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, Conservation, and Education Division

Activities Considered: Seismic survey by Lamont-Doherty Earth Observatory (L-DEO) in the eastern tropical Pacific Ocean offshore Costa Rica 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 Division

Approved by: _____

Date: APR 06 2011

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 *et seq.*) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat 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 Lamont-Doherty Earth Observatory (L-DEO) to conduct a seismic survey in the eastern tropical Pacific Ocean off the coast of Costa Rica from April to June of 2011and the NMFS' Office of Protected Resources-Permits, Conservation, and Education Division (Permits Division), which proposes to authorize the NSF and L-DEO to "take" marine mammals incidental to those seismic surveys. The consulting agency for these proposals is the NMFS' Office of Protected Resources – Endangered Species Division (Endangered Species Division).

This document represents the NMFS' biological opinion (Opinion) of 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 November 12, 2010, the Permits Division received an application from NSF for L-DEO to authorize under Section 101(a)(5)(D) the take by Level B harassment several marine mammals species incidental to a seismic survey cruise to be conducted through the eastern tropical Pacific Ocean from April to May of 2011.

On November 19, 2010, the NMFS' Endangered Species Division received a request for formal consultation from the NSF to evaluate the effects of the proposed cruise on certain species of marine mammal and sea turtle listed as threatened or endangered under the ESA during a seismic survey cruise along Central and South America. Information was determined to be sufficient to initiate consultation on this date.

On, January 14, 2011, as a result of NSFs application and the Permits Division's proposal to authorize the requested incidental harassment of listed marine mammals species, the Endangered Species Division received a request for formal consultation from the Permits Division to evaluate the effects on listed marine mammals likely to occur during a seismic survey cruise through the eastern tropical Pacific. Information was determined to be sufficient to initiate consultation on this date.

On February 4, 2011, the Permits Division published a notice of a proposed IHA in the *Federal Register* soliciting public comment.

Description of the proposed actions

The NSF proposes to fund L-DEO to conduct a seismic survey in the eastern tropical Pacific Ocean off the coast of Costa roughly in April – May, 2011 (Fig. 1). It is possible that temporary delays could occur due to weather, equipment malfunctions, or other unforeseen circumstances. Thus, the IHA is proposed to be effective from April 7, 2011 through June 6, 2011. The R/V *Marcus G. Langseth* (Langseth) would conduct the survey. The *Langseth* would deploy two subarrays of 18 airguns as an energy source and a receiving system of four hydrophone streamers. In addition, a multibeam echosounder and a sub-bottom profiler would continuously operate from the *Langseth*. 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 better understand how marine sediments record paleooceanographic information.

The survey would occur in the exclusive economic zone of Costa Rica. 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 ~2,145 km of transect lines, all in water depths ranging from <100 m to >2,500 m deep. Survey effort including turns and contingency will be a total of 3,215 km. The closest the vessel will approach the coast is ~30 km (Fig. 1).

Schedule

The *Langseth* is scheduled to depart Puerto Caldera, Costa Rica on or about 7 April 2011, for the study area (Fig. 1). The *Langseth* will transit along the transect line. In total, the NSF predicts 25-26 (maximum 28) days of seismic operations will occur. On or about 9 May 2011, the

Langseth should arrive back in Puerto Caldera after completing survey operations.

