 2005b; Sugimoto et al. 2001; Trenberth 1997). Although Guam and the Southern Marianas Islands do not appear to experience altered rainfall patterns during El Niño events, the Northern Marianas tend to experience drier dry seasons and wetter wet seasons (Pacific ENSO Applications Center 1995). Sea surface temperature in the regions also increases due to a weakening of a high pressure system over the western Pacific, potentially influencing the distribution of fish (Kubota 1987; Lehodey et al. 1997). Although typhoons tend to be more frequent during El Niño events (likely occurring at present), their tracks tend to be more to the northwest, away from the action area (Elsner and Liu 2003; Saunders et al. 2000).

Unlike El Niño and La Niña events, Pacific Decadal Oscillation events can persist for 20-30 years, but are more prominent outside the tropics, and mechanisms controlling them are relatively unknown (Hare and Mantua 2000; Mantua and Hare 2002b; Minobe 1997; Minobe 1999). PDO events should not strongly influence the action area.

Habitat degradation

A number of factors may be directly or indirectly affecting listed species in the action area by degrading habitat. These include ocean noise and fisheries impacts.

Natural sources of ambient noise include: wind, waves, surf noise, precipitation, thunder, and biological noise from marine mammals, fishes, and crustaceans. Anthropogenic sources of ambient noise include: transportation and shipping traffic, dredging, construction activities, geophysical surveys, and sonars. In general, it has been asserted that ocean background noise levels have doubled every decade for the last six decades in some areas, primarily due to shipping traffic (IWC 2004). The acoustic noise that commercial traffic contributes to the marine environment is a concern for listed species because it may impair communication between individuals (Hatch et al. 2008).

Seamounts are sensitive to fishery impacts due to the high level of endemism characteristic of this habitat. Species that inhabit seamounts tend to be long-lived and do not move widely between seamounts, meaning that their recovery can be very slow (Johnston and Santillo 2004; Richer de Forges 2000). Listed species may associate with seamounts, apparently due to prey availability here, and the deterioration of the habitat can have significant effects on listed species.

Vessel traffic

Vessel noise could affect marine animals in the proposed study area. Shipping and seismic noise generally dominates ambient noise at frequencies from 20 to 300 Hz (Andrew et al. 2002; Hildebrand 2009; Richardson et al. 1995c). Background noise has increased significantly in the past 50 years as a result of increasing vessel traffic, and particularly shipping, with increases of as much as 12 dB in low frequency ranges and 20 dB versus preindustrial periods (Hildebrand 2009; Jasny et al. 2005; McDonald et al. 2006; NRC 1994; NRC 2003; NRC 2005; Richardson et al. 1995a). Over the past 50 years, the number of commercial vessels has tripled, carrying an estimated six times as much cargo (requiring larger, more powerful vessels) (Hildebrand 2009). Seismic signals also contribute significantly to the low frequency ambient sound field (Hildebrand 2009). Baleen whales may be more sensitive to sound at those low frequencies than are toothed whales. The busiest port in Micronesia is located on Guam, where commercial waterways link the island to Hawaii and the western U.S. to the east and Asian ports such as Okinawa to the west (Matson Navigation Company 2004). Dunlop et al. (2010) found that humpback whales shifted from using vocal communication (which carries relatively large amounts of information) to surface-active communication (splashes; carry relatively little information) when low-frequency background noise increased due to increased sea state. Sonars and small vessels also contribute significantly to mid-frequency ranges (Hildebrand 2009).

Naval activities

The U.S. Navy’s Marianas Island Range Complex partially encompasses the action area. Listed species in the region are exposed to naval activities that include, among others, vessel and aircraft transects, munition detonations, and sonar use. Responses by marine mammals in the area could include no response, short-term and long-term behavioral responses and changes, temporary or permanent hearing loss, debris ingestion, ship-strike injury, and death. However, the responses that sei, humpback, and sperm whales, as well as leatherback sea turtles are expected to engage in are no response, altered vocal activity, changes in swimming speed and direction, respiration rates, dive times, and/or social interactions. Death or injury are not expected to occur as a result of exposure to naval activities here. We are unaware of any strandings associated with naval activities in this area.

Although naval vessels represent a small fraction of the total sound level and are designed to operate quietly, these ships are large and equipped with high-output sonar equipment such as ANISQS-53C tactical sonar, which produces signals at source levels of 235 dB re 1 µPa$_{rms}$ at 1 m. The signals emitted from these devices have the potential to affect marine mammals in the action area; however, empirical data are limited. No stranding or mortality events have been documented in or around other operating areas or training ranges within the action area that appear linked to naval sonar.

Scientific research and permits

Scientific research permits issued by the NMFS currently authorize studies on listed species in the Pacific Ocean, which may extend into portions of the action area for the proposed survey. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, and breath sampling. Leatherback sea turtle research includes capture/handling/restraint, satellite/sonic/PIT/flipper tagging, blood/tissue collection, and ultrasound. Research activities involve non-lethal "takes" of these whales by harassment, with none resulting in mortality.

Tables 6-9 describe the cumulative number of takes for each listed species in the action area authorized in scientific research permits.

Table 6. Sei whale takes in the North Pacific Ocean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling
2009	4,170[1]	435	75	25	0
2010	6,396[1]	730	250	100	0
2011	7,871	638	548	115	1,060
2012	5,551	638	548	115	1,060
2013	5,331	628	558	115	1,060
Total	29,519	3,069	1,969	470	3,180

Permit numbers: 1127-1921, 540-1811, 727-1915, 731-1774, 782-1719, 1058-1733, 1049-1718, 774-1714, 0642-1536, 808-1735, 14097, 14585, 14122, 14245, 14296, 14451, 14534, and 15330.

[1] The National Marine Mammal Laboratory was granted unlimited takes via approach harassment in association with surveys conducted in the North Pacific.

Table 7. Humpback whale takes in the North Pacific Ocean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Acoustic playback	Exhalation sampling	Ultrasound
2009	44,399[1]	4,650	392	77	280	10	5
2010	67,171	6,060	1,447	237	970	10	5
2011	85,301	6,700	6,755	1,590	690	1,070	5
2012	50,697	6,500	6,585	1,565	990	1,070	5
2013	37,627	6,035	6,515	1,525	390	1,060	0
Total	285, 195	21,694	21,694	4,994	3,320	3,220	20

Permit numbers: 10018, 14097, 14122, 14245, 14296, 14353, 14451, 14534, 14599, 14682, 14610, 14585, 13846, 15271, 15274, 15330, 1058-1733, 0642-1536, 0662-1661, 1049-1718, 540-1811, 1071-1770, 1127-1921, 1120-1898, 473-1700, 545-1761, 532-1822, 587-1767, 716-1705, 731-1774,753-1599, 727-1915, 774-1714, 781-1824, 782-1719, 808-1753, 945-1776, and 965-1821.

Table 8. Sperm whale takes in the North Pacific Ocean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Acoustic playback	Exhalation sampling
2009	17,895	770	100	40	0	0
2010	22,001	1,425	405	170	120	120
2011	34,621	3,785	2,885	380	120	1,060
2012	19,486	3,285	2,855	370	120	1,060
2013	18,476	3,165	2,855	360	120	1,060
Total	112,479	12,430	9,100	1,320	480	3,300

Permit numbers: 1127-1921, 1071-1770, 473-1700, 540-1811, 731-1774, 781-1824, 782-1719, 0642-1536, 1049-1718, 774-1714, 14097, 14122, 14296, 14451, 14534, 14585, 14245, 15330, 781-1824, 540-1811, and 727-1915.

Table 9. Leatherback sea turtle takes in the North Pacific Ocean.

Year	Capture/handling/restraint	Satellite/sonic/ PIT/flipper tag	Blood/tissue collection	Ultrasound
2009	191	191	191	38
2010	222	222	222	38
2011	222	222	222	38
2012	188	188	188	38
2013	112	112	122	0
Total	935	935	935	152

Permit numbers: 1596, 14381, 14097, and 14510.

Effects of the proposed actions

Pursuant to Section 7(a)(2) of the ESA, federal agencies must insure, through consultation with the NMFS, 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 funding by the NSF of the seismic survey and issuance of the IHA by the NMFS for “takes” by harassment 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 to reduce an individual’s fitness (i.e., growth, survival, annual reproductive success, or 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 and, ultimately, of the Opinion is to determine if it is reasonable to expect the proposed action 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 action would authorize non-lethal “takes” by harassment of listed species during seismic survey activities. The ESA does not define harassment nor has the 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"[1] 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.

Our analysis considers that behavioral harassment or disturbance is not limited to the "take" definition and may in fact occur in many ways. Fundamentally, if our analysis leads us to conclude that an individual changes its behavioral state (for example, from resting to traveling away from the airgun source or from traveling to evading), we consider the individual to have been harassed or disturbed, regardless of whether it has been exposed to acoustic criteria that define "take." In addition, individuals may respond in a variety of ways, some of which have more significant fitness consequences than others. For example, evasion of a seismic source would be more significant than slow travel away from the same stressor due to increased metabolic demands, stress responses, and potential for calf abandonment that this response could or would entail. As described in the *Approach to the assessment*, the universe of likely responses is considered in evaluating the fitness consequences to the individual and (if appropriate), the affected population and species as a whole to determine the likelihood of jeopardy.

Potential stressors

The assessment for this consultation identified several possible stressors associated with the proposed seismic activities, including

1. pollution by oil or fuel leakage
2. ship-strikes
3. acoustic interference from engine noise
4. ocean bottom seismometer tethers or towed hydrophone streamer
5. sound fields produced by airguns, ocean bottom seismometer release signals, sub-bottom profiler, and multibeam echosounder

Based on a review of available information, this Opinion determined which of these possible stressors would be likely to occur and which would be discountable or insignificant. The potential for fuel or oil leakages and ship strikes are extremely unlikely. The former would likely pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately to the extent possible. In the event that a leak should occur, the amount of fuel and oil onboard the *Langseth* is unlikely to cause widespread, high dose contamination (excluding the remote possibility of severe damage to the vessel) that would impact listed species directly or pose hazards to their food sources.

As stated in *Description of the proposed actions*, the propulsion system of the *Langseth* is very quiet compared to other vessels to reduce interference with seismic activities. Although noise

---

[1] 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)

originating from vessel propulsion will propagate into the marine environment, this amount would be so small as to be discountable. The *Langseth*'s passage past a whale would be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of whales to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006). In addition, the *Langseth* will be traveling at slow speeds, reducing the amount of noise produced by the propulsion system. We are not aware of a ship-strike by a seismic survey vessel. All things considered, we feel the potential for ship strike or acoustic interference from propulsion noise is discountable. Tethers holding some ocean bottom seismometers to the seafloor would occur well below the expected diving limits of any listed species. Towed hydrophone streamer or passive acoustic array could come in direct contact with a listed species and sea turtle entanglements have occurred in towed seismic gear. For example, a seismic survey in the eastern tropical Pacific during 2011 recovered a dead olive ridley sea turtle in the foil of towed seismic gear; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the streamer design as well as observations of sea turtles investigating the streamer and not becoming entangled or operating in regions of high turtle density and entanglements not occurring (Hauser et al. 2008b; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). Although the towed hydrophone streamer or passive acoustic array could come in direct contact with a listed species, entanglements are highly unlikely and considered discountable.

Accordingly, this consultation focused on the following stressors likely to occur from the proposed seismic activities and which may adversely affect ESA-listed species: 1. acoustic energy introduced into the marine environment by the airgun array and 2. acoustic energy introduced by both the multibeam echosounder and sub-bottom profiler sonars.

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 "harassed," under the MMPA (65 FR 16374). These thresholds help to develop exclusion radii around a source and the necessary power-down or shut-down criteria. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} joules), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

The *Exposure analysis* for this Opinion is concerned with the number of sei, humpback, and sperm whales as well as leatherback sea turtles likely to be exposed to received levels greater than 160 dB re 1 μPa_{rms} (166 for sea turtles), which constitute the best estimate of adverse response by listed species. In its request for an IHA, the NSF and Permits Division estimated the expected number of ESA-listed whales exposed to received levels ≥160 dB re 1 μPa_{rms}. The data and methodology used were adopted in this Opinion because the Endangered Species Act

Interagency Cooperation Division believed they represent the best available information and methods to evaluate exposure to listed species. The L-DEO estimated the exposure radii around the proposed *Langseth* operations using empirical data gathered in the Gulf of Mexico in 2007-2008 aboard the *Langseth*. The distances to which sound levels (rms) might propagate for single airgun and full airgun arrays used during the proposed study are provided in Table 1 on page 6. The maximum distance from airguns where received levels might reach 160 dB re 1 μPa_{rms} (i.e., from the full 36-gun array) at 2,000 m depth (maximum depth at which listed species are expected to occur) is 3,850 m with a 9 m tow depth. A thorough review of available literature (see *Response analysis*) supports this level as a general point at which whales tend to show some avoidance response to received seismic sound under conditions expected in the action area. The NSFs assumption that individuals will move away if they experience sound levels high enough to cause significant stress or functional impairment is also reasonable (see also *Response analysis*). Isopleth modeling tends to overestimate the distance to which various isopleths will propagate because most exposure will likely occur at depths shallower than 2,000 m, where received sound levels should be reduced. As we are unable to know where individuals will be in the water column at the time of exposure, we accept this assumption. In addition, the 160 dB re 1 μPa_{rms} 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). It should be noted that, although a received level of 166 dB re 1 μPa_{rms} is considered here to be the threshold for harassment for sea turtle response (McCauley et al. 2000a; McCauley et al. 2000b), estimates of this range were not available and the more conservative range at the 160 dB re 1 μPa_{rms} isopleth was used to estimate sea turtle harassment instead, as it was the best estimate available.

The NSF and Permits Division also provided density estimates for sei and sperm whales in the action area. Review of the local survey data and surveys in the wider North Pacific as well as knowledge of listed species life history and local oceanographic conditions supports these estimates as the best available information. We also adopted NSF's density estimates. Sei whales were frequently observed or detected during the 2007 U.S. Navy ship surveys conducted from roughly January through April through waters surrounding the Marianas Islands (including the seismic survey action area) (SRS-Parsons et al. 2007). Baleen whale life histories provide support for the area being a breeding and calving area. The 2007 Navy survey may have spotted a sei whale cow/calf pair, supporting calving of this species in the area (SRS-Parsons et al. 2007). However, trends in the sei whale sighting data and other available information support density during the time of the proposed seismic survey to be lower than the density identified in the 2007 survey. A decline in the number of sei whale sightings in the region occurred over the timeframe of the Navy survey, including two-thirds of visual sightings occurring on or before February 1 and all acoustic identifications before February 19 (SRS-Parsons et al. 2007). This survey was the first to document sei whales below 20º N (action area is 16.5-19 º N) anywhere in the Pacific. Thus, the single year Navy sightings may represent an unusual distribution pattern during that year. Certainly, these data represent a single period in time that lacks corroboration with any other sighting data from other years or proximal areas. This species should be further north feeding in the northwestern Pacific (Fujise et al. 2003; Matsuoka et al. 2009; Tamura et al. 2005; Tamura et al. 2007; Tamura et al. 2006; Zenitani et al. 1999). The Marianas region is considered oligotrophic and not likely to support significant feeding by baleen whales (NASA 1998; Radenac and Rodier 1996; Rodier and Borgne 1997), although a Bryde's whale was observed lunging feeding during 2007 Navy surveys (SRS-Parsons et al. 2007). Localized transient features should not attract individuals for feeding or other activities. However, available data do support the distinct possibility that sei whales could occur in the action area. The likelihood of encountering a sei whale should be low, but reasonably possible. As the area may serve as a calving area, it is also reasonable that a newborn or very young calf may accompany adult females. Therefore, although the densities assigned by the NSF to sei whales in the action area are likely overestimates, they represent the best estimates of acoustic exposure this species will likely receive as a result of the proposed seismic survey.

Humpback whales typically occur in winter breeding areas within low-latitude regions. This includes North Pacific regions such as Hawaii, southern Japan, the South China Sea east through the Philippines, the Marianas and Marshall Islands, and Mexico. It has been suggested that with the recent increases in population sizes throughout the Pacific, the Marianas Islands may represent habitat which humpback whales are reoccupying {Rivers, 2011 #117560}. A 2007 marine mammal survey through the Northern Marianas Islands documented several acoustic detections of singing humpback whales, indicating males were present for breeding and that, presumeably, females and calves were likely also present (SRS-Parsons et al. 2007). The time frame was the same as that of the proposed seismic survey. Based upon the known life history of the species as well as both historical and current occurrence in the action area, we expect humpback whales are likely to be exposed to the proposed seismic survey. However, no density estimate for the region currently exists and the current status of the population seasonally residing in the Northern Marianas Islands is unknown. We expect the number of individuals to be significantly less than large, well-established populations in other areas such as Hawaii and Pacific Mexico.

Sperm whale occurrence is expected to more closely follow trends seen during the 2007 Navy survey, with the area continuing to be used as a feeding, breeding, and calving area throughout the duration of the seismic survey (Fulling and Vega 2009; SRS-Parsons et al. 2007). A sperm whale stranding that included a calf has been documented for the Marianas during June and calving itself has been observed (DON 2005b; Eldredge 2003). Although adult males are known to forage in more northerly latitudes, males should be present for breeding (Kasuya and Miyashita 1988). Females and younger males should be engaged in foraging in these latitudes (Miller et al. 2004; SRS-Parsons et al. 2007; Weilgart and Whitehead 1988). Sperm whale distribution may be somewhat localized to seamounts and areas of sharp bathymetric relief for possible foraging opportunities in these areas (Clarke 1956; Jaquet and Whitehead 1996; Jaquet et al. 1996; Whitehead 2003). However, sperm whale sighting data from the 2007 Navy cruise do not clearly support this (SRS-Parsons et al. 2007).

A major mitigation factor proposed by the NSF is visual monitoring, which should reduce exposure of listed whales. However, visual monitoring has several limitations. Although regions ensonified by 160 dB re 1 μPa_{rms} and 180 dB re 1 μPa_{rms} are both within the visual range of the *Langseth* and its observers, it is unlikely that all listed species are easily visible at this distance and individuals beneath the water's surface are usually not clearly visible. Ramp-down and shut-down procedures are unlikely to be completely effective at eliminating the co-occurrence of listed individuals within the sound field ≥160 dB re 1 μPa_{rms}.

Marine mammals

Exposure of listed mammals to airguns. The exposure estimates stem from the best available information on whale densities and a planned ensonified area of approximately 15,685 km^2 along survey track lines, or 19,607 km^2 to account for areas of repeated exposure.

The NSF's exposure estimates of sperm whales use the density (1.23) per 1,000 km^2 multiplied by the total survey track area (19,607 km^2) to obtain the total number of exposures (24; rounded to the next whole number). A density of 0.29 sei whales per 1,000 km^2 was multiplied over the same area to support six exposures to sei whales. Either sex may be exposed. The NSF's exposure estimates include repeated exposure of individuals. However, the NSF assumes that individuals would not move within their environment; an assumption that is highly unlikely. We expect listed individuals to move in their environment to feed on available prey, continue migration, breed, or complete other life functions. There is no known factor which we can account for the probability of movement, and we do not know of a mechanism by which we can accurately calculate the number of exposures per individual in this situation. Therefore, we accept NSFs approach pending better information.

In addition to density estimates for sperm and sei whales, the 2007 Navy survey estimated the density of unidentified baleanopterid whales (sei and bryde's whales) in the area. To determine how many of these unknown sightings were likely sei whales, we multiplied the density (0.12/1,000 km^2) by the ensonified area (19,607 km^2) to obtain a number of expected exposures (2.35). We then determined how many of these were likely sei whales included in the unidentified balaenopterid category from the survey data by establishing the proportion of confirmed sei whale sightings in the total number of confirmed balaenopterid sightings. Here, there were 8 confirmed sei and 10 confirmed bryde's sightings; sei whales (the only listed balaenopterid sighted in the region in any data source) constituted 44% of the confirmed sightings (8 out of 18) during the 2007 Navy survey. We multiplied the number of individuals in the unidentified balaenopterid category (2.35) by the proportion we expect sei whales to constitute (0.44) to obtain a number of unidentified balaenopterid sightings that were likely sei whales (1.03, round to 2 sei whales). This brings the total number of expected sei whale exposures to eight. As neither sperm nor humpback whales were sighted or included in an unidentified category during the 2007 Navy survey, no additional exposure to these species stemming from unidentified sightings is included.

No density estimates are available for humpback whales in the region. However, individuals have been either sighted or detected acoustically in the recent past during the time frame of the proposed survey {Rivers, 2011 #117560}(SRS-Parsons et al. 2007). The detections of singing humpback whales supports the area as a seasonal breeding and/or calving area, although the relatively small number of detections and paucity of sightings (particularly in inshore waters where humpback whale populations worldwide tend to breed) suggests local abundance is small compared to better-studied Pacific breeding/calving sites such as Costa Rica and Hawaii. Unfortunately, we have no way to quantitatively determine the number of humpback whales that are likely to be exposed, but reasonably expect that a few individuals or groups may be exposed to seismic sound in excess of 160 dB re 1 μPa_{rms}. In Hawaiian waters, humpback whales occur individually (such as singers; 42% of sightings), or in groups of up to nine individuals (but ~98% less than 7) (Herman and Antinoja 1977). From 20-30% of groups in Hawaiian waters contain a calf (Salden 1988). Based upon this, we qualitatively expect from 0 to 30 humpback whales may be exposed, with all age classes and sexes potentially being exposed, but exposure to adults being more frequent than calves, and subadults/juveniles being least likely to receive exposure (these classes may not undertake breeding migrations to the extent that adults do).

Exposure of listed whales to multibeam echosounder and sub-bottom profiler. Two additional acoustic systems will operate during the proposed *Langseth* cruise: the multibeam echosounder and the sub-bottom profiler. Both of these systems have the potential to expose listed species to sound above the 160 dB re 1 μPa_{rms} threshold. Both systems operate at generally higher frequencies than airgun operations (10.5-13 kHz for the multibeam echosounder and 3.5 kHz for the sub-bottom profiler) and this mitigates effects. As such, their frequencies will attenuate more rapidly than those from airgun sources. Listed individuals would experience higher levels of airgun noise well before either multibeam echosounder or sub-bottom profiler noise of equal amplitude would reach them. Thus, operational airguns mitigate multibeam echosounder and sub-bottom profiler noise exposure. While airguns are not operational, marine mammal observers will remain on duty to collect sighting data. If listed whales were to closely approach the vessel, the *Langseth* would take evasive actions to avoid a ship-strike and simultaneously mitigate exposure to very high source levels. As ship strike has already been ruled out as an insignificant effect, so can high-level ensonification of listed whales (multibeam echosounder source level = 242 dB re 1 μPa_{rms}; sub-bottom profiler source level = 204 dB re 1 μPa_{rms}). Boebel et al. (2006) concluded that multibeam echosounders and sub-bottom profilers similar to those to be used during the proposed activities presented a low risk for auditory damage or any other injury, and that an individual would require exposure to 250–1,000 pulses from a sub-bottom profiler to be at risk for a temporary threshold shift (TTS). To be susceptible to TTS, a whale would have to pass at very close range and match the vessel's speed; we expect a very small probability of this during the proposed study. An individual would have to be well within 100 m of the vessel to experience a single multibeam echosounder pulse that could result in TTS (LGL Ltd. 2008). The same result could only occur at even closer ranges for sub-bottom profiler signals because the signals are weaker. Furthermore, we expect both multibeam echosounder and sub-bottom profiler systems to operate continuously with duty cycles of 1-20 s. It is possible, however, that some small number of listed whales (fewer than those exposed to airguns) could experience low-level multibeam echosounder and/or sub-bottom profiler sound. However, we are unable to quantify the level of exposure.

Sea turtles

Exposure of listed turtles to airguns. The NSF did not quantify the number of exposure events, or the number of exposures per individual sea turtle. Unfortunately, sea turtles are not as easy to detect from survey platforms as marine mammals and the lack of quantifiable data for the area is not surprising. Occurrence in the action area is qualitatively supported by expected migratory pathways through the area in general for individuals travelling between western Pacific nesting areas and eastern Pacific foraging areas (Peter Dutton, NMFS, pers. comm.). The only quantitative data stems from satellite tracked individuals passing the action area at various times of the year, including times near the start of the proposed seismic survey (Benson et al. 2011a). Although we cannot predict the exact number of exposures that are likely to occur, we expect up to a few leatherback sea turtles may be exposed to sound levels greater than 166 dB re 1 μPa_{rms} stemming from the airgun array during the course of the proposed survey. Although adult female migration through the area is known, the movements of other sex and age class combinations are unknown; it is plausible that males and age classes from juvenile to adult may be exposed as well.

Exposure of listed turtles to multibeam echosounder and sub-bottom profiler. As with baleen whales, sea turtles hear in the low frequency range. There is a low probability that sea turtles could experience exposure to sounds emitted by multibeam echosounder or sub-bottom profiler.

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 exposure 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.

Response of marine mammals 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 listed whales considered in this Opinion. Possible responses considered in this analysis consist of

- threshold shifts
- auditory interference (masking)
- behavioral responses
- 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 in the action area.

Marine mammals and threshold shifts. Exposure of marine mammals to very strong sound pulses can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Temporary threshold shifts (TTSs) can last minutes to days. Full recovery is expected and this condition is not considered a physical injury. At higher received levels, or in frequency ranges where animals are more sensitive, permanent threshold shifts (PTSs) can occur in which auditory sensitivity is unrecoverable. Either of these conditions can result from a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. TTS and PTS are specific only to the frequencies over which exposure occurs.

Few data are available to precisely define each listed species' hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports sound levels at a given frequency would need to be ~186 dB SEL or ~196-201 dB re 1 μPa_{rms} in order to produce a low-level TTS from a single pulse (Southall et al. 2007). If an individual experienced exposure to several airgun pulses of ~190 dB re 1 μPa_{rms}, PTS could occur. A marine mammal would have to be within 400 m of the *Langseth's* airgun array to be within the 190 dB re 1 μPa_{rms} isopleth and risk a TTS. PTS is expected at levels ~6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis (Southall et al. 2007). Estimates that are conservative for species protection are 230 dB re 1 μPa (peak) for a single pulse, or multiple exposures to ~198 dB re 1 $\mu Pa^2 \cdot s$. In terms of exposure to the *Langseth's* airgun array, an individual would need to be within a few meters of the largest airgun to experience a single pulse >230 dB re 1 μPa peak (Caldwell and Dragoset 2000).

Overall, we do not expect TTS or PTS to occur to any listed whale as a result of airgun exposure for several reasons. We expect that individuals will move away from the airgun array as it approaches. We further believe that as sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the sound source and thus avoid exposures that would induce TTS. Ramp-ups would also reduce the probability of TTS exposure at the start of seismic surveys. Furthermore, mitigation measures would be in place to initiate a ramp-down if individuals enter or are about to enter the 180 dB isopleth, which is below the levels believed to be necessary for potential TTS.

Marine mammals and auditory interference (masking). Interference, or masking, generally occurs when the interfering noise is of a similar frequency and similar to or louder than the auditory signal received by an animal processing echolocation signals or listening for acoustic information from other individuals. Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environment cues. 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).

There is frequency overlap between airgun noise and vocalizations of listed whales, particularly baleen whales. 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). 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, masking should not be a concern in the proposed action. This is primarily because masking tends to result from continuous sounds rather than short pulses, such as seismic airguns (Richardson et al. 1995b). The *Langseth's* airguns will emit a 0.1 s pulse when fired every 15-73 s. Therefore, pulses will not "cover up" the vocalizations of listed whales to a significant extent (Madsen et al. 2002). We address the response of listed whales stopping vocalizations as a result of airgun sound in behavioral responses.

Marine mammals and behavioral responses. We expect the greatest response to airgun sounds by number and overall impact to be from behavioral responses. Listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case the effects are unlikely to be individually significant. However, displacement from important feeding or breeding areas over a prolonged period would likely be significant. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors. Individual differences in responding to stressful stimuli also appear to exist and appear to have at least a partial genetic basis in trout (Laursen et al. 2011). Animals generally respond to anthropogenic perturbations as they would predators, increasing vigilance and altering habitat selection (Reep et al. 2011).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to airgun sound. Whales continue calling while seismic surveys are occurring locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002; McDonald et al. 1993; McDonald et al. 1995; Nieukirk et al. 2004; Richardson et al. 1986; Smultea et al. 2004; Tyack et al. 2003). However, some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995). A blue whale discontinued calls in response to received airgun sound of 143 dB re 1 μPa for 1 hour before resuming (McDonald et al. 1995). However, blue whales may instead attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). However, other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re 1 μPa$_{\text{p-p}}$ (Madsen et al. 2002; McCall Howard 1999). Some exposed individuals may cease calling in response to the *Langseth's* airguns. If individuals ceased calling in response to the *Langseth's* airguns during the course of the proposed survey, the effect would likely be temporary.

There are numerous studies of baleen whale responses to airguns. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of ~160 dB re 1 μPa$_{\text{rms}}$ as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c). However, activity of individuals seems to influence response, as feeding individuals seem to respond less than mother/calf pairs and migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999). Migrating bowhead whales show strong avoidance reactions to received 120–130 dB re 1 μPa$_{\text{rms}}$ exposures at distances of 20-30 km, but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152–178 dB re 1 μPa$_{\text{rms}}$; (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999; Richardson et al. 1986). Responses such as stress may occur and the threshold for displacement may simply be higher while feeding. Bowhead calling rate was found to decrease during migration in the Beaufort Sea as well as temporary displacement from seismic sources (Nations et al. 2009). Despite the above information and exposure to repeated seismic surveys, bowheads continue to return to summer feeding areas and when displaced, bowheads appear to reoccupy areas within a day (Richardson et al. 1986). We do not know whether the individuals exposed in these ensonified areas are the same returning individuals, if these individuals are less likely to return, or whether individuals that tolerate repeat exposures may still experience a stress response.

Gray whales respond similarly. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re 1 μPa$_{\text{rms}}$ (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984; Malme et al. 1986; Malme et al. 1988; Würsig et al. 1999; Yazvenko et al. 2007a; Yazvenko et al. 2007b). However, migrating gray whales began to show changes in swimming patterns at ~160 dB re 1 μPa and slight behavioral changes at 140-160 dB re 1 μPa$_{\text{rms}}$ (Malme and Miles 1985; Malme et al. 1984).

As with bowheads, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984). Johnson et al. (2007b) 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.

Humpback whales continue a pattern of lower threshold of response when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re 1 μPa_{rms} when females with calves were present, or 8-12 km from the seismic source (McCauley et al. 2000a; McCauley et al. 1998). However, a startle response occurred as low as 112 dB re 1 μPa_{rms}. Closest approaches were generally limited to 3-4 km, although some individuals (mainly males) approached to within 100 m on occasion where sound levels were 179 dB re 1 μPa_{rms}. Changes in course and speed generally occurred at estimated received level of 157–164 dB re 1 μPa_{rms}. Feeding humpbacks appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150–169 dB re 1 µPa and no clear evidence of avoidance was apparent at received levels up to 172 re 1 μPa_{rms} (Malme et al. 1984; Malme et al. 1985). However, Potter et al. (2007) found that humpbacks on feeding grounds in the Atlantic did exhibit localized avoidance to airguns. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008). However, remote sensing indicated that significant reductions in singing occurred when local seismic surveys were occurring, likely disrupting breeding behavior in the area (Gero et al. 2006).

Observational data are sparse for specific baleen whales and life history data (breeding and feeding grounds) are generally less well known. However, available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities) as well as whales being more distant during seismic operations (Moulton et al. 2006a; Moulton et al. 2006b; Moulton and Miller 2005). When spotted at the average sighting distance, individuals would have likely been exposed to ~169 dB re 1 μPa_{rms} (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found Atlantic sperm whales to show little or no response (Davis et al. 2000b; Madsen et al. 2006; Miller et al. 2009; Moulton et al. 2006a; Moulton and Miller 2005; Stone 2003; Stone and Tasker 2006; Weir 2008). However, detailed study of Gulf of Mexico sperm whales suggests some alteration in foraging from <130-162 dB re 1 μPa_{p-p}, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2004; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re 1 µPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally <188 Hz) pulses produced by seismic airguns (Richardson et al. 1995c). However, sperm whales are exposed to considerable energy above 500 Hz (Goold and Fish 1998). Breitzke et al. (2008) found that source levels were ~30 dB re 1 μPa lower at 1 kHz and 60 dB re 1 μPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. 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).

For sperm whales exposed to seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area. However, we also expect secondary foraging areas to be available that whales could continue feeding. In addition, we expect exposure of a given area to be brief and reoccupation can occur soon after the *Langseth* transects through. Although breeding may be occurring, we are unaware of any habitat features that sperm whales would be displaced from if sperm whales depart an area as a consequence of the *Langseth*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities.

Marine mammals and physical or physiological effects. Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress, that can significantly affect life history.

Stress is an adaptive response and does not normally place an animal at risk. However, distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal (HPA) axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Busch and Hayward 2009)(Gulland et al. 1999; Morton et al. 1995; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Kight and Swaddle 2011; NMFS 2006g)(Cattet et al. 2003; Delehanty and Boonstra 2009; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia et al. 2008; Moe and Bakken 1997; Noda et al. 2007; Thomson and Geraci 1986)(Dierauf and Gulland 2001; Omsjoe et al. 2009). Individual behavior with potential fitness consequences can also change as a result of anthropogenic-induced stress (Reep et al. 2011). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2008). In highly-stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan and Curry 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the HPA axis may persist for weeks (Dierauf and Gulland 2001). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Kenagy and Place 2000; Nunes et al. 2006; Romero et al. 2008; St. Aubin et al. 1996). Stress is lower in immature right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006; Kitaysky and Springer 2004).

Loud noises generally increase stress indicators in mammals and fishes (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re 1 μPa $\cdot$ m_{p-p}) and single pure tones (up to 201 dB re 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. However, these levels returned to baseline after 24 hours. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities would be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006g). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NMFS 2006g; NRC 2003). As we do not expect individuals to experience TTS or PTS, (see *Marine mammals and threshold shifts*), we also do not expect any listed individual to experience a stress response at high levels. We assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, the stressor (sounds associated with the airgun, multibeam echosounder, or sub-bottom profiler) will dissipate in a short period as the vessel (and stressor) transects away without significant or long-term harm to the individual via the stress response.

Exposure to loud noise can also adversely affect reproductive and metabolic physiology (Kight and Swaddle 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. In fish eggs and embryos exposed to sound levels only 15 dB greater than background, increased mortality was found and surviving fry had slower growth rates (a similar effect was observed in shrimp), although the opposite trends have also been found in seabream. Dogs exposed to loud music took longer to digest food. The small intestine of rats leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). Exposure to 12 hours of loud noise can alter elements of cardiac tissue. In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight and Swaddle 2011). It is noteworthy that although various exposures to loud noise appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa; the impacts of even loud sound are complex and not universally negative (Kight and Swaddle 2011).

Marine mammals and strandings. There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys.

Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). In September 2002, two Cuvier's beaked whales stranded in the Gulf of California, Mexico. The *R/V Ewing* had been operating a 20-airgun, 8,490-in^3 airgun array 22 km offshore the general area at the time that strandings occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002) as some vacationing marine mammal researchers who happened upon the stranding were ill-equipped to perform an adequate necropsy. Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between seismic sound sources and beaked whale strandings (Cox et al., 2006).

Responses of marine mammal prey. Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for listed whales. Unfortunately, species-specific information on the prey of listed whales is not generally available. Until more specific information is available, we expect that teleost, cephalopod, and krill prey of listed whales to react in manners similar to those described herein.

Some support has been found for fish or invertebrate mortality resulting from airgun exposure, and this is limited to close-range exposure to high-amplitudes (Bjarti 2002; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004). However, we expect fish to be capable of moving away from the airgun array if it causes them discomfort.

More evidence exists for sub-lethal effects. Several species at various life stages have been exposed to high-intensity sound sources (220-242 dB re 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). TTS was not found in whitefish at received levels of ~175 dB re 1 $\mu Pa^2 \cdot s$, but pike did show 10-15 dB of hearing loss with recovery within 1 day (Popper et al. 2005). Caged pink snapper have experienced PTS when exposed over 600 times to received seismic sound levels of 165-209 dB re 1 μPa_{p-p}.

By far the most common response by fishes is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column. Startle responses were observed in rockfish at received airgun levels of 200 dB re 1 μPa_{0-p} and alarm responses at >177 dB re 1 μPa_{0-p} (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20-60 minutes after seismic firing ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186–191 re 1 μPa_{0-p}. Caged European sea bass showed elevated stress levels when exposed to airguns, but levels returned to normal after 3 days (Skalski et al. 1992). These fish also showed a startle response when the survey vessel was as much as 2.5 km away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after ~2 hours following cessation of airgun activity. Whiting exhibited a downward distributional shift upon exposure to 178 dB re 1 μPa_{0-p} airgun sound, but habituated to the sound after 1 hour and returned to normal depth (sound environments of 185-192 dB re 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from airgun sound (Dalen and Knutsen 1986). Hake may redistribute downward (La Bella et al. 1996). Lesser sandeels exhibited initial startle responses and upward vertical movements before fleeing from the survey area upon approach of an active seismic vessel (Hassel et al. 2003; Hassel et al. 2004). McCauley et al. (2000; 2000a) found smaller fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156–161 dB re 1 μPa_{rms}, but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock did not respond to airgun sounds received at 195–218 dB re 1 μPa_{0-p}, but did exhibit continual startle responses and fled from the seismic source when visible (Wardle et al. 2001). Blue whiting and mesopelagic fishes were found to redistribute 20–50 m deeper in response to airgun ensonification and a shift away from the survey area was also found (Slotte et al. 2004). Salmonid swim bladders were reportedly damaged by received sound levels of ~230 dB re 1 μPa (Falk and Lawrence 1973). Startle responses were infrequently observed from salmonids receiving 142–186 dB re 1 $\mu Pa_{p\text{-}p}$ sound levels from an airgun (Thomsen 2002). Cod and haddock likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160–180 dB re 1 $\mu Pa_{0\text{-}p}$ (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994). However, bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163–191 dB re 1 $\mu Pa_{0\text{-}p}$ (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a 4-5 month seismic survey (Pickett et al. 1994).

Squid responses to airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re 1 μPa_{rms} by first ejecting ink and then moving rapidly away from the area (McCauley et al. 2000a; McCauley et al. 2000b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156–161 dB re 1 μPa_{rms}

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We do not expect krill (the primary prey of most listed baleen whales) to experience effects from airgun sound. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales. However, sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed survey. Based upon the best available information, fishes and squids ensonified by the ~160 dB isopleths could vacate the area and/or dive to greater depths, and be more alert for predators. We do not expect indirect effects from airgun activities through reduced feeding opportunities sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both sperm whales and their prey would re-distribute back into the area once survey activities have passed.

Marine mammal response to multibeam echosounder and sub-bottom profiler. We expect listed whales to experience ensonification from not only airguns, but also seafloor mapping systems. However, multibeam echosounder and sub-bottom profiler frequencies are much higher than frequencies used by all listed whales except humpback and sperm whales. Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80-90 dB re 1 μPa range, it is difficult to determine the significance of this because the source was a signal designed to be alarming and the sound level was well below typical ambient noise. Hearing is poorly understood for listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multibeam echosounder and sub-bottom profiler systems (Ketten 1997; Richardson et al. 1995c). Thus, if sei whales are exposed, they are unlikely to hear these frequencies well (if at all) and a response is not expected.

Assumptions for humpback and sperm whale hearing are much different than for other listed whales. Humpback and sperm whales vocalize between 3.5-12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002; Frazer and Mercado 2000; Goold and Jones 1995; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Weir et al. 2007; Winn et al. 1970). Maybaum (1990; 1993) observed that Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1-3.6 kHz sonar. 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. Sperm whales have stopped vocalizing in response to 6-13 kHz pingers, but did not respond to 12 kHz echo-sounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975).