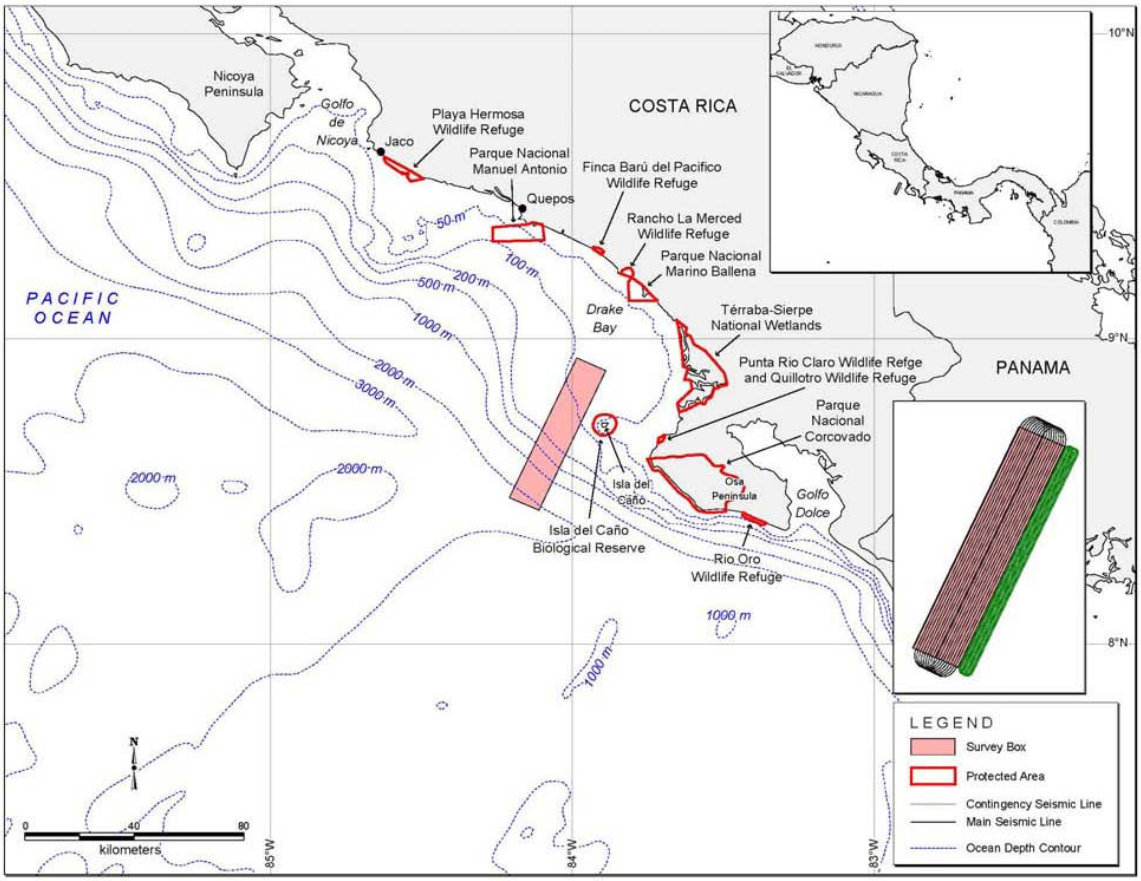

Figure 1. Study area, protected areas near the survey area, and proposed seismic transect lines for the L-DEO survey planned for April–May 2011 in the ETP off Costa Rica.

Source vessel specifications

The R/V *Marcus G. Langseth* will be used as the source vessel. The *Langseth* will tow the airgun array and four streamers along predetermined lines (Fig. 1). When the *Langseth* is towing the airgun array and the hydrophone streamers, the turning rate of the vessel is limited to five degrees per minute. Thus, the maneuverability of the vessel is limited during operations with the streamers.

The *Langseth* was designed as a seismic research vessel, with a propulsion system designed to be as quiet as possible to avoid interference with the seismic signals. The ship is powered by two Bergen BRG-6 diesel engines, each producing 3550 hp, which drive the two propellers directly. Each propeller has four blades, and the shaft typically rotates at 750 revolutions per minute (rpm). The vessel also has an 800 hp bowthruster, which is not used during seismic acquisition. The operation speed during seismic acquisition will be ~8.5 km/h. When not towing seismic survey gear, the *Langseth* can cruise at 20–24 km/h. The *Langseth* has a range of 25,000 km.