We do not expect masking of sperm or humpback whale communications to appreciably occur due to multibeam echosounder or sub-bottom profiler signal directionality, low duty cycle, and the brief period when an individual could be within its beam.

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. However, the sonars proposed for use by L-DEO differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multibeam echosounder and sub-bottom profiler. The sound energy received by any individuals exposed to the multibeam echosounder and sub-bottom profiler sources during the proposed activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multibeam echosounder and sub-bottom profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Although thousands of vessels around the world operate navigational sonars routinely, stranding incidence has not been associated with use of these sonars. Because of these differences, we do not expect these systems to contribute to a stranding event.

Sea turtles

Sea turtle response to airguns. As with marine mammals, sea turtles may experience

- threshold shifts
- behavioral responses
- non-auditory physical or physiological effects

Sea turtles and threshold shifts. Few data are available to assess sea turtle hearing, let alone the effects seismic equipment may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead experienced TTS upon multiple airgun exposures in a shallow water enclosure, but recovered within 1 day.

Although data on the precise levels that can result in TTS or PTS are lacking, we do not expect either of these to occur to any sea turtle as a result of the proposed action. As with marine mammals, we assume that sea turtles will not move towards a source of stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sources (McCauley et al. 2000a; McCauley et al. 2000b; Moein et al. 1994), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of seismic airgun pulses (Smultea and Holst 2003). For this reason, mitigation measures are also in place to limit sea turtle exposure. We do not expect reduction in foraging opportunities by the proposed action.

Sea turtles and behavioral responses. As with listed whales, it is likely that sea turtles will experience behavioral responses in the form of avoidance. O'Hara and Wilcox (1990) found loggerhead sea turtles exhibited an avoidance reaction at an estimated sound level of 175–176 dB re 1 µPa $_{rms}$ (or slightly less) in a shallow canal (McCauley et al. 2000a). Green and loggerhead sea turtles avoided airgun sounds at received sound levels of 166 dB re 1 µPa and 175 dB re 1 µPa, respectively (McCauley et al. 2000a; McCauley et al. 2000b). Sea turtle swimming speed increased and becomes more erratic at 175 dB re 1 µPa, with individuals becoming agitated. Loggerheads also appeared to move towards the surface upon airgun exposure (Lenhardt 1994; Lenhardt et al. 1983). Recent monitoring studies show that some sea turtles move away from approaching airguns, although sea turtles may approach active seismic arrays within 10 m (Holst et al. 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006e; NMFS 2006h).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are expected when sound levels rise above received sound levels of 166 dB re 1 µPa. This corresponds with previous reports of sea turtle hearing thresholds being generally higher than for marine mammals (DFO 2004). At 166 dB re 1 µPa, we anticipate some change in swimming patterns and a stress response of exposed individuals. Some turtles may approach the active seismic array to closer proximity, but we expect them to eventually turn away. We expect temporary displacement of exposed individuals from some portions of the action area while the *Langseth* transects through. We are aware of a single stranding event associated with a seismic survey involving 30 dead sea turtles (Jaszy and Horowitz 2005). Evidence linking the survey with the stranding is inconclusive and characteristics of that survey (shallow nearshore waters) are dissimilar to the proposed survey. We do not expect lethal effects on sea turtles for the proposed survey or an appreciable reduction in their feeding potential.

Sea turtles and stress. Direct evidence of seismic sound causing stress is lacking in sea turtles. However, sea turtles actively avoid high-intensity exposure to airguns in a fashion similar to predator avoidance. As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles experience a stress response to airguns when they exhibit behavioral avoidance or when they are exposed to sound levels apparently sufficient to initiate an avoidance response (~166 dB re 1 µPa). We expect breeding adult females may experience a lower stress response, as female loggerhead, hawksbill, and green sea turtles appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). Individuals may experience a stress response at levels lower than ~166 dB re 1 µPa, but data are lacking to evaluate this possibility.

Response of sea turtles to multibeam echosounder and subbottom profiler. Sea turtles do not possess a hearing range that includes frequencies emitted by these systems. Therewfore, listed sea turtles will not hear these sounds even if they are exposed and are not expected to respond to them.

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.

We expect that those aspects described in the *Environmental baseline* will continue to impact listed resources into the foreseeable future. We expect climate change, ship-strikes, bycatch, and harvests to continue into the future. Movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring through the Pacific Ocean, which may aid in abating the downward trajectory of sea turtle populations.

Integration and synthesis of effects

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 (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if the assessment indicates that 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) to which those individuals belong, and then to the species those population(s) represent.

Listed whales. The NSF proposes to fund a seismic survey by L-DEO that could incidentally harass three listed whale species. These species include: sei whales (*Balaenoptera borealis*), humpback whales (*Megaptera novaeangliae*), and sperm whales (*Physeter macrocephalus*), all of whom are endangered throughout their ranges.

The *Status of listed resources* section identified commercial whaling as the primary reason for reduced populations, many of whom are a small fraction of their former abundance. Although large-scale commercial harvests no longer occur for these species, some harvests from subsistence and scientific research in regional and worldwide populations still occur. Other worldwide threats to the survival and recovery of listed whale species include: ship strike, entanglement in fishing gear, toxic chemical burden and biotoxins, ship noise, competition with commercial fisheries, and killer whale predation. Populations of whales inhabiting the west central North Pacific face area-specific threats identified in the *Environmental baseline,* including: altered prey base and habitat quality as a result of global warming, human noise sources, ship strike, and entanglement.

Despite these pressures, available trend information indicate most populations of listed whales are stable or increasing. As previously mentioned, the *Cumulative effects* section identifies actions in the *Environmental baseline* we expect to generally continue for the foreseeable future.

The *Effects analysis* supports the conclusion of harassment to low numbers of listed whales by proposed seismic activities. We expect exposure of up to eight sei, 30 humpback, and 24 sperm whales to airgun sounds which will elicit a behavioral response of temporarily moving out of the area. We expect a low-level, transitory stress response to accompany this behavior. The number of individuals exposed represent a tiny fraction of the populations and reactions should not limit the fitness of any single individual. The other actions we considered in the Opinion, the operation of multibeam echosounder and sub-bottom profiler systems, are not expected to be audible to sei whales and consequently are not expected to have any direct effects on this species. However, humpback and sperm whales could hear sounds produced by these systems. Responses could include cessation of vocalization by sperm whales and/or movement out of the survey area by both species. We do not expect these effects to have fitness consequences for any individual. The *Effects analysis* also found that, although sperm whales may experience temporarily reduced feeding opportunities, this indirect effect would be transient and not reduce individual fitness of any whale. Overall, we do not expect a fitness reduction to any individual whale. As such, we do not expect fitness consequences to populations or listed whale species as a whole. We do not expect jeopardy to any whale species as a consequence of the proposed action.

Listed turtles. Listed turtles that are expected to occur within the action area include endangered leatherback sea turtles. The *Status of listed resources* section found that most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and turtles, as well as severe bycatch pressure in worldwide fishing industries. As previously mentioned, the *Cumulative effects* section identified actions in the *Environmental baseline* (including bycatch, harvest, and climate change) to generally continue for the foreseeable future.

From the *Effects analysis*, we expect that leatherback sea turtles could experience exposure to airgun sounds and be harassed by these sounds. These sounds may induce a temporary effect in low-level stress levels, swimming patterns, and movement out of the action area. Population size is not available to calculate the subset of each population affected. Data were not available to calculate the number of exposures, but we do not expect the number of ensonifications to alter critical life functions. We do expect transient responses that do not affect the fitness of any one individual. We do not expect impairment of local nesting by the proposed survey. As we do not expect any sea turtle to be capable of hearing signals produced by the multibeam echosounder and sub-bottom profiler systems, we do not expect direct effects from these systems on sea turtle fitness. We do not anticipate any indirect effects from the proposed actions to influence sea turtles. Overall, we do not expect any individual sea turtle to undergo a fitness.

Conclusion

After reviewing the current status of sei, humpback, and sperm whales as well as leatherback sea turtles; the *Environmental baseline* for the action area; the anticipated effects of the proposed activities; and the *Cumulative effects*, it is the NMFS' Opinion that the actions (NSF's funding of and the Permits Division's issuance of an IHA for seismic surveys off the Northern Marianas Islands) are not likely to jeopardize the continued existence of these species. Similarly, it is the NMFS' Opinion that the issuance of an IHA by the NMFS' Permits Division for harassment that would occur incidental to the proposed action is not likely to jeopardize the continued existence of these species. No critical habitat co-occurs within the action area and thus the proposed action would have no effect on critical habitat.

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 the NMFS as an act which actually kills or injures wildlife, which may include significant habitat modification or degradation which actually kills or injures fish or wildlife 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 NSF and the Permits Division so that they become binding conditions for L-DEO 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, the 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 the Permits Division's proposed authorization of the incidental taking of sei, humpback, and sperm whales pursuant to Section 101(a)(5)(D) of the MMPA. 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.

The NMFS anticipates the incidental harassment of sei whales (*Balaenoptera borealis*), humpback whales (*Megaptera novaeanigliae*), and sperm whales (*Physeter macrocephalus*) during the proposed seismic activities.

Amount or extent of take

The NMFS anticipates the proposed seismic survey in the Pacific Ocean off the Marianas Islands might result in the incidental take of listed species. The proposed action is expected to take up to eight sei whales, 30 humpback whales, and 24 sperm whales by exposing individuals to received seismic sound levels greater than 160 dB re 1 μPa by harassment. These estimates are based on the best available information of whale densities in the area to be ensonified above 160 dB re 1 μPa during the proposed activities. This incidental take would result primarily from exposure to acoustic energy during seismic operations and 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 expect the proposed action will also take individual leatherback sea turtles as a result of exposure to acoustic energy during seismic studies, and we expect this take would also be in the form of harassment, with no death or injury expected for individuals exposed. Harassment of sea turtles is expected to occur at received levels above 166 dB re 1 μPa. As we cannot determine the number of individuals to which harassment will occur, we expect the extent of exposure will occur within the 166 dB isopleth of the *Langseth's* airgun array.

Harassment of sei, humpback, and sperm whales exposed to seismic studies at levels less than 160 dB re 1 µPa is not expected. However, if overt adverse reactions (for example, startle responses, dive reactions, or rapid departures from the area) by listed whales are observed outside of the 160 dB or 166 dB re 1 µPa isopleths, respectively, while airguns are operating, incidental take may be exceeded. If such reactions by listed species are observed while airguns, multibeam echosounder, or sub-bottom profiler are in operation, this may constitute take that is not covered in this Incidental Take Statement. The NSF and the Permits Division must contact the Endangered Species Act Interagency Cooperation Division to determine whether reinitiation of consultation is required because of such operations.

Any incidental take of sei whales, humpback whales, and sperm whales as well as leatherback sea turtles is restricted to the permitted action as proposed. If the actual incidental take meets or exceeds the predicted level, the NSF and Permits Division must reinitiate consultation. All anticipated takes would be "takes by harassment", as described previously, involving temporary changes in behavior.

Reasonable and prudent measures

The NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impact of incidental take of listed whales and sea turtles resulting from the proposed action. These measures are non-discretionary and must be binding conditions of the NSF funding of the proposed seismic studies and the NMFS' authorization for the exemption in Section 7(o)(2) to apply. If the NSF or the NMFS fail to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse.

1. For listed sea turtle and marine mammal species these measures include the following; vessel-based visual monitoring by marine mammal and sea turtle observers; real-time passive acoustic monitoring by marine mammal and sea turtle observers; speed or course alteration as practicable; implementation of a marine mammal and sea turtle exclusion zone within the 180 dB re 1 μPa_{rms} isopleth for power-down and shut-down procedures; emergency shutdown procedures in the event of an injury or mortality of a listed marine mammal or sea turtle; and ramp-up procedures when starting up the array. The measures for marine mammals are required to be implemented through the terms of the IHA issued under section 101(a)(5)(D) and 50 CFR 216.107.
2. The implementation and effectiveness of mitigation measures incorporated as part of the Reasonable and Prudent Measure mentioned above and the associated Terms and Conditions must be monitored.

Terms and conditions

In order to be exempt from the prohibitions of Section 9 of the ESA, the NSF, Permits Division, and L-DEO must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These terms and conditions are non-discretionary.

To implement the Reasonable and Prudent Measures, the NSF and the NMFS shall ensure that

1. L-DEO implements the mitigation, monitoring, and reporting conditions contained in the IHA and this Opinion.

2. The Chief of the Endangered Species Act Interagency Cooperation Division is immediately informed of any changes or deletions to any portions of the monitoring plan or IHA.
3. L-DEO immediately reports all sightings and locations of injured or dead endangered and threatened species to the Permits Division and NSF.
4. The NSF and the Permits Division provide a summary of the implementation and effectiveness of the terms of the IHA to the Chief of the Endangered Species Act Interagency Cooperation Division. This report shall confirm the implementation of each term and summarize the effectiveness of the terms for minimizing the adverse effects of the project on listed whales and sea turtles.

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. *Effects of seismic noise on sea turtles.* The NSF should promote and fund research examining the potential effects of seismic surveys on listed sea turtle species.

In order for the 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, the Permits 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 seismic source survey to be funded by the NSF and conducted by the L-DEO on board the *R/V Langseth* in the Pacific Ocean off the Northern Marianas Islands, and the issuance of an incidental harassment authorization for the proposed studies pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA). As provided in 50 CFR §402.16, consultation must be reinitiated if 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.

Literature Cited

Abraham, T., and coauthors. 2004. Status of the coral reefs in Micronesia and American Samoa. Pages 381-409 *in* R. Kelty, and J. Kuartei, editors. Status of Coral Reefs of the World. Australian Institute of Marine Science, Townsville, Queensland.

Acevedo-Whitehouse, K., and A. L. J. Duffus. 2009. Effects of environmental change on wildlife health. Philosophical Transactions of the Royal Society of London B Biological Sciences 364(1534):3429-3438.

Aguilar, A. 1983. Organochlorine pollution in sperm whales, Physeter macrocephalus, from the temperate waters of the eastern North Atlantic. Marine Pollution Bulletin 14(9):349-352.

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

Andrew, R. K., B. M. Howe, and J. A. Mercer. 2002. Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. Journal of the Acoustical Society of America 3:65-70.

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

Andriolo, A., P. G. Kinas, M. H. Engel, C. C. Albuquerque Martins, and A. M. Rufino. 2010. Humpback whales within the Brazilian breeding ground: distribution and population size estimate. Endangered Species Research 11(3):233-243.

Angliss, R. P., and A. L. Allen. 2007. Draft Alaska marine mammal stock assessments 2008. National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, Washington.

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 K. L. Lodge. 2004. Alaska marine mammal stock assessments, 2003. NOAA Technical Memorandum NMFS-AFSC-144. 230pp.

Angliss, R. P., and R. B. Outlaw. 2005. Alaska marine mammal stock assessments, 2005. U.S. Department of Commerce, NOAA Technical Memorandum NMFSAFSC-161, 250 p.

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

Atkinson, A., V. Siegel, E. Pakhomov, and P. Rothery. 2004. Long-term decline in krill stock and increase in salps within the Southern Ocean. Nature 432:100-103.

Au, W. W. L. 2000. Hearing in whales and dolphins: an overview. Chapter 1 *In:* Au, W.W.L., A.N. Popper, and R.R. Fay (eds), Hearing by Whales and Dolphins. Springer-Verlag New York, Inc. pp.1-42.

Au, W. W. L., and coauthors. 2006. Acoustic properties of humpback whale songs. Journal of the Acoustical Society of America 120(2):1103-1110.

Backus, R. H., and W. E. Schevill. 1966. Physeter clicks. Pages 510-528 *in* K. S. Norris, editor. Whales, dolphins, and porpoises. University of California Press, Berkeley, California.

Bain, D. E., and R. Williams. 2006. Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. International Whaling Commission Working Paper SC/58/E35.

Baker, C. S. 1985. The behavioral ecology and populations structure of the humpback whale (*Megaptera novaeangliae*) in the central and eastern Pacific. Unpublished Dissertation. University of Hawaii at Manoa.

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

Baker, N., P. Fryer, F. Martinez, and T. Yamazaki. 1996. Rifting history of the northern Mariana Trough:

SeaMARC II and seismic reflection surveys. Journal of Geophysical Research 101(B5):11427-11455.

Balcomb III, K. C., and G. Nichols, Jr. 1982. Humpback whale censuses in the West Indies. Report of the International Whaling Commission 32:401-406.

Bannister, J. C. 2005. Intersessional working group on Southern Hemisphere humpback whales: revised tables by breeding stock (as at 1 May 2005). IWC Paper SC/57/SH11. 15p.

Baraff, L., and M. T. Weinrich. 1993. Separation of humpback whale mothers and calves on a feeding ground in early autumn. Marine Mammal Science 9(4):431-434.

Barendse, J., and coauthors. 2010. Migration redefined? Seasonality, movements and group composition of humpback whales Megaptera novaeangliae off the west coast of South Africa. African Journal of Marine Science 32(1):1-22.

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

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon, and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, California.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464.

Barlow, J., and coauthors. 2009. Humpback whale abundance in the North Pacific estimated by phographic capture-recapture with bias correction from simulation studies. Pages 25 *in* 18th Biennial Conference on the Biology of Marine Mammals.

Barlow, J., and coauthors. 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.

Barlow, J., and B. L. Taylor. 2005. Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. Marine Mammal Science 21(3):429-445.

Benson, S. R., and coauthors. 2007a. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6(1):150-154.

Benson, S. R., and coauthors. 2011a. Large-scale movements and high-use areas of western Pacific leatherback turtles, Dermochelys coriacea. Ecosphere 2(7).

Benson, S. R., and coauthors. 2011b. Large-scale movements and high-use areas of western Pacific leatherback turtles,Dermochelys coriacea. Ecosphere 2(7):art84.

Benson, S. R., and coauthors. 2007b. Beach use, internesting movement, and migration of leatherback turtles, *Dermochelys coriacea*, nesting on the north coast of Papua New Guinea. Chelonian Conservation and Biology 6(1):7-14.

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. 1972. The sperm whale. Pacific Scientific Research Institute of Fisheries and Oceanography, Moscow. (Translated from Russian 1971 version by Israel Program for Scientific Translation, Jerusalem).

Best, P. B., P.A.S. Canham, and N. Macleod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Report of the International Whaling Commission Special Issue 8:51-79.

Biggs, D. C., R. R. Leben, and J. G. Ortega-Ortiz. 2000. Ship and satellite studies of mesoscale circulation and sperm whale habitats in the northeast Gulf of Mexico during GulfCet II. Gulf of Mexico Science 2000(1):15-22.

Binckley, C. A., J. R. Spotila, K. S. Wilson, and F. V. Paladino. 1998. Sex determination and sex ratios of Pacific leatherback turtles, *Dermochelys coriacea*. Copeia 2(291-300).

Bjarti, T. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen.

Bjorndal, K. A., and A. B. Bolten. 2000. Proceedings on a workshop on accessing abundance and trends for in-water sea turtle populations. NOAA.

Bjorndal, K. A., and A. B. Bolten. 2010. Hawksbill sea turtles in seagrass pastures: success in a peripheral habitat. Marine Biology 157:135-145.

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].

Boehlert, G. W., and A. Genin. 1987. A review of the effects of seamounts on biological processes. Pages 319-334 *in* B. H. Keating, P. Fryer, R. Batiza, and G. W. Boehlert, editors. Seamounts, islands, and atolls. American Geophysical Union, Washignton, D.C.

Booman, C., and coauthors. 1996. Effecter av luftkanonskyting på egg, larver og yngel. Fisken Og Havet 1996(3):1-83.

Borrell, A. 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. Marine Pollution Bulletin 26(3):146.

Borrell, A., and A. Aguilar. 1987. Variations in DDE percentage correlated with total DDT burden in the blubber of fin and sei whales. Marine Pollution Bulletin 18:70-74.

Bouchard, S., and coauthors. 1998. Effects of exposed pilings on sea turtle nesting activity at Melbourne Beach, Florida. Journal of Coastal Research 14(4):1343-1347.

Bourgeois, S., E. Gilot-Fromont, A. Viallefont, F. Boussamba, and S. L. Deem. 2009. Influence of artificial lights, logs and erosion on leatherback sea turtle hatchling orientation at Pongara National Park, Gabon. Biological Conservation 142(1):85-93.

Bowlby, C. E., G. A. Green, and M. L. Bonnell. 1994. Observations of leatherback turtles offshore of Washington and Oregon. Northwestern Naturalist 75:33-35.

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.

Boyd, I. L. 2002. Antarctic marine mammals. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig AND J. G. M. Thewissen (eds.). p.30-36. Academic Press, San Diego, CA. 1414pgs.

Boye, T. K., M. Simon, and P. T. Madsen. 2010. Habitat use of humpback whales in Godthaabsfjord, West Greenland, with implications for commercial exploitation. Journal of the Marine Biological Association of the United Kingdom in press(in press):in press.

Boyle, M. C., and C. J. Limpus. 2008. The stomach contents of post-hatchling green and loggerhead sea turtles in the southwest Pacific: an insight into habitat association. Marine Biology 155(2):233-241.

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.

Brashares, J. S. 2003. Ecological, behavioral, and life-history correlates of mammal extinctions in West Africa. Conservation Biology 17:733-743.

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, Cambridge, United Kingdom.

Breitzke, M., O. Boebel, S. El Naggar, W. Jokat, and B. Werner. 2008. Broad-band calibration of marine seismic sources used by R/V *Polarstern* for academic research in polar regions. Geophysical Journal International 174:505-524.

Brito, J. L. 1998. The marine turtle situation in Chile. Pages 12-15 *in* S. P. Epperly, and J. Braun, editors. Seventeenth Annual Symposium on Sea Turtle Biology and Conservation. .

Brodie, P., and G. Vikingsson. 2009. On the feeding mechanisms of the sei whale (Balaenoptera borealis). Journal of Northwest Atlantic Fishery Science 42(Article No.5):49-54.

Brown, C. J., and coauthors. 2009. Effects of climate-driven primary production change on marine food webs: implications for fisheries and conservation. Global Change Biology 16(4):1194-1212.

Buchanan, R. A., J. R. Christian, S. Dufault, and V. D. Moulton. 2004. Impacts of underwater noise on threatened or endangered species in United States waters. American Petroleum Institute, LGL Report SA791, Washington, D.C.

Busch, D. S., and L. S. Hayward. 2009. Stress in a conservation context: A discussion of glucocorticoid actions and how levels change with conservation-relevant variables. Biological Conservation 142:2844-2853.

Butterworth, D. S., D. L. Borchers, S. Chalis, and J. B. DeDecker. 1995. Estimation of abundance for Southern Hemisphere blue, fin, sei, humpback, sperm, killer, and pilot whales from the 1978/79 to 1990/91 IWC/IDCR sighting survey cruises, with extrapolations to the area south of 30° for the first five species based on Japanese scouting vessel data. Unpubl. doc. SC/46/SH24 submitted to the Report of the International Whaling Commission, 54 p.

Byrne, R., J. Fish, T. K. Doyle, and J. D. R. Houghton. 2009. Tracking leatherback turtles (Dermochelys coriacea) during consecutive inter-nesting intervals: Further support for direct transmitter attachment. Journal of Experimental Marine Biology and Ecology 377(2):68-75.

Calambokidis, J. 1997. Humpback whales and the California - Costa Rica connection. Whales. Journal of the Oceanic Society Fall 1997:4-10.

Calambokidis, J., and coauthors. 2008. SPLASH: Structure of populations, levels of abundance, and status of humpback whales in the North Pacific. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington.

Calambokidis, J., and coauthors. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science 17(4):769-794.

Calambokidis, J., and coauthors. 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.

Calkins, D. G. 1986. Marine Mammals. In The Gulf of Alaska, Physical Environment and Biological Resources:D.W. Hood and S.T. Zimmerman (editors), Government Printing Office, Washington, D.C. p.527‒558.

Carder, D. A., and S. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale. Journal of the Acoustic Society of America 88(Supplement 1):S4.

Cardillo, M. 2003. Biological determinants of extinction risk: Why are smaller species less vulnerable? Animal Conservation 6:63-69.

Cardillo, M., G. M. Mace, K. E. Jones, and J. Bielby. 2005. Multiple causes of high extinction risk in large mammal species. Science 309:1239-1241.

Cardona, L., A. Aguilar, and L. Pazos. 2009. Delayed ontogenic dietary shift and high levels of omnivory in green turtles (Chelonia mydas) from the NW coast of Africa. Marine Biology 156(7):1487-1495.

Carretta, J. V., and K. A. Forney. 1993. Report of the 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. NMFS, SWFSC.

Carretta, J. V., and coauthors. 2008. Draft U.S. Pacific marine mammal stock assessments: 2008. Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-XXX.

Carretta, J. V., and coauthors. 2005. U.S. Pacific Marine Mammal Stock Assessments - 2004. .U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-375, 322p.

Carretta, J. V., and coauthors. 2006. U.S. Pacific Marine Mammal Stock Assessments: 2005. U.S. Department of Commerce NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-388. 325p.

Casale, P., P. Nicolosi, D. Freggi, M. Turchetto, and R. Argano. 2003. Leatherback turtles (Dermochelys coriacea) in Italy and in the Mediterranean basin. Herpetological Journal 13:135-139.

Cattanach, K. L., J. Sigurjónsson, S. T. Buckland, and T. Gunnlaugsson. 1993. Sei whale abundance in the North Atlantic estimated from NASS-87 and NASS-89 data. Report of the International Whaling Commission 43:315-321.

Caurant, F., P. Bustamante, M. Bordes, and P. Miramand. 1999. Bioaccumulation of cadmium, copper and zinc in some tissues of three species of marine turtles stranded along the French Atlantic coasts. Marine Pollution Bulletin 38(12):1085-1091.

Caut, S., E. Guirlet, and M. Girondot. 2009a. Effect of tidal overwash on the embryonic development of leatherback turtles in French Guiana. Marine Environmental Research 69(4):254-261.

Caut, S., E. Guirlet, and M. Girondot. 2009b. Effect of tidal overwash on the embryonic development of leatherback turtles in French Guiana. Marine Environmental Research in press(in press):in press.

CETAP. 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf.Cetacean and Turtle Assessment Program, University of Rhode Island. Final Report #AA551-CT8-48 to the Bureau of Land Management, Washington, DC, 538 pp.

Chacón-Chaverri, D., and K. L. Eckert. 2007. Leatherback sea turtle nesting at Gandoca Beach in Caribbean Costa Rica: Management recommendations from fifteen years of conservation. Chelonian Conservation and Biology 6(1):101-110.

Chacón Chaverri, D. 1999. Anidacíon de la tortuga *Dermochelys coriacea* (Testudines: Dermochelyidae) en playa Gandoca, Costa Rica (1990 a 1997). Revista de Biologia Tropical 47(1-2):225-236.

Chan, E. H., and H. C. Liew. 1996. Decline of the leatherback population in Terengganu, Malaysia, 1956-1995. Chelonian Conservation and Biology 2(2):196-203.

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.

Cheung, W. W. L., and coauthors. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Global Change Biology 16:24-35.

Christal, J., and H. Whitehead. 1997. Aggregations of mature male sperm whales on the Galápagos Islands breeding ground. Marine Mammal Science 13(1):59-69.

Christal, J., H. Whitehead, and E. Lettevall. 1998. Sperm whale social units: variation and change. Canadian Journal of Zoology 76:1431-1440.

Christensen, I., T. Haug, and N. Øien. 1992a. A review of feeding, and reproduction in large baleen whales (Mysticeti) and sperm whales Physeter macrocephalus in Norwegian and adjacent waters. Fauna Norvegica Series A 13:39-48.

Christensen, I., T. Haug, and N. Øien. 1992b. 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., and coauthors. 2009. Catches of humpback whales, Megaptera novaeangliae, by the Soviet Union and other nations in the Southern Ocean, 1947–1973. Marine Fisheries Review 71(1):39-43.

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., and coauthors. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71:440-443.

Clapham, P. J., and coauthors. 2003. Abundance and demographic parameters of humpback whales in the Gulf of Maine, and stock definition relative to the Scotian shelf. Journal of Cetacean Research and Management 5(1):13-22.

Clapham, P. J., and C. A. Mayo. 1987. Reproduction and recruitment of individually identified humpback whales, *Megaptera novaeangliae*, observed in Massachusetts Bay, 1979-1985. Canadian Journal of Zoology 65:2853-2863.

Clapham, P. J., and C. A. Mayo. 1990. Reproduction of humpback whales (*Megaptera novaeangliae*) observed in the Gulf of Maine. Report of the International Whaling Commission Special Issue 12:171-175.

Clapham, P. J., S. B. Young, and R. L. Brownell Jr. 1999. Baleen whales: conservation issues and the status of the most endangered populations. Mammal Review 29(1):35-60.

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 G. C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales.

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

Clarke, M. R. 1977. Beaks, nets and numbers. Symposium of the Zoological Society of London 38:89-126.

Clarke, M. R. 1980a. Cephalopods in the diet of sperm whales of the Southern Hemisphere and their bearing on sperm whale biology. Discovery Reports 37.

Clarke, M. R. 1996. Cephalopods as prey. III. Cetaceans. Philosophical Transactions of the Royal Society of London B 351:1053-1065.

Clarke, M. R. 1997. Cephalopods in the stomach of a sperm whale stranded between the islands of Terschelling and Ameland, southern North Sea. Bulletin de L'Institut Royal des Sciences Naturelles de Belgique, Biologie 67-Suppl.:53-55.

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

Clarke, R. 1980b. Catches of sperm whales and whalebone whales in the southeast Pacific between 1908 and 1975. Report of the International Whaling Commission 30:285-288.

Cohen, A. N., and B. Foster. 2000. The regulation of biological pollution: preventing exotic species invasions from ballast water discharged into california coastal waters. Golden Gate University Law Review 30(4):787-773.

Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005. Mortality and seriously injury determinations for North Atlantic Ocean large whale stocks 1999-2003. Northeast Fisheries Science Center Reference Document 05-08:U.S. Department of Commerce, NOAA, National Marine Fisheries Service Northeast Fisheries Science Center. Woods Hole, MA. 18p.

Collard, S. B. 1990. Leatherback turtles feeding near a watermass boundary in the eastern Gulf of Mexico. Marine Turtle Newsletter 50:12-14.

Cowan, D. E., and B. E. Curry. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical pacific ocean: Research planning. National Marine Fisheries Service, Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-254.

Cowan, D. E., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery. National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS SWFSC administrative report LJ-02-24C.

Cowan, D. E., and B. E. Curry. 2008. Histopathology of the alarm reaction in small odontocetes. Journal of Comparative Pathology 139(1):24-33.

Cowan, E., and coauthors. 2002. Influence of filtered roadway lighting on the seaward orientation of hatchling sea turtles. Pages 295-298 *in* A. Mosier, A. Foley, and B. Brost, editors. Twentieth Annual Symposium on Sea Turtle Biology and Conservation.

Cranford, T. W. 1992. Functional morphology of the odontocete forehead: implications for sound generation. University of California at Santa Cruz, Santa Cruz, California.

Crognale, M. A., S. A. Eckert, D. H. Levenson, and C. A. Harms. 2008. Leatherback sea turtle Dermochelys coriacea visual capacities and potential reduction of bycatch by pelagic longline fisheries. Endangered Species Research 5:249-256.

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical report for LFA EIS, 28 February 1999. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz. 437p.

Curran, M. A. J., T. D. v. Ommen, V. I. Morgan, K. L. Phillips, and A. S. Palmer. 2003. Ice core evidence for Antarctic sea ice decline since the 1950s. Science 302(5648):1203-1206.

Dalen, J., and G. M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. Pp.93-102 In: H.M. Merklinger (Ed), Progress in Underwater Acoustics. Plenum, New York. 839p.

Dalla Rosa, L., E. R. Secchi, Y. G. Maia, A. N. Zerbini, and M. P. Heide-Jørgensen. 2008. Movements of satellite-monitored humpback whales on their feeding ground along the Antarctic Peninsula. Polar Biology 31(7):771-781.

Danilewicz, D., M. Tavares, I. B. Moreno, P. H. Ott, and C. C. Trigo. 2009. Evidence of feeding by the humpback whale (Megaptera novaeangliae) in mid-latitude waters of the western South Atlantic. Jmba2 - Biodiversity Records-Published Online 3Pgs.

Darling, J. D., and K. Mori. 1993. Recent observations of humpback whales (Megaptera novaeangliae) in Japanese waters, Ogasawara, and Okinawa. Canadian Journal of Zoology 71:325-333.

Darling, J. D., and H. Morowitz. 1986. Census of Hawaiian humpback whales (*Megaptera novaeangliae*) by individual identification. Canadian Journal of Zoology 64(1):105-111.

Darnitsky, V. B. 1980. On the synoptic variability of the geostrophic circulation in areas of underwater elevations in the North Pacific Ocean, Leningrad.

Davenport, J., and G. H. Balazs. 1991. “Fiery bodies” – are pyrosomas an important component of the diet of leatherback turtles? The British Herpetological Society Bulletin 31:33-38.

Davenport, J., J. Wrench, J. McEvoy, and V. Carnacho-Ibar. 1990. Metal and PCB concentrations in the "Harlech" leatherback. Marine Turtle Newsletter 48:1-6.

Davis, G. Guam turtle history. Guam Division of Aquatic and Wildlife Resources, Mangilao, Guam.

Davis, R. W., W. E. Evans, and B. Würsig. 2000a. 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.

Davis, R. W., W. E. Evans, and B. Würsig. 2000b. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume II: Technical Report. 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 2000-03. 364p.

Davis, R. W., W. E. Evans, and B. Würsig. 2000c. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume III: Data Appendix. 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 2000-04. 229p.

Davis, R. W., and coauthors. 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. Deep Sea Research, Part 1: Oceanographic Research Papers 49(1):121-142.

Deem, S. L., and coauthors. 2007. Artificial lights as asignificant cause of morbidity of leatherback sea turtles in Pongara National Park, Gabon. Marine Turtle Newsletter 116:15-17.

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.

Dierauf, L., and F. Gulland. 2001. CRC Handbook of Marine Mammal Medicine. CRC Press, Boca Raton, Florida.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-83: Status, abundance, and distribution.Final Report to the Minerals Management Service, Contract No. 14-12-0001-29090. 284p.

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.

DON. 2003a. Final environmental assessment, Inner Apra Harbor maintenance dredging Guam. Department of the Navy, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii.

DON. 2003b. Integrated natural resources management plan--Farallon de Medinilla and Tinian military lease areas--Commonwealth of the Northern Mariana Islands. Plan duration: FY 03-12. Commander, U.S. Naval Forces Marianas, Department of the Navy.

DON. 2004. Year 2003 assessment of marine and fisheries resources---Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Final report. Department of the Navy, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii.

DON. 2005a. Tinian sea turtle nesting data. Scott Vogt, Biologist, Naval Facilities Engineering Command Pacific, Department of the Navy, Pearl Harbor, Hawaii.

DON. 2005b. Year 2004 assessment of marine and fisheries resources: Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Department of the Navy, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii.

DoN. 2011. Marine species monitoring for the U.S. Navy's Mariana Islands range complex. Department of the Navy, Commander, U.S. Pacific Fleet.

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

Dufault, S., and H. Whitehead. 1995. The geographic stock structure of female and immature sperm whales in the South Pacific. Report of the International Whaling Commission 45:401-405.

Dufault, S., H. Whitehead, and M. Dillon. 1999. An examination of the current knowledge on the stock structure of sperm whales (*Physeter macrocephalus*) worldwide. Journal of Cetacean Research and Management 1(1):1-10.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2008. Non-song acoustic communication in migrating humpback whales (Megaptera novaeangliae). Marine Mammal Science 24(3):613-629.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2010. Your attention please: increasing ambient noise levels elicits a change in communication behaviour in humpback whales (Megaptera novaeangliae). Proceedings of the Royal Society of London Series B: Biological Sciences in press(in press):in press.

Dutton, D. L., B. W. Bowen, D. W. Owens, A. Barragan, and S. K. Davis. 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). Journal of Zoology 248:397-409.

Dutton, P. 2005-2006. Building our knowledge of the leatherback stock structure. SWOT Report 1:10-11.

Dutton, P., G. Balazs, A. Dizon, and A. Barragan. 2000. Genetic stock identification and distribution of leatherbacks in the Pacific: potential effects on declining populations. Pages 38-39 *in* F. A. Abreu-Grobois, R. Briseño-Dueñas, R. Márquez, and L. Sarti, editors. Eighteenth International Sea Turtle Symposium.

Dutton, P., S. R. Benson, and S. A. Eckert. 2006. Identifying origins of leatherback turtles from Pacific foraging grounds off central California, U.S.A. . Pages 228 *in* N. J. Pilcher, editor 23rd Annual Symposiumon Sea Turtle Biology and Conservation. NMFS.

Dutton, P. H., G. H. Balazs, and A. E. Dizon. 1998. Genetic stock identification of sea turtles caught in the Hawaii-based pelagic longline fishery. Pages 45-46 *in* S. P. Epperly, and J. Braun, editors. Seventeenth Annual Symposium on Sea Turtle Biology and Conservation.

Dutton, P. H., and coauthors. 2007. Status and genetic structure of nesting populations of leatherback turtles (*Dermochelys coriacea*) in the western Pacific. Chelonian Conservation and Biology 6(1):47-53.

Dwyer, C. M. 2004. How has the risk of predation shaped the behavioural responses of sheep to fear and distress? Animal Welfare 13(3):269-281.

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

Eckert, K. L. 1993b. The biology and population status of marine turtles in the North Pacific Ocean. NOAA, NMFS, SWFSC, Honolulu, Hawaii.

Eckert, S. A. 1997. Distant fisheries implicated in the loss of the world’s largest leatherback nesting population. Marine Turtle Newsletter 78:2-7.

Eckert, S. A. 1998. Perspectives on the use of satellite telemetry and electronic technologies for the study of marine turtles, with reference to the first year long tracking of leatherback sea turtles. Pages 44-46 *in* S. P. Epperly, and J. Braun, editors. 17th Annual Symposium on Sea Turtle Biology and Conservation.

Eckert, S. A. 1999. Data acquisition systems for monitoring sea turtle behavior and physiology. Pages 88-93 *in* K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly, editors. Research and Management Techniques for the Conservation of Sea Turtles. UCN/SSC Marine Turtle Specialist Group Publication No. 4.

Eckert, S. A. 2002. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. Marine Ecology Progress Series 230:289-293.

Eckert, S. A. 2006. High-use oceanic areas for Atlantic leatherback sea turtles (*Dermochelys coriacea*) as identified using satellite telemetered location and dive information. Marine Biology 149(5):1257-1267.

Eckert, S. A., D. Bagley, S. Kubis, L. Ehrhart, and C. Johnson. 2006. Internesting and postnesting movements and foraging habitats of leatherback sea turtles (Dermochelys coriacea) nesting in Florida. Chelonian Conservation and Biology 5(2):239–248.

Eckert, S. A., K. L. Eckert, P. Ponganis, and G. L. Kooyman. 1989. Diving and foraging behavior of leatherback sea turtles (Dermochelys coriacea). Canadian Journal of Zoology 67:2834-2840.

Eckert, S. A., H. C. Liew, K. L. Eckert, and E. H. Chan. 1996. Shallow water diving by leatherback turtles in the South China Sea. Chelonian Conservation and Biology 2:237-243.

Eckert, S. A., D. W. Nellis, K. L. Eckert, and G. L. Kooyman. 1986. Diving patterns of two leatherback sea turtles (Dermochelys coriacea) during internesting intervals at Sandy Point, St. Croix, USVI. Herpetologica 42(3):381-388.

Edwards, M., D. G. Johns, P. Licandro, A. W. G. John, and D. P. Stevens. 2007. Ecological Status Report: results from the CPR survey 2005/2006, Plymouth, UK.