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 two subarrays of 18 airguns, each with a total volume of ~3300 in^3. The airguns would be spaced 16 m apart between the first and last airguns in the strings, ~140 m behind the *Langseth*. The tow depth of the array would be seven meters. The airgun array would fire every 25 m along the transect line. During firing, a brief (~0.1 s) pulse of sound would be emitted, but airguns would be silent during the intervening periods.

Because the actual source originates from both 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 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.

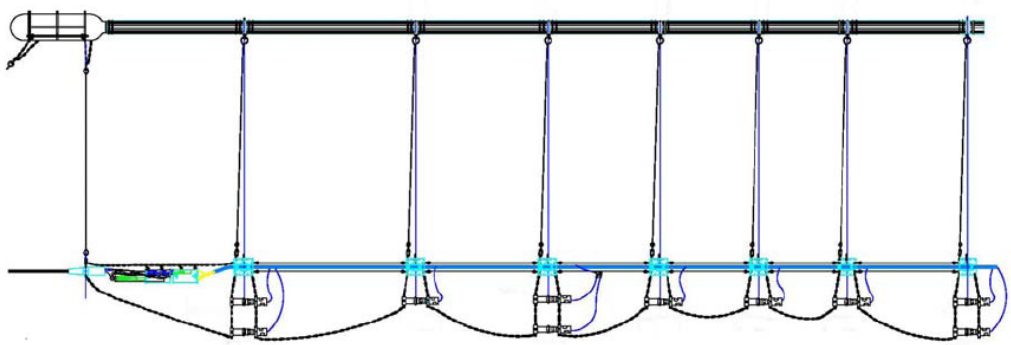

Figure 2. One linear airgun array or string with ten airguns, nine of which would be operating.

<u>18-airgun array (2 Strings) specifications</u>

• Energy source	Eighteen 2000 psi Bolt airguns of 40-360 in^3
• Source output (downward)	0-pk is 42 bar-m (252 dB re 1 μPa·m); pk-pk is 87 bar-m (259 dB re 1 μPa·m)
• Air discharge volume	~3300 in^3
• Dominant frequency components	0–188 Hz

Multibeam echosounder and sub-bottom profiler

Along with airgun operations, two additional acoustical data acquisition systems would operate during the survey except during coring and water sampling operations. 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 (usually 12) kHz. The beam width 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 $\mu Pa \cdot m_{rms}$. For operations in water up to 2,600 m deep, each "ping" consists of eight successive fan-shaped transmissions, each 2 to 15 ms in duration once every 5-20 s and each ensonifying a sector that extends 1° fore–aft. In water deeper than 2,600 m, frequency-modulated chirps up to 100 ms long replace continuous wave pulses. 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.

<u>*Langseth* sub-bottom profiler specifications</u>

- Maximum/normal source output (downward) — 204 dB re 1 μPa·m; 800 W
- Dominant frequency component — 3.5 kHz
- Nominal beam width — 30º
- 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
- Pulse duration — 1, 2, or 4 ms

Predicted sound levels vs. distance and depth. Empirical data concerning 180, 170, and 160 dB re 1 μPa_{rms} distances were acquired during an acoustic calibration study in 2003 (Tolstoy et al. 2004). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. The L-DEO has predicted received sound levels, in relation to distance and direction for two subarrays of 18 airguns similar those to be used in the proposed survey (Fig. 2). However, G airguns generally have more energy than GI guns; therefore, the model overestimates distances of given isopleths. The model does not incorporate bottom or surface interactions or water chemistry.

Table 1 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the airgun array. The 180 dB re 1 μPa_{rms} distance is the the safety criterion as specified by NMFS (1995,2000) and are applicable to cetaceans. The 180 dB distance would also be used as the exclusion zone for sea turtles, as required by the NMFS during most other recent NSF-funded seismic projects (Holst and Beland 2008; Holst and Smultea 2008b; Holst et al. 2005d; Holt 2008; Smultea et al. 2004).

Table 1. Predicted distances to which sound levels ≥190, 180, 170, and 160 dB re 1 μParms could be received during the proposed survey during April–June 2011 using an 18-airgun, 3300-in^3 subarray towed at a depth of 7 m.