EERI. 1993. The Guam earthquake of August 8, 1993. Earthquake Engineering Research Institute.

Eisenberg, J. F., and J. Frazier. 1983. A leatherback turtle (Dermochelys coriacea) feeding in the wild. Journal of Herpetology 17(1):81-82.

Eldredge, L. G. 1983. Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: Historical background, description of the islands, and review of the climate, oceanography, and submarine topography. National Oceanic and Atmospheric Administration.

Eldredge, L. G. 1991. Annotated checklist of the marine mammals of Micronesia. Micronesica 24:217-230.

Eldredge, L. G. 2003. The marine reptiles and mammals of Guam. Micronesica 35-36:653-660.

Elfes, C. T., and coauthors. 2010. Geographic variation of persistent organic pollutant levels in humpback whale

(Megaptera novaeangliae) feeding areas of the North Pacific and North Atlantic. Environmental Toxicology and Chemistry 29(4):824-834.

Elsner, J. B., and K. Liu. 2003. Examining the ENSO-typhoon hypothesis. Climate Research 25:43-54.

Embley, R. W., and coauthors. 2004. Explorations of Mariana Arc volcanoes reveal new hydrothermal systems. EOS 85(4):37-44.

Engås, A., S. Løkkeborg, E. Ona, and A. Vold Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Sciences 53:2238-2249.

Engås, A., S. Løkkeborg, A. V. Soldal, and E. Ona. 1993. Comparative trials for cod and haddock using commercial trawl and longline at two different stock levels. Journal of Northwest Atlantic Fisheries Science 19:83-90.

Erbe, C. 2002. Hearing abilities of baleen whales. Contractor Report DRDC Atlantic CR 2002-065. Defence R&D Canada, Queensland, Australia. 40p.

Evans, K., M. A. Hindell, and G. Hince. 2004. Concentrations of organochlorines in sperm whales (Physeter macrocephalus) from Southern Australian waters. Marine Pollution Bulletin 48:486-503.

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).

Falk, M. R., and M. J. Lawrence. 1973. Seismic exploration: Its nature and effects on fish. Department of the Environment, Fisheries and Marine Service, Resource Management Branch, Fisheries Operations Directorate, Central Region (Environment), Winnipeg, Canada.

Fedorov, V. V., and S. D. Chistikov. 1985. Landscapes of seamounts as indicators of the biological productivity of the surrounding waters. Pages 221-230 *in* M. E. Vinogradev, and M. V. Flint, editors. Biological bases of the commercial exploitation of the open areas of the ocean. Nauka Publications, Moscow.

Ferguson, M. C., and J. Barlow. 2001. Spatial distribution and density of cetaceans in the Eastern Tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Admin. Rep. LJ-01-04, SWFSC, NMFS, La Jolla, CA. 61p.

Ferraroli, S., J. Y. Georges, P. Gaspar, and Y. L. Maho. 2004. Where leatherback turtles meet fisheries. Nature 429:521-522.

Findlay, K. P., and P. B. Best. 1995. Summer incidence of humpback whales on the west coast of South Africa. (Megaptera novaeangliae). South African Journal of Marine Science 15:279-282.

Finkbeiner, E. M., and coauthors. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation.

Forcada, J., P. N. Trathan, K. Reid, and E. J. Murphy. 2005. The effects of global climate variability in pup production of Antarctic fur seals. (Arctocephalus gazella). Ecology 86(9):2408-2417.

Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: antipredator strategies of baleen whales. Mammal Review 38(1):50-86.

Formia, A., M. Tiwari, J. Fretey, and A. Billes. 2003. Sea turtle conservation along the Atlantic Coast of Africa. Marine Turtle Newsletter 100:33-37.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fishery Bulletin 93:15-26.

Fossette, S., and coauthors. 2009a. Thermal and trophic habitats of the leatherback turtle during the nesting season in French Guiana. Journal of Experimental Marine Biology and Ecology.

Fossette, S., and coauthors. 2009b. Spatio-temporal foraging patterns of a giant zooplanktivore, the leatherback turtle. Journal of Marine Systems in press(in press):in press.

Frair, W. R., G. Ackman, and N. Mrosovsky. 1972. Body temperature of Dermochelys coriacea: warm turtle from cold water. Science 177:791-793.

Franko's Maps. 2005. Franko's Guide Map of Guam U.S.A.

Frantzis, A., O. Nikolaou, J. M. Bompar, and A. Cammedda. 2004. Humpback whale (*Megaptera novaeangliae*) occurrence in the Mediterranean Sea. Journal of Cetacean Research and Management 6(1):25-28.

Fraser, W. R., and E. E. Hofmann. 2003. A predator's perspective on causal links between climate change, physical forcing and ecosystem response. Marine Ecology Progress Series 265:1-15.

Frazer, L. N., and E. Mercado, III. 2000. A sonar model for humpback whales. IEEE Journal of Oceanic Engineering 25(1):160-182.

Frazier, J. G. 2001. General natural history of marine turtles. Proceedings: Marine turtle conservation in the Wider Caribbean Region: A dialogue for effective regional management, Santo Domingo, Dominican Republic.

Fretey, J. 2001. Biogeography and conservation of marine turtles of the Atlantic coast of Africa. CMS Technical Series Publication, No. 6, UNEP/CMS Secretariat, Bonn, Germany.

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.

Fryer, P. 1999. Evolution of the Mariana convergent plate margin system. Reviews of Geophysics 34(1):89-125.

Fuentes, M., M. Hamann, and C. J. Limpus. 2009a. Past, current and future thermal profiles of green turtle nesting grounds: Implications from climate change. Journal of Experimental Marine Biology and Ecology 383(1):56-64.

Fuentes, M. M. P. B., M. Hamann, and C. J. Limpus. 2009b. Past, current and future thermal profiles of green turtle nesting grounds: Implications from climate change. Journal of Experimental Marine Biology and Ecology in press(in press):in press.

Fuentes, M. M. P. B., C. J. Limpus, and M. Hamann. 2010. Vulnerability of sea turtle nesting grounds to climate change. Global Change Biology in press(in press):in press.

Fuentes, M. M. P. B., and coauthors. 2009c. Proxy indicators of sand temperature help project impacts of global warming on sea turtles in northern Australia. Endangered Species Research 9:33-40.

Fujise, Y., and coauthors. 2003. Cruise Report of the Japanese Whale Research Program under Special Permit in the western North Pacific-Phase II (JARPNII) in 2002 (part I) - Offshore component. IWC Scientific Committee.

Fulling, G. L., and J. C. S. Vega. 2009. Unique sperm whale (Physeter macrocephalus) encounter in the Mariana Islands. 18th Biennial Conference on the Biology of Marine Mammals, Quebec City, Quebec.

Gabriele, C. M., J. M. Straley, and J. L. Neilson. 2007. Age at first calving of female humpback whales in southeastern Alaska. Marine Mammal Science 23(1):226-239.

Gailey, G., B. Würsig, and T. L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast 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/s10661-007-9812-1. 17p.

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

Gambell, R. 1985a. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). Pages 171-192 *in* S. H. Ridgway, and R. Harrison, editors. Handbook of marine mammals, Volume 3: The sirenians and baleen whales. Academic Press, London, United Kingdom.

Gambell, R. 1985b. Sei whale *Balaenoptera borealis* (Lesson, 1828). Pages 193-240 *in* S. H. Ridgway, and R. Harrison, editors. Handbook of Marine Mammals. Vol. 3: The sirenians and baleen whales. Academic Press, London, United Kingdom.

Garcon, J. S., A. Grech, J. Moloney, and M. Hamann. 2010. Relative Exposure Index: an important factor in sea turtle nesting distribution. Aquatic Conservation: Marine and Freshwater Ecosystems 20(2):140-149.

Gaskin, D. E. 1973. Sperm whales in the western South Pacific. New Zealand Journal of Marine and Freshwater Research 7(1&2):1-20.

Gauthier, J. M., C. D. Metcalfe, and R. Sears. 1997. Chlorinated organic contaminants in blubber biopsies from Northwestern Atlantic Balaenopterid whales summering in the Gulf of St Lawrence. Marine Environmental Research 44(2):201-223.

Gendron, D., and J. Urban. 1993. Evidence of feeding by humpback whales (Megaptera novaeangliae) in the Baja California breeding ground, Mexico. Marine Mammal Science 9:76-81.

Genov, T., P. Kotnjek, and L. Lipej. 2009. New rescord of the humpback whale (Megaptera novaengliae) in the Adriatic Sea. Annales 19(1):25-30.

Gero, S., D. Engelhaupt, L. Rendell, and H. Whitehead. 2009. Who cares? Between-group variation in alloparental caregiving in sperm whales. Behavioral Ecology.

Gero, S., J. Gordon, C. Carlson, P. Evans, and H. Whitehead. 2006. Population estimate and inter-island movement of sperm whales, Physeter macrocephalus, in the Eastern Caribbean. IWC Scientific Committee, St Kitts and Nevis, West Indies.

Gerrodette, T., and D. M. Palacios. 1996. Estimates of cetacean abundance in EEZ waters of the Eastern Tropical Pacific. U.S. Department of Commerce, NOAA, NMFS-SWFSC Admin. Rep. LJ-96-10. 60p.

Giese, B. S., and J. A. Carton. 1999. Interannual and decadal variability in the tropical and midlatitude Pacific Ocean. Journal of Climate 12(3402-3418).

Gill, B. J. 1997. Records of turtles, and sea snakes in New Zealand, 1837-1996. New Zealand Journal of Marine and Freshwater Research 31:477-486.

Gilman, E. L. 2009. Guidelines to reduce sea turtle mortality in fishing operations. FAO, Rome.

Girondot, M., M. H. Godfrey, L. Ponge, and P. Rivalan. 2007. Modeling approaches to quantify leatherback nesting trends in French Guiana and Suriname. Chelonian Conservation and Biology 6(1):37-46.

Gless, J. M., M. Salmon, and J. Wyneken. 2008. Behavioral responses of juvenile leatherbacks Dermochelys coriacea to lights used in the longline fishery. Endangered Species Research 5:239-247.

Glockner-Ferrari, D. A., and M. J. Ferrari. 1985. Individual identification, behavior, reproduction, and distribution of humpback whales, Megaptera novaeangliae, in Hawaii. U.S. Marine Mammal Commission, Washington, D.C.; National Technical Information Service, Springfield, Virginia: 36p.

Godley, B. J., D. R. Thompson, S. Waldron, and R. W. Furness. 1998. The trophic status of marine turtles as determined by stable isotope analysis. Marine Ecology Progress Series 166:277-284.

Goff, G. P., and J. Lien. 1988. Atlantic leatherback turtles, Dermochelys coriacea, in cold water off Newfoundland and Labrador. Canadian Field Naturalist 102(1):1-5.

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 R. F. W. Coates. 2006. Near source, high frequency air-gun signatures. Paper SC/58/E30, prepared for the International Whaling Commmission (IWC) Seismic Workshop, St. Kitts, 24-25 May 2006. 7p.

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., H. Whitehead, and R. J. Reid. 2002. North Atlantic Sperm Whale, *Physeter macrocephalus*, strandings on the coastlines of the British Isles and Eastern Canada. Canadian Field-Naturalist 116:371-388.

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, A. N., A. R. Pople, and J. Ng. 1998. Trace metal concentrations in livers and kidneys of sea turtles from south-eastern Queensland, Australia. Marine and Freshwater Research 49(5):409-414.

Gordon, J., and coauthors. 2004. 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.

Gotelli, N. J., and A. M. Ellison. 2004. A Primer of Ecological Statistics.Sinauer Associates, Inc. Sunderland, Massachusetts. 510p.

Grant, G. S., and D. Ferrell. 1993. Leatherback turtle, Dermochelys coriacea (Reptilia: Dermochelidae): Notes on near-shore feeding behavior and association with cobia. Brimleyana 19:77-81.

Green, G. A., and coauthors. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426.

Green, G. A., R. A. Grotefendt, M. A. Smultea, C. E. Bowlby, and R. A. Rowlett. 1993. Delphinid aerial surveys in Oregon and Washington offshore waters. Final report. National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Washignton.

Greene Jr, C. R., N. S. Altman, and W. J. Richardson. 1999. Bowhead whale calls. Western Geophysical and NMFS.

Greer, A. E., J. D. Lazell Jr., and R. M. Wright. 1973. Anatomical evidence for counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). Nature 244:181.

Gregr, E. J., L. Nichol, J. K. B. Ford, G. Ellis, and A. W. Trites. 2000. Migration and population structure of northeastern Pacific whales off coastal British Columbia: an analysis of commercial whaling records from 1908-1967. Marine Mammal Science 16(4):699-727.

Greze, N. V., and A. V. Kovalev. 1985. Distribution of plankton in areas of elevations of the ocean bottom. Pages 204-210 *in* M. E. Vinogradev, and M. V. Flint, editors. Biological bases of the commercial exploitation of the open areas of the ocean. Mauka Publications, Moscow.

Griffin, R. B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Marine Mammal Science 15(1):33-51.

Grimm, G., and J. Farley. 2008. Sea turtle nesting activity on Navy lands, Guam 2007-2008. U.S. Navy, Pacific Fleet, Marianas Environmental, Guam.

Gunnlaugsson, T., and J. Sigurjónsson. 1990. NASS-87: estimation of whale abundance based on observations made onboard Icelandic and Faroese survey vessels. Report of the International Whaling Commission 40:571-580.

Gutierrez, J. 2004. Guam sea turtle recovery annual progress report. Guam Division of Aquatic and Wildlife Resources, Mangilao, Guam.

Hain, J. H. W., G. R. Carter, S. D. Kraus, C. A. Mayo, and H. E. Winn. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae,* in the western North Atlantic. Fishery Bulletin 80(2):259-268.

Hain, J. H. W., and coauthors. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. Marine Mammal Science 11(4):464-479.

Hain, J. H. W., W. A. M. Hyman, R. D. Kenney, and H. E. Winn. 1985. The role of cetaceans in the shelf-edge region of the U.S. Marine Fisheries Review 47(1):13-17.

Hamann, M., C. Limpus, G. Hughes, J. Mortimer, and N. Pilcher. 2006. Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South East Asia, including consideration of the impacts of the December 2004 tsunami on turtles and turtle habitats. IOSEA Marine Turtle MoU Secretariat, Bangkok.

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.

Hansen, L. J., K. D. Mullin, T. A. Jefferson, and G. P. Scott. 1996. Visual surveys aboard ships and aircraft. In: R. W. Davis and G. S. Fargion (eds). Distribution and abundance of marine mammals in the north-central and western Gulf of Mexico: Final report. Volume II: Technical report:OCS Study MMS 96- 0027, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans. p.55-132.

Hare, S. R., and N. J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Progress in Oceanography 47:103-145.

Harris, R. E., T. Elliott, and R. A. Davis. 2007. Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006. GX Technology Corporation, Houston, Texas.

Harvey, J., S. Benson, and T. Graham. 2006. Foraging ecology of leatherbacks in the California Current. . Pages 192 *in* M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. Abstracts of the Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation, Athens, Greece.

Hashagen, K. A., G. A. Green, and B. Adams. 2009. Observations of humpback whales, Megaptera novaeangliae, in the Beaufort Sea, Alaska. Northwestern Naturalist 90:160-162.

Hassel, A., and coauthors. 2003. Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study. Institute of Marine Research, Bergen, Norway.

Hassel, A., and coauthors. 2004. Influence of seismic shooting on the lesser sandeel (Ammodytes marinus). ICES Journal of Marine Science 61:1165-1173.

Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto. 2006. Individual variation in feeding habitat use by adult female green sea turtles (Chelonia mydas): Are they obligately neritic herbivores? Oecologia 149:52-64.

Hatch, L., and coauthors. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management 42:735-752.

Hauser, D. D. W., M. Holst, and V. D. Moulton. 2008a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific, April–August 2008. LGL, Ltd., King City, Ontario.

Hauser, D. W., M. Holst, and V. Moulton. 2008b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific, April – August 2008. LGL, Ltd., King City, Ontario.

Hawkes, L. A., A. C. Broderick, M. H. Godfrey, and B. J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. Global Change Biology 13:1-10.

Hays, G. C., M. R. Farquhar, P. Luschi, S. L. H. Teo, and T. M. Thys. 2009. Vertical niche overlap by two ocean giants with similar diets: Ocean sunfish and leatherback turtles. Journal of Experimental Marine Biology and Ecology 370(1-2):134-143.

Hays, G. C., J. D. R. Houghton, and A. E. Myers. 2004. Pan-Atlantic leatherback turtle movements. Nature 429:522.

Hazel, J. 2009. Evaluation of fast-acquisition GPS in stationary tests and fine-scale tracking of green turtles. Journal of Experimental Marine Biology and Ecology 374(1):58-68.

HDLNR. 2002. Application for an individual incidental take permit pursuant to the Endangered Species Act of 1973 for listed sea turtles in inshore marine fisheries in the main Hawaiian Islands managed by the State of Hawaii. State of Hawaii, Division of Aquatic Resources.

Heithaus, M. R., J. J. McLash, A. Frid, L. M. Dill, and G. J. Marshall. 2002. Novel insights into green sea turtle behaviour using animal-borne video cameras. Journal of the Marine Biological Association of the United Kingdom 82:1049-1050.

Henry, J., and P. B. Best. 1983. Organochlorine residues in whales landed at Durban, South Africa. Marine Pollution Bulletin 14(6):223-227.

Heppell, S. S., M. L. Snover, and L. B. Crowder. 2003. Sea turtle population ecology. Chapter 11 In: Lutz, P.L., J.A. Musick, and J. Wyneken (eds), The Biology of Sea Turtles: Volume II. CRC Press. Pp.275-306.

Herman, L. M. 1979. Humpback whales in Hawaiian waters: A study in historical ecology. Pacific Science 33:1-15.

Herman, L. M., and R. C. Antinoja. 1977. Humpback whales in the Hawaiian breeding waters: Population and pod characteristics. (Megaptera novaeangliae). Scientific Reports of the Whales Research Institute 29:59-85.

Hernandez, R., J. Buitrago, H. Guada, H. Hernandez-Hamon, and M. Llano. 2007. Nesting distribution and hatching success of the leatherback, Dermochelys coriacea, in relation to human pressures at Playa Parguito, Margarita Island, Venezuela. Chelonian Conservation and Biology 6(1):79-86.

Herraez, P., and coauthors. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. Journal of Wildlife Diseases 43(4):770-774.

Heyning, J. E., and T. D. Lewis. 1990. Entanglements of baleen whales in fishing gear off southern California. (Eschrichtius robustus, Balaenoptera acutorostrata, Megaptera novaeangliae). Report of the International Whaling Commission 40:427-431.-Sc/41/Ps14).

Higdon, J. W., and S. H. Ferguson. 2009. Loss of Arctic sea ice causing punctuated change in sightings of killer whales (Orcinus orca) over the past century. Ecological Applications 19(5):1365-1375.

Higgins, H. W., and D. J. Mackey. 2000. Algal class abundances, estimated from chlorophyll and carotenoid pigments, in the western Equatorial Pacific under El Niño and non-El Niño conditions. Deep-Sea Research I 47:1461-1483.

Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Hill, P. S., and D. P. DeMaster. 1998. Alaska marine mammal stock assessments, 1998.

Hill, P. S., and D. P. DeMaster. 1999. Alaska Marine Mammal Stock Assessments - 1999. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-110.:Alaska Fisheries Science Center; Auke Bay, Alaska. 177p.

Hilterman, M. L., and E. Goverse. 2003. Aspects of Nesting and Nest Success of the Leatherback Turtle (*Dermochelys coriacea*) in Suriname, 2002. Guianas Forests and Environmental Conservation Project (GFECP). Technical Report, World Wildlife Fund Guianas/Biotopic Foundation, Amsterdam, the Netherlands, 31p.

Hodge, R. P., and B. L. Wing. 2000. Occurrences of marine turtles in Alaska waters: 1960-1998. Herpetological Review 31(3):148-151.

Holliday, D. V., R. E. Piper, M. E. Clarke, and C. F. Greenlaw. 1987. The effects of airgun energy release on the eggs, larvae, and adults of the northern anchovy (Engraulis mordax). American Petroleum Institute, Washington, D.C.

Holst, M., and coauthors. 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., and M. Smultea. 2008a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off central America, February-April 2008 LGL, Ltd., King City, Canada.

Holst, M., M. Smultea, W. Koski, and B. Haley. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory’s marine seismic program in the eastern tropical PAcific off central America, November-December 2004. LGL, Ltd., King City, Ontario.

Holst, M., M. Smultea, W. 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. LGL, Ltd., King City, Ontario.

Holst, M., and M. A. Smultea. 2008b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory’s marine seismic program off Central America, Feburary-April 2008. Lamont-Doherty Earth

Observatory of Columbia University, Palisades, New York.

Holst, M., M. A. Smultea, W. R. Koski, and B. Haley. 2005c. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific Ocean off Central America, November–December 2004. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. Report TA2822-30. 125 p.

Hornell, J. 1927. The turtle fisheries of the Seychelles Islands. H.M. Stationery Office, London, UK.

Horwood, J. W. 1987. The sei whale: population biology, ecology and management.Croom Helm Ltd., Kent, Engl., 375 p.

Hughes, G. R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. Journal of Experimental Marine Biology and Ecology 229(1998):209-217.

Iniguez, M., and coauthors. 2010. On the occurrence of sei whales, Balaenoptera borealis, in the south-western Atlantic. Marine Biodiversity Records 3: e68.

Iorio, L. D., and C. W. Clark. 2009. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters in press(in press):in press.

IPCC, editor. 2000. Land use, land-use change, and forestry. Cambridge University Press, Cambridge, England.

IPCC, editor. 2001a. Climate change 2001: Impacts, adaptation and vulnerability, contribution of working group II to the third assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, England.

IPCC, editor. 2001b. Climate change 2001: The scientific basis, contribution of working group I to the third assessment report of the intergovernmental panel of climate change. Cambridge University Press, Cambridge, England.

IPCC, editor. 2002. Climate change and biodiversity.

Isaac, J. L. 2008. Effects of climate change on life history: Implications for extinction risk in mammals. Endangered Species Research.

Issac, J. L. 2009. Effects of climate change on life history: Implications for extinction risk in mammals. Endangered Species Research 7(2):115-123.

IWC. 1980a. Report of the Special Meeting on Southern Hemisphere Sei Whales, Cambridge, 18-21 June 1979. Report of the International Whaling Commission 30:493-511.

IWC. 1980b. Sperm Whales. Report of the International Whaling Commission (Special Issue 2):245p.

IWC. 1988. Report of the Scientific Committee. Report of the International Whaling Commission 38:32-155.

IWC. 1996. Report of the sub-committee on Southern Hemisphere baleen whales, Annex E Report of the International Whaling Commission 46:117-131.

IWC. 2004. Scientific committee - Annex K: Report of the standing working group on environmental concerns. Sorrento, Italy.

IWC. 2005. Chair's Report of the 57th Annual Meeting. International Whaling Commission. Available online at: http://www.iwcoffice.org/_documents/meetings/ulsan/CRREP57.pdf Accessed 7/26/2006.

IWC. 2007. Whale Population Estimates. International Whaling Commission. Accessed 02/07/2007 online at: http://www.iwcoffice.org/conservation/estimate.htm.

IWC. 2008. Catch limits & catches taken. International Whalign Commission.

James, M. C., S. A. Eckert, and R. A. Myers. 2005. Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea*). Marine Biology 147:845-853.

James, M. C., C. A. Ottensmeyer, S. A. Eckert, and R. A. Myers. 2006. Changes in the diel diving patterns accompany shifts between northern foraging and southward migration in leatherback turtles. . Canadian

Journal of Zoology 84:754-765.

James, M. C., S. A. Sherrill-Mix, and R. A. Myers. 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. Marine Ecology Progress Series 337:245-254.

Jaquet, N., and D. Gendron. 2009. The social organization of sperm whales in the Gulf of California and comparisons with other populations. Journal of the Marine Biological Association of the United Kingdom 89(05):975.

Jaquet, N., and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. Marine Ecology Progress Series 135:1-9.

Jaquet, N., H. Whitehead, and M. Lewis. 1996. Coherence between 19th century sperm whale distributions and satellite-derived pigments in the tropical Pacific. Marine Ecology Progress Series 145:1-10.

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

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.

Jefferson, T. A. P. J. S., and R. W. Baird. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review 21:151-180.

Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25.

Jensen, A. S., and G. K. Silber. 2004. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR. 37p. Available at: http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/lwssdata.pdf.

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 254:57-65.

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:S91-S94.

Jochens, A., and coauthors. 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. 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.

Johnson, C. R., and coauthors. 2011. Climate change cascades: Shifts in oceanography, species' ranges and subtidal marine community dynamics in eastern Tasmania. Journal of Experimental Marine Biology and Ecology.

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

Johnson, M., and P. Miller. 2002. Sperm whale diving and vocalization patterns from digital acoustic recording tags and assessing responses of whales to seismic exploration. MMS Information Transfer Meeting, Kenner, LA.

Johnson, S. R., and coauthors. 2007a. 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.

Johnson, S. R., and coauthors. 2007b. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment.

Johnston, P. A., and D. Santillo. 2004. Conservation of seamount ecosystems: Application of a marine protected areas concept. Archive of Fishery and Marine Research 51(1-3):305-319.

Jonsgård, Å., and K. Darling. 1977. On the biology of the eastern North Atlantic sei whales, Balaenoptera borealis Lesson. Reports of the International Whaling Commission Special Issue 11:123-129.

Jurasz, C. M., and V. Jurasz. 1979. Feeding modes of the humpback whale, Megaptera novaeangliae, in southeast Alaska. Scientific Reports of the Whales Research Institute, Tokyo 31:69-83.

Kamezaki, N., K. Oki, K. Mizuno, T. Toji, and O. Doi. 2002. First nesting record of the leatherback turtle, Oermochelys coriacea, in Japan. Current Herpetology 21(2):95-97.

Karl, D. M. 1999. A sea of change: Biogeochemical variability in the North Pacific Subtropical Gyre. Ecosystems 2:181-214.

Kaschner, K., D. P. Tittensor, J. Ready, T. Gerrodette, and B. Worm. 2011. Current and future patterns of global marine mammal biodiversity. PLoS ONE 6(5):e19653.

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

Kasuya, T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. Scientific Reports of the Whales Research Institute, Tokyo 39:31-75.

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.

Kawamura, A. 1974. Food and feeding ecology of the southern sei whale. Scientific Reports of the Whales Research Institute, Tokyo 26:25-144.

Kenney, R. D., M. A. M. Hyman, and H. E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States Outer Continental Shelf. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/NEC-41.

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

Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. Ecology Letters:no-no.

Kirkwood, G. P. 1992. Background to the development of revised management procedures, Annex I. Report of the International Whaling Commission 42:236-239.

Kiszka, J., M. Vely, and O. Breysse. 2010. Preliminary account of cetacean diversity and humpback whale (Megaptera novaeangliae) group characteristics around the Union of the Comoros (Mozambique Channel). Mammalia 74(1):51-56.

Kolinski, S. P. 2001. Sea turtles and their marine habitats at Tinian and Aguijan, with projections on resident turtle demographics in the southern arc of the Commonwealth of the northern Mariana Islands. National Marine Fisheries Service.

Kolinski, S. P., L. I. Ilo, and J. M. Manglona. 2004. Green turtles and their marine habitats at Tinian and Aguijan, with projections on resident turtle demographics in the southern arc of the Commonwealth of the Northern Mariana Islands. Micronesica 37(1):97-118.

Kolinski, S. P., D. Parker, L. I. Ilo, and J. K. Ruak. 1999. A preliminary assessment of the sea turtles and sea turtle habitats of Saipan, Commonwealth of the Northern Mariana Islands. National Marine Fisheries Service.

Konishi, K., and coauthors. 2009. Feeding strategies and prey consumption of three baleen whale species within the Kuroshio-Current Extension. Journal of Northwest Atlantic Fishery Science 42(Article No.3):27-40.

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.

Kragh Boye, T., M. Simon, and P. T. Madsen. 2010. Habitat use of humpback whales in Godthaabsfjord, West

Greenland, with implications for commercial exploitation. Journal of the Marine Biological Association of the United Kingdom 90(8):1529-1538.

Kremser, U., P. Klemm, and W. D. Kötz. 2005. Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. Antarctic Science 17(1):3-10.

Kubota, I. 1987. The western Pacific and El Niño. Oceanus 30(1):75-77.

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.

La Bella, G., and coauthors. 1996. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227-238 *in* Society of Petroleum Engineers, International Conference on Health, Safety and Environment, New Orleans, Louisiana.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35-75.

Lambertsen, R. H. 1992. Crassicaudosis: a parasitic disease threatening the health and population recovery of large baleen whales. Rev. Sci. Technol., Off. Int. Epizoot. 11(4):1131-1141.

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.

Laurance, W. F., and coauthors. 2008. Does rainforest logging threaten endangered sea turtles? Oryx 42:245-251.

Laursen, D. C., H. L. Olsén, M. d. L. Ruiz-Gomez, S. Winberg, and E. Höglund. 2011. Behavioural responses to hypoxia provide a non-invasive method for distinguishing between stress coping styles in fish. Applied Animal Behaviour Science 132(3-4):211-216.

Law, R. J., R. L. Stringer, C. R. Allchin, and B. R. Jones. 1996. Metals and organochlorines in sperm whales (Physeter macrocephalus) stranded around the North Sea during the 1994/1995 winter. Marine Pollution Bulletin 32(1):72-77.

Le Bouteiller, A., J. Blanchot, and M. Rodier. 1992. Size distribution patterns of phytoplankton in the western Pacific: Towards a generalization for the tropical open ocean. Deep-Sea Research 39(5):805-823.

Learmonth, J. A., and coauthors. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: an Annual Review 44:431-464.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters: a guide to their identification.U.S. Department of Commerce, NOAA Technical Report NMFS Circular 444. 245p.

Lee, T. 1993. Summary of cetacean survey data collected between the years of 1974 and 1985.

Lehodey, P., M. Bertignac, J. Hampton, A. Lewis, and J. Picaut. 1997. El Niño Southern Oscillation and tuna in the western Pacific. 389 (715-718).

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.

Levenson, C. 1974. Source level and bistatic target strength of the sperm whale (Physeter catodon) measured from an oceanographic aircraft. Journal of the Acoustic Society of America 55(5):1100-1103.

Levenson, C., and W. T. Leapley. 1978. Distribution of humpback whales (*Megaptera novaeangliae*) in the Caribbean determined by a rapid acoustic method. Journal of the Fisheries Research Board of Canada

35:1150-1152.

LGL Ltd. 2005a. 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.

LGL Ltd. 2005b. Marine mammal monitoring during Lamont-Doherty Earth Observatory’s marine seismic study of the Blanco Fracture Zone in the Northeastern Pacific Ocean, October-November 2004.

LGL Ltd. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory’s marine seismic program off Central America, Feburary–April 2008. Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.

LGL Ltd. 2007. Environmental Assessment of a Marine Geophysical Survey by the *R/V Marcus G. Langseth* off Central America, January–March 2008. Prepared for the Lamont-Doherty Earth Observatory, Palisades, NY, and the National Science Foundation, Arlington, VA, by LGL Ltd., environmental research associates, Ontario, Canada. LGL Report TA4342-1.

LGL Ltd. 2008. Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Gulf of Alaska, September 2008. Prepared by LGL Ltd., environmental research associates, King City, Ontario for the Lamont-Doherty Earth Observatory, Palisades, New York, and the National Science Foundation, Arlington, Virginia. LGL Report TA4412-1. 204p.

Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). Reports of the International Whaling Commission Special Issue 15:149-157.

Limpus, C. 2002. Conservation, and research of sea turtles in the western Pacific region: an overview. Pages 41-50 *in* I. Kinan, editor Western Pacific Sea Turtle Cooperative Research and Management Workshop. . Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Ljungblad, D. K., B. Würsig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (Balaena mysticetus) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41(3):183-194.

Lockyer, C. 1981. Estimates of growth and energy budget for the sperm whale, Physeter catodon. FAO Fisheries Series 5:489-504.

Løkkeborg, S. 1991. Effects of geophysical survey on catching success in longline fishing. Pages 1-9 *in* International Council for the Exploration of the Sea (ICES) Annual Science Conference.

Løkkeborg, S., and A. V. Soldal. 1993. The influence of seismic explorations on cod (Gadus morhua) behaviour and catch rates. ICES Marine Science Symposium 196:62-67.

López-Mendilaharsu, M., C. F. D. Rocha, A. Domingo, B. P. Wallace, and P. Miller. 2009. Prolonged deep dives by the leatherback turtle Dermochelys coriacea: pushing their aerobic dive limits. Marine Biodiversity Records 2(01).

Lopez, P., and J. Martin. 2001. Chemosensory predator recognition induces specific defensive behaviours in a fossorial amphisbaenian. Animal Behaviour 62:259-264.

Luschi, P., G. C. Hays, and F. Papi. 2003. A review of long-distance movements by marine turtles, and the possible role of ocean currents. Oikos 103:293-302.

Luschi, P., and coauthors. 2006. A review of migratory behaviour of sea turtles off southeastern Africa. South African Journal of Science 102:51-58.

Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22(4):802-818.

Lutcavage, M. E., P. Plotkin, B. E. Witherington, and P. L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 *in* P. L. Lutz, and J. A. Musick, editors. Biology of sea turtles. CRC Press, New York, New York.

Lux, J., R. Reina, and L. Stokes. 2003. Nesting activity of leatherback turtles (*Dermochelys coriacea*) in relation to tidal and lunar cycles at Playa Grande, Costa Rica. Pp.215-216 *In:* J.A. Seminoff (compiler), Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-503.

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.

Lyrholm, T., O. Leimar, and U. Gyllensten. 1996. Low diversity and biased substitution patterns in the mitochondrial DNA control region of sperm whales: implications for estimates of time since common ancestry. Molecular Biology and Evolution 13(10):1318-1326.

Lyrholm, T., O. Leimar, B. Johanneson, and U. Gyllensten. 1999. Sex-biased dispersal in sperm whales: Contrasting mitochondrial and nuclear genetic structure of global populations. Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences 266(1417):347-354.

Mackey, D. J., J. S. Parslow, F. B. Griffiths, H. W. Higgins, and B. Tilbrook. 1997. Phytoplankton productivity and the carbon cycle in the western Equatorial Pacific under El Niño and non-El Niño conditions. Deep-Sea Research II 44(9-10):1951-1978.

Macleod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. Endangered Species Research 7(2):125-136.

Macleod, C. D., M. B. Santos, R. J. Reid, B. E. Scott, and G. J. Pierce. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: Could climate change mean more starving porpoises? Biology Letters 3(2):185-188.

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

Maison, K. 2006. Do turtles move with the beach? Beach profiling and possible effects of development on a leatherback (Dermochelys coriacea) nesting beach in Grenada. Pages 145 *in* M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Malme, C. I., and P. R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. Pages 253-280 *in* G. D. Greene, F. R. Engelhard, and R. J. Paterson, editors. Proc. Workshop on Effects of Explosives Use in the Marine Environment. Canada Oil & Gas Lands Admininstration, Environmental Protection Branch, Ottawa, Canada.

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.

Malme, C. I., P. R. Miles, P. Tyack, C. W. Clark, and J. E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. Minerals Management Service, Anchorage, Alaska.

Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling.

Malme, C. I. B., B. Würsig, J. E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. W. M. Sackinger, M. O. Jeffries, J. L. Imm, and S. D. Treacy, editors. Port and Ocean Engineering Under Arctic Conditions: Symposium on noise and marine mammals, University of Alaska at Fairbanks.

Mantua, N., and S. R. Hare. 2002a. The Pacific Decadal Oscillation. Journal of Oceanography 58:35-44.

Mantua, N. J., and S. R. Hare. 2002b. The Pacific Decadal Oscillation. Journal of Oceanography 58:35-44.

Maritime, K. 2005. SBP 120 sub-bottom profiler.

Márquez, M. R. 1990. Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date. FAO Species Catalog, FAO Fisheries Synopsis 11(125):81p.

Martin, A. R., and M. R. Clarke. 1986. The diet of sperm whales (Physeter macrocephalus) between Iceland and Greenland. Journal of the Marine Biological Association of the United Kingdom 66:779-790.

Masaki, Y. 1976. Biological studies on the North Pacific sei whale. Bulletin of Far Seas Fishery Research 14:1-104.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Report of the International Whaling Commission (Special Issue 1):71-79.

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.

Mateo, J. M. 2007. Ecological and hormonal correlates of antipredator behavior in adult Belding's ground squirrels (Spermophilus beldingi). Behavioral Ecology and Sociobiology 62(1):37-49.

Matson Navigation Company. 2004. Ocean services: Guam & Micronesia.

Matsuoka, K., H. Kiwada, Y. Fujise, and T. Miyashita. 2009. Distribution of blue (Balaenoptera musculus), fin (B. physalus), humpback (Megaptera novaeangliae) and north pacific right (Eubalaena japonica) whales in the western North Pacific based on JARPN and JARPN II sighting surveys (1994 to 2007). IWC Scientific Committee.

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.

Maybaum, H. L. 1990. Effects of 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. EOS 71(2):92.

Maybaum, H. L. 1993. Responses of humpback whales to sonar sounds. Journal of the Acoustical Society of America 94(3 Pt. 2):1848-1849.

Mazaris, A. D., A. S. Kallimanis, S. P. Sgardelis, and J. D. Pantis. 2008. Do long-term changes in sea surface temperature at the breeding areas affect the breeding dates and reproduction performance of Mediterranean loggerhead turtles? Implications for climate change. Journal of Experimental Marine Biology and Ecology.

McCall Howard, M. P. 1999. Sperm whales Physeter macrocephalus in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying. Dalhousie University, Halifax, Nova Scotia.

McCauley, R. D., and coauthors. 2000a. 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., and coauthors. 2000b. 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.

McDonald, M. A., and coauthors. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical

Society of America 118(6):3941-3945.

McDonald, M. A., S. L. Mesnick, and J. A. Hildebrand. 2006. Biogeographic characterization of blue whale song worldwide: using song to identify populations. Journal of Cetacean Research and Management 8(1):55-65.

Mckenzie, C., B. J. Godley, R. W. Furness, and D. E. Wells. 1999. Concentrations and patterns of organochlorine contaminants in marine turtles from Mediterranean and Atlantic waters. Marine Environmental Research 47:117-135.

McMahon, C. R., and H. R. Burton. 2005. Climate change and seal survival: Evidence for environmentally mediated changes in elephant seal, Mirounga leonina, pup survival. Proceedings of the Royal Society of London Series B Biological Sciences 272(1566):923-928.

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.

Mellgren, R. L., and M. A. Mann. 1996. Comparative behavior of hatchling sea turtles. Pages 202-204 *in* J. A. Keinath, D. E. Barnard, J. A. Musick, and B. A. Bell, editors. Fifteenth Annual Symposium on Sea Turtle Biology and Conservation.

Mellgren, R. L., M. A. Mann, M. E. Bushong, S. R. Harkins, and V. K. Krumke. 1994. Habitat selection in three species of captive sea turtle hatchlings. Pages 259-260 *in* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.

Metcalfe, C., B. Koenig, T. Metcalfe, G. Paterson, and R. Sears. 2004. Intra- and inter-species differences in persistent organic contaminants in the blubber of blue whales and humpback whales from the Gulf of St. Lawrence, Canada. Marine Environmental Research 57:245–260.

Michael, M. 2004. Incidental observations of dolphins, whales, and turtles during scuba diving excursions off Rota. Mr. Mark Michael, Dive Rota, Commonwealth of the Northern Mariana Islands.

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

Miller, C. 2007. Current state of knowledge of cetacean threats, diversity, and habitats in the Pacific Islands Region. WDCS Australia, Inc.

Miller, G. W., R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Whales. R. W.J., editor. Marine mammal and acoustical monitoring of Western Geophysical’s open-water seismic program in the Alaskan Beaufort Sea, 1998.