			Predicted RMS Radii (m)		
Source and Volume	**Water Depth**	**190 dB**	**180dB**	**170dB**	**160dB**
	>1000 m	12	40	120	385
Single Bolt airgun (40 in^3)	100-1000 m	18	60	180	578
	<100 m	150	296	500	1050
	>1000 m	140	450	1400	3800
18-airgun subarray	100-1000m	210	675	2100	5700
(3300 in^3)	<100 m	235	1030	4500	19,500[1]

[1] This is likely an overestimate, as the measured distance for the 36-gun array operating in shallow waters of the northern Gulf of Mexico was 17.5 km.

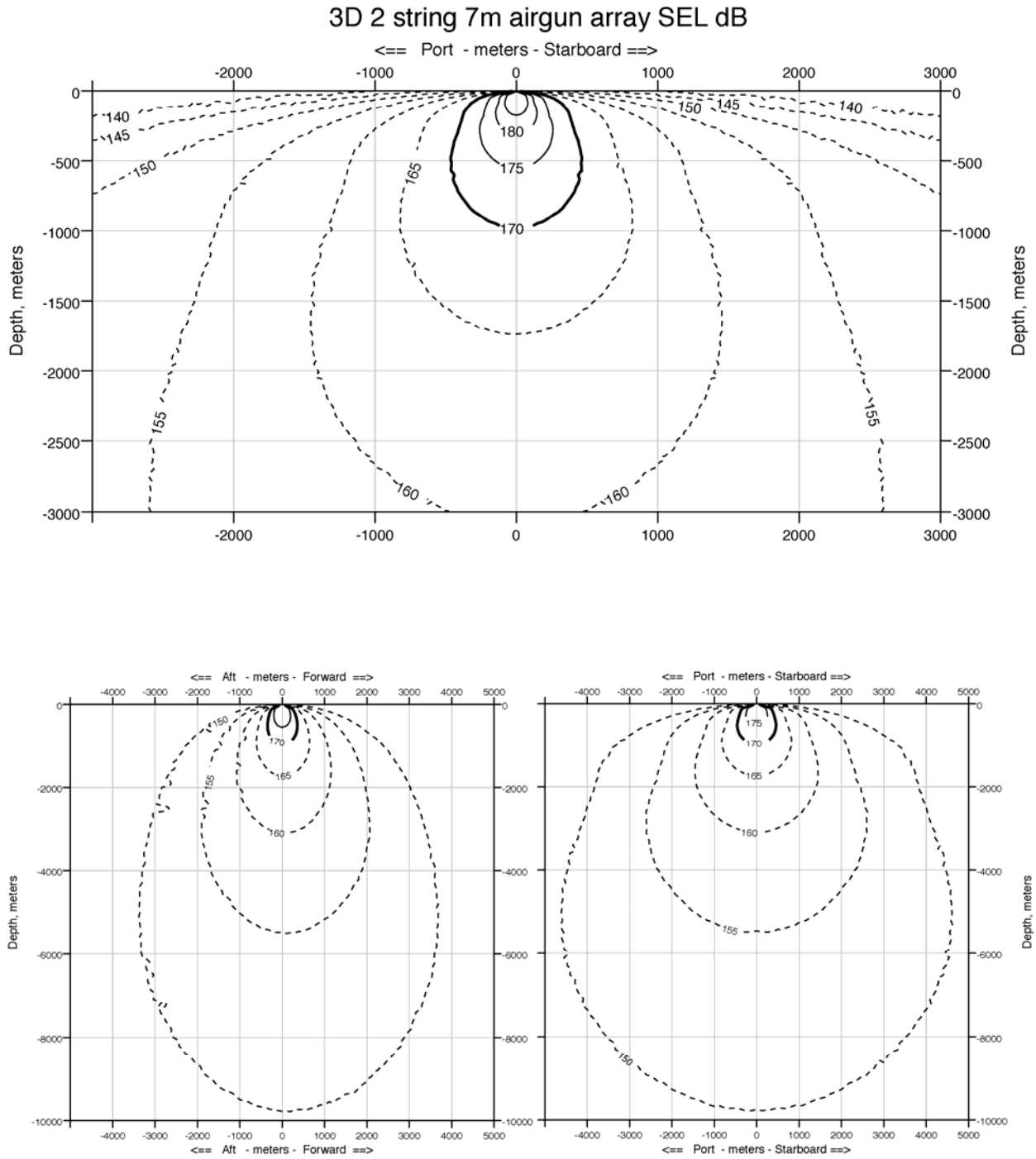

Figure **3**. Modeled received sound levels (SELs) from the 18-airgun subarray planned for use during the survey in the ETP during 2011, at a 7-m tow depth. Received rms levels (spls) are expected to be ~10 Db higher. Sound intensity decreases with increasing distance from the source array. As sound is directed downward, sound intensity in surface/shallow waters is generally less than in deeper waters.

Incidental Harassment Authorization

The NMFS' Permits Division is proposing to issue an IHA authorizing "takes" by Level B 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). Level B harassment would result in behavioral modification only, Incidental take by injury, serious injury or mortality would neither be anticipated nor authorized. The IHA would be valid from April 7, 2011 to June 6, 2011, and would authorize the incidental harassment of the following endangered species: blue whales (*Balaenoptera musculus*), humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and other non-listed marine mammals. The proposed IHA identifies the following requirements that L-DEO would be required to comply with should a final authorization be issued.

A. Establish a safety radius corresponding to the anticipated 180-dB isopleth for airgun operations.

B. Use at least one, and when practical two, NMFS-approved, vessel-based Protected Species Visual Observers (PSVO) (except during meal times and restroom breaks, when at least one PSVO will be on watch) to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from civil twilight-dawn to civil twilight-dusk), and before and during start-ups of airguns day or night, and while the seismic array is being deployed and retrieved. Vessel crew would also assist in detecting marine mammals, when practical. PSVOs would have access to reticle binoculars (7 X 50) and optical range finders. PSVO shifts will last no longer than four hours at a time. PSVOs will also observe during daytime periods when the seismic system is not operating for comparisons of animal abundance and behavior, when feasible.

   PSVOs will conduct monitoring while the airgun array and streamers are being deployed or recovered from the water.

C. Record the following information when a marine mammal is sighted:

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

   ii. Time, location, heading, speed, activity of the vessel (including 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 PSVOs, for at least 30 min prior to starting the airgun (day or night). If the PSVO 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 PSVO sees a mysticete or large odontocete surface, then dive below the surface, the L-DEO shall wait 30 minutes. If the PSVO 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 minutes (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.

E. 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 minutes, 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. This means the second airgun would be started 5 minutes later. During ramp-up, the MMOs will monitor the safety radius, and if marine mammals are sighted, a course/speed alteration or shut-down will occur as though the full array were operational.

F. 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 shut-down, will be taken.

G. Shut-down of the airguns upon marine mammal detection within, approaching, or entering the safety radius. 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 minutes (small odontocetes) or 30 minutes (mysticetes and large odontocetes).

H. Emergency shutdown. In the unanticipated event that any taking of a marine mammal in a manner not permitted by the proposed IHA 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.