Miller, G. W., and coauthors. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Pages 511-542 *in* S. L. Armsworthy, P. J. Cranford, and K. Lee, editors. Offshore Oil and Gas Environmental Effects Monitor-ing/Approaches and Technologies. Battelle Press, Columbus, Ohio.

Miller, P. J. O., M. P. Johnson, and P. L. Tyack. 2004. Sperm whale behaviour indicates the use of echolocation click buzzes ‘creaks’ in prey capture. Proceedings of the Royal Society of London, Part B 271:2239-2247.

Miller, P. J. O., and coauthors. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Research in press.

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

Minobe, S. 1997. A 50-70 year climatic oscillation over the North Pacific and North America. Geophysical Research Letters 24(6):683-686.

Minobe, S. 1999. Resonance in bidecadal and pentadecadal climate oscillations over the North Pacific: Role in climatic regime shifts. Geophysical Research Letters 26(7):855-858.

Minton, G., M. Collins, and K. Finlay. 2003. A note on re-sights of individually identified humpback whales (Megaptera novaeangliae) off the coast of Oman. Unpublished paper to the IWC Scientific Committee. 7

pp. Berlin, May (SC/55/O10).

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.

Mitchell, E., and R. R. Reeves. 1983. Catch history, abundance and present status of northwest Atlantic humpback whales. Report of the International Whaling Commission (Special Issue 5):153-212.

Miyashita, T., H. Kato, and T. Kasuya. 1995. Worldwide map of cetacean distribution based on Japanese sighting data. Volume 1. National Research Institute of Far Seas Fisheries, Shizuoka, Japan. 140pp.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984. The sei whale, *Balaenoptera borealis*. Marine Fisheries Review 46(4):25-29.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman. 1999. Distribution and movements of fin whales (Balaenoptera physalus) in the Pacific Ocean. Thirteen Biennial Conference on the Biology of Marine Mammals, 28 November - 3 December Wailea Maui HI. p.127.

Mobley Jr ., J. R., S. S. Spitz, K. A. Forney, R. A. Grotefendt, and P. H. Forestall. 2000. Distribution and abundance of odontocete species in Hawaiian waters: preliminary results of 1993-98 aerial surveys. Southwest Fisheries Science Center, National Marine Fisheries Service.

Moein Bartol, S., and D. R. Ketten. 2006. Turtle and tuna hearing. Pp.98-103 In: Swimmer, Y. and R. Brill (Eds), Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-7.

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., and coauthors. 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.

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

Moline, M. A., H. Claustre, T. K. Frazer, O. Schofields, and M. Vernet. 2004. Alterations of the food web along the Antarctic Peninsula in response to a regional warming trend. Global Change Biology 10:1973-1980.

Moore, S. E., and R. P. Angliss. 2006. Overview of planned seismic surveys offshore northern Alaska, July-October 2006. Paper SC/58/E6 presented to IWC Scientific Committee, St Kitts and Nevis.

Morreale, S. J., E. A. Standora, F. V. Paladino, and J. R. Spotila. 1994. Leatherback migrations along deepwater bathymetric contours. Pp.109-110 In: Schoeder, B.A. and B.E. Witherington (Eds), Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-341, Miami, Florida.

Moulton, V. D., B. D. Mactavish, and R. A. Buchanan. 2006a. Marine mammal and seabird monitoring of Conoco-Phillips' 3-D seismic program in the Laurentian Sub-basin, 2005.

Moulton, V. D., B. D. Mactavish, R. E. Harris, and R. A. Buchanan. 2006b. Marine mammal and seabird monitoring of Chevron Canada Limited's 3-D seismic program on the Orphan Basin, 2005.

Moulton, V. D., and G. W. Miller. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003.

Mrosovsky, N. 1994. Sex ratios of sea turtles. The Journal of Experimental Zoology 270:16-27.

Mrosovsky, N., S. R. Hopkins-Murphy, and J. I. Richardson. 1984. Sex ratio of sea turtles: seasonal changes. Science 225(4663):739-741.

Mrosovsky, N., G. D. Ryan, and M. C. James. 2009. Leatherback turtles: The menace of plastic. Marine Pollution Bulletin 58(2):287-289.

Mullin, K., and coauthors. 1994. Cetaceans on the upper continental slope in the north-central Gulf of Mexico.

Fishery Bulletin 92(773-786).

Mullin, K. D., W. Hoggard, and L. J. Hansen. 2004. Abundance and seasonal occurrence of cetaceans in Outer Continental Shelf and Slope waters of the north-central and northwestern Gulf of Mexico. Gulf of Mexico Science 2004(1):62-73.

Musick, J. A., and C. J. Limpus. 1997. Habitat utilization, and migration in juvenile sea turtles. Pages 137-163 *in* P. L. Lutz, and J. A. Musick, editors. The biology of sea turtles. CRC Press, Boca Raton, Florida.

NASA. 1998. Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. National Atmospheric and Space Administration.

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.

Nations, C. S., and coauthors. 2009. Effects of seismic exploration in the Beaufort Sea on bowhead whale call distributions. Journal of the Acoustical Society of America 126(4):2230.

Neilson, J. L., and C. M. Gabriele. 2007. Results of humpback whale monitoring in Glacier Bay and adjacent waters: 2007. Glacier Bay National Park & Preserve, Division of Resource Management.

Nelson, W. G., R. Brock, H. Lee II, J. O. Lamberson, and F. Cole. 2007. Condition of bays and estuaries of Hawaii for 2002: A statistical summary. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, EPA/620-R-07/001, Washington, D.C. .

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

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

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. 1987. Marine Mammal Protection Act of 1972. National Marine Fisheries Service.

NMFS. 1995. Small takes of marine mammals incidental to specified activities; offshore seismic activities in southern California: Notice of issuance of an incidental harassment authorization. Federal Register 60(200):53753-53760.

NMFS. 1998. Endangered Species Act - Section 7 Consultation: Use of the Farallon de Medinilla live fire range by the U.S. Navy and other services. Biological opinion. National Marine Fisheries Service, Silver Spring, Maryland.

NMFS. 2001a. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic.

NMFS. 2001b. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455.

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

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

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.

NMFS. 2008. Draft U.S. Atlantic marine mammal stock assessments 2008.

NMFS. 2009. Sperm whale 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

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 population of the east Pacific green turtle (Chelonia mydas). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Pacific Region. Silver Spring, Maryland.

NMFS and USFWS. 2007d. Leatherback Sea Turtle (*Dermochelys coriacea*) 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. 81p.

NMFS/SEFSC. 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic.U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-455.

NOAA. 2004. Sea surface temperature time series at Guam. National Oceanic and Atmospheric Association.

NOAA. 2005a. What is an El Niño? National Oceanic and Atmospheric Administration.

NOAA. 2005b. What is La Niña? National Oceanic and Atmospheric Administration.

Norris, K. S., and G. W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale. Pages 393-417 *in* S. R. Galler, editor. Animal Orientation and Navigation.

Notarbartolo di Sciara, G., and M. Demma. 1997. Guida dei Mammiferi Marini del Mediterraneo, 2nd edition. Franco Muzzio Editore: Padova.

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

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

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

O'Hara, J., and J. R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia 1990(2):564-567.

Ohsumi, S., and Y. Fukuda. 1975. On the estimates of exploitable population size and replacement yield for the Antarctic sei whale by use of catch and effort data. Reports of the International Whaling Commission 25:102-105.

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.

Øien, N. 2001. Humpback whales in the Barents and Norwegian Seas.Paper SC/53/NAH21 presented to the International Whaling Commission Scientific Committee. Available from IWC, 135 Station Road, Impington, Cambridge, UK.

Olsen, E., and coauthors. 2009. First satellite-tracked long-distance movement of a sei whale (Balaenoptera borealis) in the North Atlantic. Aquatic Mammals 35(3):313-318.

Omsjoe, E. H., and coauthors. 2009. Evaluating capture stress and its effects on reproductive success in Svalbard reindeer. Canadian Journal of Zoology-Revue Canadienne De Zoologie 87(1):73-85.

Oros, J., O. M. Gonzalez-Diaz, and P. Monagas. 2009. High levels of polychlorinated biphenyls in tissues of Atlantic turtles stranded in the Canary Islands, Spain. Chemosphere 74(3):473-478.

Pacific ENSO Applications Center. 1995. General information and imagemap of USAPI. US-Affiliated Pacific Islands (USAPI) information and maps.

Pack, A. A., and coauthors. 2009. Male humpback whales in the Hawaiian breeding grounds preferentially associate with larger females. Animal Behaviour 77(3):653-662.

Palacios, D. M., and B. R. Mate. 1996. Attack by false killer whales (*Pseudorca crassidens*) on sperm whales (*Physeter macrocephalus*) in the Galápagos Islands. Marine Mammal Science 12(4):582-587.

Palsbøll, P. J., and coauthors. 1997. Genetic tagging of humpback whales. Nature 388:767-769.

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.

Parente, C. L., J. P. Araujo, and M. E. Araujo. 2007. Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. Biota Neotropica 7(1).

Parin, N. V., V. G. Neiman, and Y. A. Rudyakov. 1985. To the question of the biological productivity of waters in areas of submerged elevations of the open ocean. M. E. Vinogradov, and M. V. Flint, editors. Biological basis of the commercial exploitation of the open areas of the ocean. Mauka Publications, Moscow.

Parker, D. M., and G. H. Balazs. in press. Diet of the oceanic green turtle, Chelonia mydas, in the North Pacific. Twenty-fifth Annual Symposium on Sea Turtle Biology and Conservation.

Payne, K., and R. Payne. 1985. Large scale changes over 19 years in songs of humpback whales in Bermuda. Zeitschrift Fur Tierpsychologie 68:89-114.

Payne, P., J. Nicholas, L. O'Brien, and K. Powers. 1986. The distribution of the humpback whale, Megaptera novaeangliae, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, Ammodytes americanus. Fisheries Bulletin 84:271-277.

Payne, P. M., and coauthors. 1990a. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fishery Bulletin 88:687-696.

Payne, P. M., and coauthors. 1990b. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fishery Bulletin 88:687-696.

Payne, R. S. 1970. Songs of the humpback whale. Capital Records, Hollywood.

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.

Perkins, J., and D. Beamish. 1979. Net entanglements of baleen whales in the inshore fishery of Newfoundland. Journal of the Fisheries Research Board of Canada 36:521-528.

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.

Petersen, S. L., M. B. Honig, P. G. Ryan, R. Nel, and L. G. Underhill. 2009. Turtle bycatch in the pelagic longline fishery off southern Africa. African Journal of Marine Science 31(1):87-96.

Picanco, C., I. Carvalho, and C. Brito. 2009. Occurrence and distribution of cetaceans in Sao Tome and Príncipe tropical archipelago and their relation to environmental variables. Journal of the Marine Biological Association of the United Kingdom 89(5):1071-1076.

Pickard, G. L., and W. J. Emery. 1982. Descriptive physical oceanography: An introduction, volume 4th edition. Pergamon Press, Oxford, United Kingdom.

Pickett, G. D., D. R. Eaton, R. M. H. Seaby, and G. P. Arnold. 1994. Results of bass tagging in Poole Bay during 1992. MAFF Direct. Fish. Res., Lowestoft, Endland.

Pike, D. G., C. G. M. Paxton, T. Gunnlaugsson, and G. A. Víkingsson. 2009. Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001. Nammco Scientific Publications 7:117-142.

Pinela, A. M., and coauthors. 2009. Population genetics and social organization of the sperm whale (Physeter macrocephalus) in the Azores inferred by microsatellite analyses. Canadian Journal of Zoology 87(9):802-813.

Pinto De Sa Alves, L. C., A. Andriolo, A. N. Zerbini, J. L. A. Pizzorno, and P. J. Clapham. 2009. Record of feeding by humpback whales (Megaptera novaeangliae) in tropical waters off Brazil. Marine Mammal Science 25(2):416-419.

Pitman, R. L., L. T. Ballance, S. I. Mesnick, and S. J. Chivers. 2001. Killer whale predation on sperm whales: observations and implications. Marine Mammal Science 17(3):494-507.

Pitman, R. L., and P. H. Dutton. 2004. Killer whale predation on a leatherback turtle in the Northeast Pacific. Northwest Science 58:497-498.

Plotkin, P. 2003. Adult migrations and habitat use. Pages 225-241 *in* P. L. Lutz, J. A. Musick, and J. Wyneken, editors. Biology of sea turtles, volume II. CRC Press, Boca Raton, Florida.

Plotkin, P. T., (Ed). 1995. National Marine Fisheries Service and the U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.

Poloczanska, E. S., C. J. Limpus, and G. C. Hays. 2009. Vulnerability of marine turtles in climate change. Pages 151-211 *in* Advances in Marine Biology, volume 56. Academic Press, New York.

Polovina, J. J., D. R. Kobayashi, D. M. Parker, M. P. Seki, and G. H. Balazs. 2000. Turtles on the edge: Movement of loggerhead turtles (Caretta caretta) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997-1998. Fisheries Oceanography 9:71-82.

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., and coauthors. 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., and coauthors. 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. 1971. The leatherback or leathery turtle, Dermochelys coriacea. IUCN Monograph 1:1-39.

Pritchard, P. C. H. 1977. Marine turtles of Micronesia. Chelonia Press, San Francisco, California.

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

Pritchard, P. C. H. 1995. Marine turtles of Micronesia. Pages 263-274 *in* K. A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Programme), S. S. o. t. P. R. E. 2007. Pacific Islands Regional marine species program 2008-2012. SPREP, Apia, Samoa.

Pultz, S., D. O'Daniel, S. Krueger, H. McSharry, and G. H. Balazs. 1999. Marine turtle survey on Tinian, Mariana

Islands. Micronesica 32(1):85-94.

Purvis, A., J. L. Gittleman, G. Cowlishaw, and G. M. Mace. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society B-Biological Sciences 267:1947-1952.

Radenac, M., and M. Rodier. 1996. Nitrate and chlorophyll distributions in relation to thermohaline and current structures in the western tropical Pacific during 1985-1989. Deep-Sea Research II 43(4-6):725-752.

Ramp, C., W. Hagen, P. Palsboll, M. Berube, and R. Sears. 2010. Age-related multi-year associations in female humpback whales (Megaptera novaeangliae). Behavioral Ecology and Sociobiology 64(10):1563-1576.

Randall, R. H., and coauthors. 1975. Marine biological survey of the Cocos Barrier Reefs and enclosed lagoon. University of Guam Marine Laboratory.

Rankin, S., and J. Barlow. 2007. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. Bioacoustics - The International Journal of Animal Sound and Its Recording 16(2):137-145.

Rasmussen, K., and coauthors. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. Biology Letters 3:302-305.

Reep, R. L., and coauthors. 2011. Manatee vibrissae: Evidence for a lateral line function. Annals of the New York Academy of Sciences 1225(1):101-109.

Reeves, R. R., P. J. Clapham, and S. E. Wetmore. 2002. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. Journal of Cetacean Research and Management 4(3):235-253.

Reeves, R. R., J. A. Khan, R. R. Olsen, S. L. Swartz, and T. D. Smith. 2001a. History of whaling in Trinidad and Tobago. Journal of Cetacean Research and Management 3(1):45-54.

Reeves, R. R., S. Leatherwood, G. S. Stone, and L. G. Eldredge. 1999a. Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP), Apria, Samoa.

Reeves, R. R., S. Leatherwood, G. S. Stone, and L. G. Eldredge. 1999b. Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP). SPREP, Apia, Samoa.

Reeves, R. R., S. L. Swartz, S. E. Wetmore, and P. J. Clapham. 2001b. Historical occurrence and distribution of humpback whales in the eastern and southern Caribbean Sea, based on data from American whaling logbooks. Journal of Cetacean Research and Management 3(2):117-129.

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

Reid, K., and J. Croxall. 2001. Environmental response of upper trophic-level predators reveals a system change in an Antarctic marine ecosystem. Proceedings of the Royal Society London Series B 268:377–384.

Reina, R. D., J. R. Spotila, F. V. Paladino, and A. E. Dunham. 2008. Changed reproductive schedule of eastern Pacific leatherback turtles Dermochelys coriacea following the 1997–98 El Niño to La Niña transition. Endangered Species Research.

Reiner, F., M. E. Dos Santos, and F. W. Wenzel. 1996. Cetaceans of the Cape Verde archipelago. Marine Mammal Science 12(3):434-443.

Rice, D. W. 1960. Distribution of the bottle-nosed dolphin in the leeward Hawaiian Islands. Journal of Mammalogy 41:407-408.

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.

Rice, D. W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Report of the International Whaling Commission (Special Issue 1):92-97.

Rice, D. W. 1978a. The humpback whale in the North Pacific: distribution, exploitation, and numbers. In K. S. Norris and R. R. Reeves (Editors), Report on a Workshop on Problems Related to Humpback Whales (*Megaptera novaeangliae*) in Hawaii. Contr. Rep. to U.S. Mar. Mammal Comm., NTIS PB-280-794.pp.

29–44.

Rice, D. W. 1978b. Sperm whales.p.82-87 *In*: D. Haley (ed), Marine Mammals of the Eastern North Pacific and Arctic Waters. Pacific Search Press, Seattle, Washington. 256p.

Rice, D. W. 1989a. Sperm whale, *Physeter macrocephalus* Linnaeus, 1758. Pp.177-233 In: S. H. Ridgway and R. Harrison (Eds), Handbook of Marine Mammals: Volume 4, River Dolphins and the Larger Toothed Whales. Academy Press, London.

Rice, D. W. 1989b. Sperm whale, Physeter macrocephalus Linnaeus, 1758. Pages 177-233 *in* S. H. Ridgway, and R. Harrison, editors. Handbook of marine mammals: Volume 4: River dolphins and the larger toothed whales. Academy Press, London.

Rice, D. W. 1998. Marine Mammals of the World. Systematics and Distribution.Special Publication Number 4. The Society for Marine Mammalogy, Lawrence, Kansas.

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

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

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

Richardson, W. J., G. W. Miller, and J. C.R. Greene. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America 106(4-2):2281.

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.

Richer de Forges, B. e. a. 2000. The MUSORSTOM 10 cruise in the Fijian archipelago: report and list of stations. Pages 9-23 *in* A. Crosnier, editor. Results of the MUSORSTOM expeditions, volume 184, Paris.

Richter, C., S. Dawson, and E. Slooten. 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. Marine Mammal Science 22(1):46-63.

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.

Rivalan, P., P. H. Dutton, E. Baudry, S. E. Roden, and M. Girondot. 2006. Demographic scenario inferred from genetic data in leatherback turtles nesting in French Guiana and Suriname. Biological Conservation 130(1):1-9.

Rizzo, L. Y., and D. Schulte. 2009. A review of humpback whales' migration patterns worldwide and their consequences to gene flow. Journal of the Marine Biological Association of the United Kingdom 89(5):995-1002.

Robinson, R. A., and coauthors. 2008. Travelling through a warming world: climate change and migratory species. Endangered Species Research.

Rodier, M., and R. L. Borgne. 1997. Export flux in the western and central Pacific ocean. Deep-Sea Research II 44(9-10):2085-2113.

Rogers, A. D. 1994. The biology of seamounts. Pages 306-350 *in* J. H. Blaxter, and A. J. Southward, editors. Advances in Marine Biology, volume 30. Academic Press, San Diego, California.

Roman, J., and S. R. Palumbi. 2003. Whales before whaling in the North Atlantic. Science 301:508-510.

Romero, A., A. I. Agudo, S. M. Green, and G. Notarbartolo Di Sciara. 2001. Cetaceans of Venezuela: Their Distribution and Conservation Status. NOAA Technical Report NMFS-151. Seattle, Washington. 60p.

Saba, V. S., J. R. Spotila, F. P. Chavez, and J. A. Musick. 2007. Bottom-up and climatic forcing on the global population of leatherback turtles. Pages 162-163 in: Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams, editors. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina.

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

Sale, A., and P. Luschi. 2009. Navigational challenges in the oceanic migrations of leatherback sea turtles. Proceedings of the Royal Society B-Biological Sciences 276(1674):3737-3745.