I. 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 IHA is required to submit a report on all activities and monitoring results to the Office of Protected Resources 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 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, as well as those of any interdependent or interrelated action, that are likely to have direct or 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 or 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 species 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 species are likely to be exposed to an action's effects and the nature of that exposure, we examine the best scientific and commercial data available to determine whether and how those listed species 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. If information on a given species is lacking, we consider the use of surrogate species where appropriate (Favreau et al. 2006; Hitt and Frissell 2004). 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 review all of the evidence available to us and rely on the best available evidence. 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, and 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 try 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 evaluate, 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. Our assumptions included:

- Baleen whales can generally hear low-frequency sound better than high frequencies, as the former is the primary range in which they vocalize. 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 (blue whales) and those that hear at low- to mid-frequencies (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. Hearing in sea turtles is generally similar within the taxa, with data from loggerhead and green sea turtles being representative of the taxa as a whole.
- 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; same for sea turtles).
- Although we may not know why individuals occur in a specific location, we assume that the individuals have located themselves in particular locations to maximize their survive and/or reproductive potential. Individuals displaced from these locations may or may not have secondary locations that are capable of meeting the individual's biological needs. Even if available, these habitats may not offer the potential for survival and reproduction of the displaced location.

Action area

The proposed seismic survey will occur in water depths ranging from less than 100 m to greater than 2,500 m, and will take place in the EEZ of Costa Rica between April through June, 2011 (Fig 1 on page 3). The survey would encompass the area from 8.5-9º N, and 83.75-84.25° W in the eastern tropical Pacific Ocean.

The action area encompasses the survey transect lines (3,215 km) with the additional area that would be ensonified by the airgun pulses, as well as the transit to and from Puerto Caldera, Costa Rica. Sounds generated by the airguns would likely propagate spherically. In order to calculate the extent to which would remain above ambient noise, and therefore salient and detectable by listed species, we employed a modified transmission loss formula. Sound intensity decreases as the inverse square of the range for spherical spreading. Noise intensity values at a certain radial distance (r) from sound sources may be calculated by using the following spherical transmission loss formula:

$$\text{Spherical Transmission Loss} = 20 \log10 (r) \text{ dB}$$

Although multiple factors may affect the spreading of sound in seawater, this formula gives us a reasonable approximation of the extent to which the proposed sound will travel while remaining above ambient noise levels. Responses to seismic sound sources by listed species are expected to occur within the 160 dB isopleths (modeled to be 3,800-19,500 m depending on water depth) (Richardson et al. 1995a).

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 ESA.

Table 2. Listed species 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
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	*Caretta caretta*	Threatened
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered/ Threatened

Two listed whales (fin and sei) rarely occur in the action area or the surrounding region, but we do not expect exposure to the proposed action due to their rarity and likely occurrence elsewhere. Systematic surveys over more than 20 years through the region during the time frame of the proposed action have failed to produce a single fin whale sighting or acoustic detection (Félix and Haase 2001; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001). These surveys have, however, found fin whales further north along the Mexican and American coastline, as well as in the Gulf of California (areas known to be foraging locations for this species (Félix and Haase 2001; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001). Furthermore, fin whales do not distribute equatorially, preferring temperate and sub-tropical regions (Brito et al. 2009; Clark 1995; Gambell 1985a; Mizroch et al. 1999; Rice 1998). Based upon the general distribution of fin whales in the Pacific and their specific absence from the action area despite significant survey effort, we find the likelihood of fin whale exposure to be discountable.

We also find the likelihood of sei whale occurrence in the action area to be discountable for similar reasons. Marine mammal and seabird surveys have failed to identify a single sei whale in the eastern tropical Pacific (Félix and Haase 2001; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001). Although many dozens of sightings since 1985 have been made of individuals that were either sei or Bryde's whales, we expect that all or nearly all of these sightings are of the frequently-sighted and tropically distributed Bryde's whale, which is difficult to differentiate at sea from the temperately-distributed sei whale (Félix and Haase 2001; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001). In fact, no sei whale had been seen within 20 degrees of the equator until 2007, when several were observed in the Marianas Islands, except for a single report off Costa Rica (Rodríguez-Herrera et al. 2002). Sei whales would be expected further north or south in the Northern and Southern Hemispheres, respectively, where individuals have been identified during the time frame of the proposed seismic survey (Gambell 1985b; Jonsgård and Darling 1977; Masaki 1977; Olsen et al. 2009; Reeves et al. 1999).