Sale, A., and coauthors. 2006. Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. Journal of Experimental Marine Biology and Ecology 328:197-210.

Santana Garcon, J., A. Grech, J. Moloney, and M. Hamann. 2010. Relative Exposure Index: an important factor in sea turtle nesting distribution. Aquatic Conservation: Marine and Freshwater Ecosystems 20:140-149.

Santidrián Tomillo, P., and coauthors. 2007. Reassessment of the leatherback turtle (*Dermochelys coriacea*) nesting population at Parque Nacional Marino Las Baulas, Costa Rica: Effects of conservation efforts. Chelonian Conservation and Biology 6(1):54-62.

Santulli, A., and coauthors. 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.

Sarti, L. M., S. A. Eckert, N. T. Garcia, and A. R. Barragan. 1996. Decline of the world’s largest nesting assemblage of leatherback turtles. Marine Turtle Newsletter 74:2-5.

Saunders, M. A., R. E. Chandler, C. J. Merchant, and F. P. Roberts. 2000. Atlantic hurricanes and NW Pacific typhoons: ENSO spatial impacts on occurrence and landfall. Geophysical Research Letters 27(8):1147-1150.

Schilling, M. R., and coauthors. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. Fishery Bulletin 90:749–755.

Schroeder, B. A., and N. B. Thompson. 1987. Distribution of the loggerhead turtle, Caretta caretta, and the leatherback turtle, Dermochelys coriacea, in the Cape Canaveral, Florida area: Results of aerial surveys. Pages 45-53 *in* W. N. Witzell, editor Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop.

Schwartz, F. J. 2003. Bilateral asymmetry in the rostrum of the smalltooth sawfish, *Pristis pectinata* (Pristiformes: Family Pristidae). Journal of the North Carolina Academy of Science 119(2):41-47.

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

Sea Around Us. 2009. Sea Around Us Project.

Seminoff, J. A., A. Resendiz, and W. J. Nichols. 2002. Diet of East Pacific green turtles (Chelonia mydas) in the central Gulf of California, Mexico. Journal of Herpetology 36(3):447-453.

Shallenberger, E. W. 1981. The status of Hawaiian cetaceans. Final report to U.S. Marine Mammal Commission. MMC-77/23.

Shillinger, G. L., and coauthors. 2010. Four years and fourty-six turtles: tracking the movements and behaviors of leatherback sea turtles in the eastern Pacific. Pages 53 *in* K. Dean, and M. C. L. Castro, editors. 28th Annual Symposium on Sea Turtle Biology and Conservation. National Marine Fisheries Service.

Shoop, C. R., and R. D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

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

Simmonds, M. P., and W. J. Eliott. 2009. Climate change and cetaceans: Concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom 89(1):203-210.

Sims, D. W., M. J. Genner, A. J. Southward, and S. J. Hawkins. 2001. Timing of squid migration reflects the North Atlantic climate variability. Proceedings of the Royal Society of London Part B 268:2607–2611.

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.

Slotte, A., K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research 67:143-150.

Smith, A. W., and A. B. Latham. 1978. Prevalence of vesicular exanthema of swine antibodies among feral animals associated with the southern California coastal zones. American Journal of Veterinary Research 39:291–296.

Smith, T. D., and coauthors. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science 15(1):1-32.

Smith, T. D., and D. G.Pike. 2009. The enigmatic whale: the North Atlantic humpback. Nammco Scientific Publications 7:161-178.

Smith, T. D., and R. R. Reeves. 2003. Estimating American 19th century catches of humpback whales in the West Indies and Cape Verde Islands. Caribbean Journal of Science 39(3):286-297.

Smithsonian Institute. 1995. Submarine eruption. Bulletin of the Global Volcanism Network.

Smultea, M., and M. Holst. 2003. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic study in the Hess Deep area of the eastern equatorial tropical Pacific, July 2003. Prepared for Lamont-Doherty Earth Observatory, Palisades, New York, and the National Marine Fisheries Service, Silver Spring, Maryland, by LGL Ltd., environmental research associates. LGL Report TA2822-16.

Smultea, M. A., M. Holst, W. R. Koski, and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004. LGL Rep. TA2822-26. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. 106 p.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis. 2010. Rare sightings of a bryde's whale (Balaenoptera edeni) and sei whales (B. borealis) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i. Pacific Science 64(3):449-457.

Southall, B. L., and coauthors. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33:411-521.

Southwood, A. L., and coauthors. 1999. Heart rates and dive behavior of leatherback sea turtles in the eastern Pacific Ocean. Journal of Experimental Biology 202:1115-1125.

Spotila, J. R. 2004a. Sea turtles: A complete guide to their biology, behavior, and conservation. The Johns Hopkins University Press and Oakwood Arts, Baltimore, Maryland.

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

Spotila, J. R., and coauthors. 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.

Spring, D. 2011. L-DEO seismic survey turtle mortality. NMFS.

SRS-Parsons, Geo-Marine, and Bio-Waves. 2007. Marine mammal and sea turtle survey and density estimates for Guam and the Commonwealth of the Northern Mariana Islands. Naval Facilities Engineering Command Pacific.

Standora, E. A., J. R. Spotila, J. A. Keinath, and C. R. Shoop. 1984. Body temperatures, diving cycles, and movement of a subadult leatherback turtle, Dermochelys coriacea. Herpetologica 40:169-176.

Starbird, C. H., A. Baldridge, and J. T. Harvey. 1993. Seasonal occurrence of leatherback sea turtles (Dermochelys coriacea) in the Monterey Bay region, with notes on other sea turtles, 1986-1991. California Fish and Game 79(2):54-62.

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

Steiger, G. H., and coauthors. 2008. Geographic variation in killer whale attacks on humpback whales in the North Pacific: Implications for predation pressure. Endangered Species Research 4:247-256.

Stevick, P., and coauthors. 2003a. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258:263-273.

Stevick, P. T., and coauthors. 2001. Trends in abundance of North Atlantic humpback whales, 1979-1993.Paper SC/53/NAH2 presented to the International Whaling Commission Scientific Committee. Available from IWC, 135 Station Road, Impington, Cambridge, UK.

Stevick, P. T., and coauthors. 2003b. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology 259:231-237.

Stinson, M. L. 1984. Biology of sea turtles in San Diego Bay, California, and in northeastern Pacific Ocean. Master’s thesis. San Diego State University, San Diego, California.

Stojkovich, J. O. 1977. Survey and species inventory of representative pristine marine communities on Guam. University of Guam Marine Laboratory for Government of Guam, Bureau of Planning, Coastal Management Section, Mangilao, Guam.

Stone, C. J. 2003. The effects of seismic activity on marine mammals in UK waters 1998-2000. Joint Nature Conservation Committee, Aberdeen, Scotland.

Stone, C. J., and M. L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research and Management 8(3):255-263.

Strong, C. S. 1990. Ventilation patterns and behavior of balaenopterid whales in the Gulf of California, Mexico. Unpublished master’s thesis, San Francisco State University, California.

Sugimoto, T., S. Kimura, and K. Tadokoro. 2001. Impact of El Niño events and climate regime shift on living resources in the western North Pacific. Progress in Oceanograpy 49:113-127.

Swartz, S. L., and coauthors. 2003. Acoustic and visual survey of humpback whales (*Megaptera novaeangliae*) distribution in the Eastern and Southeastern Caribbean Sea. Caribbean Journal of Science 39(2):195-208.

Tamura, T., and coauthors. 2005. Cruise report of the Japanese whale research program under special permit in the western North Pacific - Phase II (JARPN II) in 2004 (part I) - offshore component. IWC Scientific Committee.

Tamura, T., and coauthors. 2007. Report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2006 (part I) - Offshore component. IWC Scientific Committee.

Tamura, T., and coauthors. 2006. Cruise report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2005 - Offshore component. IWC Scientific Committee.

TEWG. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555. 116p.

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

Thomsen, B. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen, Aberdeen, Scotland.

Thomson, D. H., and W. J. Richardson. 1995. Marine mammal sounds. Pages 159-204 *in* W. J. Richardson, C. R. G.

Jr., C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (Dermochelys coriacea) from Labrador. Canadian Field Naturalist 92(3):287.

Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. Report of the International Whaling Commission (Special Issue 1):98-106.

Todd, S., J. Lien, and A. Verhulst. 1992. Orientation of humpback whales (Megaptera novaengliae) and minke whales (Balaenoptera acutorostrata) to acoustic alarm devices designed to reduce entrapment in fishing gear. J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine mammal sensory systems. Plenum Press, New York, New York.

Tolstoy, M., and coauthors. 2009. Broadband calibration of R/V Marcus G. Langseth four-string seismic sources. Geochemistry Geophysics Geosystems 10.

Tomilin, A. G. 1967. Mammals of the USSR, and adjacent countries. Volume 9, Cetacea. Israel Program Sci. Transl. No. 124, National Technical Information Service TT 65-50086. Springfield, Virginia (Translation of Russian text published in 1957).

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

Trenberth, K. E. 1997. The definition of El Niño. Bulletin of the American Meteorological Society 78(12):2771-2777.

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.

Turnpenny, A. W. H., K. P. Thatcher, and J. R. Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound. Research Report for the Defence Research Agency, Fawley Aquatic Research Laboratories, Ltd., FRR 127/94. 34p.

Twiss, S. D., C. Thomas, V. Poland, J. A. Graves, and P. Pomeroy. 2007. The impact of climatic variation on the opportunity for sexual selection. Biology Letters 3(1):12-15.

Tyack, P. 1983. Differential response of humpback whales, *Megaptera novaeangliae*, to playback of song or social sounds. Behavioral Ecology and Sociobiology 13(1):49-55.

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. Pages 115-120 *in* A. E. Jochens, and D. C. Biggs, editors. Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1, volume OCS Study MMS 2003-069. Texas A&M University and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.

Tyack, P., and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. Behaviour 83:132-153.

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

USFWS, N. a. 1995. Status reviews for sea turtles listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.

USGS. 2004. Historical seismicity, Rota Region Northern Mariana Islands, seismicity 1990 to present, seismicity in 2004, and magnitude 7 and greater earthquakes since 1900. United States Geological Survey, Earthquake Hazards Program.

USGS. 2005a. Earthquake history of Guam. United States Geological Survey, Earthquake Hazards Program.

USGS. 2005b. Major volcanoes of the Mariana Islands. United States Geological Survey.

Vanderlaan, A. S. M., C. T. Taggart, A. R. Serdynska, R. D. Kenney, and M. W. Brown. 2008. Reducing the risk of lethal encounters: Vessels and right whales in the Bay of Fundy and on the Scotian Shelf. Endangered Species Research 4(3):283-297.

Venrick, E. L. 1990. Phytoplankton in an oligotrophic ocean: Species structure and interannual variability. Ecology 71(4):1547-1563.

Villegas-Amtmann, S., and D. P. Costa. 2010. Oxygen stores plasticity linked to foraging behaviour and pregnancy in a diving predator, the Galapagos sea lion. Functional Ecology 24(4):785-795.

Vinogradov, M. Y., and N. V. Parin. 1973. On the vertical distribution of macroplankton in the tropical Pacific. Oceanology 13:104-113.

Vogt, S. 2009. Wildlife surveys on military leased lands, Tinian, Commonwealth of the Northern Mariana Islands. U.S. Navy, Pacific Fleet, Honolulu, Hawaii.

Wade, P. R., and S. Baker. 2010. A review of the plausible range of stock structure hypotheses of western North Pacific minke whales using genetic and other biological information. IWC Scientific Committee, Agadir, Morocco.

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).

Wallace, B. P., and coauthors. 2010. Global patterns of marine turtle bycatch. Convervation Letters in press(in press):in press.

Wardle, C. S., and coauthors. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21:1005-1027.

Waring, G., D. Belden, M. Vecchione, and R. Gibbons. 2003. Mid-water prey in beaked whale and sperm whale deep-water habitat south of Georges Bank. Pages 172 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Waring, G. T., C. P. Fairfield, C. M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. Fisheries Oceanography 2(2):101-105.

Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2006. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2005. NOAA Technical Memorandum NMFS-NE-194. Woods Hole, Massachusetts. 358p.

Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2008. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2007. U.S. Department of Commerce. NOAA Technical Memorandum NMFS NE:205.

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.

Waring, G. T., and coauthors. 1999. U.S. Atlantic Marine Mammal Stock Assessments - 1998. NOAA Technical Memorandum NMFS-NEFSC: Woods Hole, Mass. 193p.

Waring, G. T., and coauthors. 2001. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2001. NOAA Technical Memorandum NMFS-NE-168:Woods Hole, Massachusetts. 318p.

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

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, 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.

Watwood, S. L., P. J. O. Miller, M. Johnson, P. T. Madsen, and P. L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). Journal of Animal Ecology 75:814-825.

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. 1988. Distinctive vocalizations from mature sperm whales (*Physeter macrocephalus*). Canadian Journal of Zoology 66:1931-1937.

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.

Weinrich, M. T., J. Bove, and N. Miller. 1993. Return and survival of humpback whale (*Megaptera novaeangliae*) calves born to a single female in three consecutive years. Marine Mammal Science 9(3):325-328.

Weinrich, M. T., and coauthors. 1992. Behavioral reactions of humpback whales *Megaptera novaeangliae* to biopsy procedures. Fishery Bulletin 90:588-598.

Weir, C. R. 2007. Observations of marine turtles in relation to seismic airgun sound off Angola. Marine Turtle Newsletter 116:17-20.

Weir, C. R. 2008. Overt responses of humpback whales (Megaptera novaeangliae), sperm whales (Physeter macrocephalus), and Atlantic spotted dolphins (Stenella frontalis) to seismic exploration off Angola. Aquatic Mammals 34(1):71-83.

Weir, C. R., A. Frantzis, P. Alexiadou, and J. C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). Journal of the Marine Biological Association of the U.K. 87(1):39-46.

Weller, D. W., and coauthors. 1996. Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. Marine Mammal Science 12(4):588-594.

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

Whitehead, H. 1997. Sea surface temperature and the abundance of sperm whale calves off the Galapagos Islands: Implications for the effects of global warming. Report of the International Whaling Commission 47:941-944.-Sc/48/O30).

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

Whitehead, H. 2002b. Sperm whale. In: W.F. Perrin, B. Wursig, and J.G. Thewissen (Eds), Encyclopedia of Marine Mammals. Academic Press, San Diego, CA. Pp.1165-1172.

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

Whitehead, H., and T. Arnbom. 1987. Social organization of sperm whales off the Galapagos Islands, February-April 1985. Canadian Journal of Zoology 65(4):913-919.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. 2008. Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361:291-300.

Whitehead, H., and M. J. Moore. 1982. Distribution, and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60:2203-2211.

Whitehead, H., S. Waters, and T. Lyrholm. 1991. Social organization of female sperm whales and their offspring: Constant companions and casual acquaintances. Behavioral Ecology and Sociobiology 29(5):385-390.

Wiles, G. J., J. A.B. Amerson, and J. R.E. Beck. 1989. Notes on the herpetofauna of Tinian, Mariana Islands. Micronesica 22(1):107-118.

Wiles, G. J., C. F. Aguon, G. W. Davis, and D. J. Grout. 1995. The status and distribution of endangered animals and plants in northern Guam. Micronesica 28(1):31-49.

Wiles, G. J., G. H. Rodda, T. H. Fritts, and E. M. Taisacan. 1990. Abundance and habitat use of reptiles on Rota, Mariana Islands. Micronesica 23(2):153-166.

Williams, K. L., and coauthors. 1996. Population ecology, nesting, and sucess of leatherback turtles, *Dermochelys* *coriacea*, at Las Baulas de Guanacaste National Park, Costa Rica. P.340 *In:* J.A. Keinath, D.E. Barnard, J.A. Musick, and B.A. Bell (Compilers), Proceedings of the 15th Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-351.

Wing, B. L., and R. P. Hodge. 2002. Occurrence terminology for marine turtles. Marine Turtle Newsletter 95:15-16.

Winn, H. E., R. K. Edel, and A. G. Taruski. 1975. Population estimate of the humpback whale in the West Indies by visual and acoustic techniques. Journal of the Fisheries Research Board of Canada 32:499–506.

Winn, H. E., P. J. Perkins, and T. Poulter. 1970. Sounds of the humpback whale. 7th Annual Conf Biological Sonar. Stanford Research Institute, Menlo Park, California.

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.

Winsor, M. H., and B. R. Mate. 2006. Seismic survey activity and the proximity of satellite tagged sperm whales.

Wise, J. P., Sr., and coauthors. 2009. A global assessment of chromium pollution using sperm whales (Physeter macrocephalus) as an indicator species. Chemosphere 75(11):1461-1467.

Witherington, B. E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48(1):31-39.

Witherington, B. E., and K. A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles Caretta caretta. Biological Conservation 55:139-149.

Witt, M. J., and coauthors. 2009. Aerial surveying of the world's largest leatherback turtle rookery: A more effective methodology for large-scale monitoring. Biological Conservation 142(8):1719-1727.

Witteveen, B. H., R. J. Foy, K. M. Wynne, and Y. Tremblay. 2008. Investigation of foraging habits and prey selection by humpback whales (Megaptera novaeangliae) using acoustic tags and concurrent fish surveys. Marine Mammal Science 24(3):516-534.

Witzell, W. N., A. A. Geis, J. R. Schmid, and T. Wibbels. 2005. Sex ratio of immature Kemp's ridley turtles (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, south-west Florida. Journal of the Marine Biological Association of the U.K. 85:205-208.

Wolanski, E., R. H. Richmond, G. Davis, E. Deleersnijder, and R. R. Leben. 2003. Eddies around Guam, an island in the Mariana Islands group. Continental Shelf Research 23:991-1003.

Wormuth, J. H., P. H. Ressler, R. B. Cady, and E. J. Harris. 2000. Zooplankton and micronekton in cyclones and anticyclones in the northeast Gulf of Mexico. Gulf of Mexico Science 18(1):23-34.

Wright, A. J. 2005. Lunar cycles and sperm whale (Physeter macrocephalus) strandings on the north Atlantic coastlines of the British isles and eastern Canada. Marine Mammal Science 21(1):145-149.

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.

Würsig, B. G., and coauthors. 1999. Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint U.S.-Russian scientific investigation. Final Report. Sakhalin Energy Investment Co. Ltd and Exxon Neftegaz Ltd, Yuzhno-Sakhalinsk, Russia.

Yablokov, A. V., and V. A. Zemsky. 2000. Soviet whaling data (1949-1979). Center for Russian Environmental Policy, Moscow.

Yablokov, A. V., V. A. Zemsky, Y. A. Mikhalev, V. V. Tormosov, and A. A. Berzin. 1998. Data on Soviet whaling in the Antarctic in 1947–1972 (population aspects). Russian Journal of Ecology 29:38–42.

Yañez, I. L., A. R. Gaos, and R. M. Aruaz. 2010. Eastern Pacific leatherback, green, and olive ridley sea turtle nesting at Playa Naranjo; first census in eight years K. Dean, and M. C. L. Castro, editors. 28th Annual Symposiumon Sea Turtle Biology and Conservation. National Marine Fisheries Service.

Yazvenko, S. B., and coauthors. 2007a. 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.

Yazvenko, S. B., and coauthors. 2007b. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9810-3. 14p.

Zaika, V. E., and A. V. Kovalev. 1984. To the study of the ecosystems of submarine mountain. Biologiya Morya 5:3-8.

Zárate, P. M., M. A. Parra, M. Robles, P. H. Dutton, and J. A. Seminoff. 2010. Sea turtle strandings and mortality in the Galapagos Archipelago: causes and threats Pages 126 *in* K. Dean, and M. C. L. Castro, editors. 28th Annual Symposiumon Sea Turtle Biology and Conservation. National Marine Fisheries Service.

Zenitani, R., and coauthors. 1999. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific in 1998. IWC Scientific Committee.

Zhang, J., and T. Lay. 1992. The April 5, 1990 Mariana Islands earthquake and subduction zone stresses. Physics of the Earth and Planetary Interiors 72:99-121.