By regulation NMFS does not designate critical habitat outside the United States Exclusive Economic Zone (US EEZ) and thus no critical habitat has been designated for any affected species within the action area. We conclude that critical habitat therefore will not be affected 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.

Cetaceans

Blue whale

Distribution. Blue whales occur primarily in the open ocean from tropical to polar waters worldwide. Blue whales are highly mobile, and their migratory patterns are not well known

(Perry et al. 1999; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998).

Subspecies. Several blue whale subspecies have been characterized from morphological and geographical variability, but the validity of blue whale subspecies designations remains uncertain (McDonald et al. 2006). The largest, the Antarctic or true blue whale (*Balaenoptera musculus intermedia*), occurs in the highest Southern Hemisphere latitudes (Gilpatrick and Perryman. 2009). During austral summers, "true" blue whales occur close to Antarctic ice. A slightly smaller blue whale, *B. musculus musculus*, inhabits the Northern Hemisphere (Gilpatrick and Perryman. 2009). The pygmy blue whale (B. *musculus brevicauda*), may be geographically distinct from *B. m. musculus* (Kato et al. 1995). Pygmy blue whales occur north of the Antarctic Convergence (60°-80° E and 66°-70° S), while true blue whales are south of the Convergence (58° S) in the austral summer (Kasamatsu et al. 1996; Kato et al. 1995). A fourth subspecies, *B. musculus indica*, may exist in the northern Indian Ocean (McDonald et al. 2006).

Population structure. We know little about population and stock structure[1] of blue whales. Studies suggest a wide range of alternative population and stock scenarios based on movement, feeding, and acoustic data. Some suggest that as many as 10 global populations, while others suggest that the species is composed of a single panmictic population (Gambell 1979; Gilpatrick and Perryman. 2009; Reeves et al. 1998). For management purposes, the International Whaling Commission (IWC) considers all Pacific blue whales as a single stock, whereas under the MMPA, the NMFS recognizes four stocks of blue whales: western North Pacific Ocean, eastern North Pacific Ocean, Northern Indian Ocean, and Southern Hemisphere.

Until recently, blue whale population structure had not been tested using molecular or nuclear genetic analyses (Reeves et al. 1998). A recent study by Conway (2005) suggested that the global population could be divided into four major subdivisions, which roughly correspond to major ocean basins: eastern North and tropical Pacific Ocean, Southern Indian Ocean, Southern Ocean, and western North Atlantic Ocean. The eastern North/tropical Pacific Ocean subpopulation includes California, western Mexico, western Costa Rica, and Ecuador, and the western North Atlantic Ocean subpopulation (Conway 2005). For this Opinion, blue whales as treated four distinct populations as outlined by Conway (2005).

North Atlantic. Blue whales are found from the Arctic to at least mid-latitude waters, and typically inhabit the open ocean with occasional occurrences in the U.S. EEZ (Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Yochem and Leatherwood (1985) summarized records suggesting winter range extends south to Florida and the Gulf of Mexico. The U.S. Navy's Sound Surveillance System acoustic system has detected blue whales in much of the North Atlantic, including subtropical waters north of the West Indies and deep waters east of the U.S. Atlantic EEZ (Clark 1995). Blue whales are rare in the shelf waters of the eastern U.S. In the western North Atlantic, blue whales are most frequently sighted from the

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"Populations" herein are a group of individual organisms that live in a given area and share a common genetic heritage. While genetic exchange may occur with neighboring populations, the rate of exchange is greater between individuals of the same population than among populations---a population is driven more by internal dynamics, birth and death processes, than by immigration or emigration of individuals. To differentiate populations, NMFS considers geographic distribution and spatial separation, life history, behavioral and morphological traits, as well as genetic differentiation, where it has been examined. In many cases, the behavioral and morphological differences may evolve and be detected before genetic variation occurs. In some cases, the term "stock" is synonymous with this definition of "population" while other usages of "stock" are not.

Gulf of St. Lawrence and eastern Nova Scotia and in waters off Newfoundland, during the winter (Sears et al. 1987). In the eastern North Atlantic, blue whales have been observed off the Azores, although Reiner et al. (1993) did not consider them common in that area.

North Pacific. Blue whales occur widely throughout the North Pacific. Acoustic monitoring has recorded blue whales off Oahu and the Midway Islands, although sightings or strandings in Hawaiian waters have not been reported (Barlow et al. 1997a; Northrop et al. 1971; Thompson and Friedl 1982). Nishiwaki (1966a) notes blue whale occurrence among the Aleutian Islands and in the Gulf of Alaska, but until recently, no one has sighted a blue whale in Alaska for some time, despite several surveys (Carretta et al. 2005; Forney and Brownell Jr. 1996; Leatherwood et al. 1982; Stewart et al. 1987), possibly supporting a return to historical migration patterns (Anonmyous. 2009).

Blue whales are thought to summer in high latitudes and move into the subtropics and tropics during the winter (Yochem and Leatherwood 1985). Minimal data suggest whales in the western region of the North Pacific may summer southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska, and winter in the lower latitudes of the western Pacific (Sea of Japan, the East China, Yellow, and Philippine seas) and less frequently in the central Pacific, including Hawaii (Carretta et al. 2005; Stafford 2003; Stafford et al. 2001; Watkins et al. 2000), although this population is severely depleted or has been extirpated (Gilpatrick and Perryman. 2009). Acoustic recordings made off Oahu showed bimodal peaks of blue whales, suggesting migration into the area during summer and winter (McDonald and Fox 1999; Thompson and Friedl 1982). In the eastern North Pacific, blue whales appear to summer off California and occasionally as far north as British Columbia, migrating south to productive areas off Mexico and as far south as the Costa Rica Dome (CRD) (10° N) from June through November (Calambokidis et al. 1998; Calambokidis et al. 1990; Chandler and Calambokidis 2004; Mate et al. 1999; Reilly and Thayer 1990; Stafford et al. 1999b; Wade and Friedrichsen 1979; Wade and Gerrodette 1993a). Data indicate, though, that some individuals may remain here year-round (Reilly and Thayer 1990; Wade and Friedrichsen 1979). The CRD's productivity may allow blue whales to feed during their winter calving/breeding season and not fast (Gilpatrick and Perryman. 2009; Mate et al. 1999).

Blue whales off southern California appear to feed on dense euphausiid schools between 100-200 m below the surface (Croll et al. 1998; Fiedler et al. 1998). These concentrations of krill are associated with upwelling regions near steep topography off the continental shelf break (Croll et al. 1999). Blue whale migrations to and from California probably reflect seasonal patterns and productivity (Croll et al. 2005). Blue whales also feed in cool, offshore, upwelling-modified waters in the eastern tropical and equatorial Pacific (Palacios 1999; Reilly and Thayer 1990). Mean group size during yearly NMFS cruises has ranged from 1.7-2.4 (Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001; Smultea and Holst 2003b). Feeding areas may be associated with a greater incidence of blue whale vocalizations (Moore et al. 2002). During summer, blue whales calls in water of the Northwest Pacific were closely associated with cold water and sharp sea surface temperature gradients or fronts, probably corresponding to zooplankton concentrations. Call locations were concentrated primarily near the Emperor seamounts, the continental sloped of the Kamchatka Peninsula and Aleutian Islands, as well as frontal boundaries (Moore et al. 2002). Seasonal differences in calling patterns have been documented, with blue whales moving along seamounts in fall and winter (Moore et al. 2002).

Blue whale sightings, although fewer than sperm whales and other odontocetes, occur consistently from year to year during October and November in the region of the action area (Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001; Smultea and Holst 2003b). In the eastern tropical Pacific, observers have seen concentrations of blue whales near the CRD, the Galápagos Islands (including west and southwest of the islands), and along the coasts of Ecuador and northern Peru throughout the year (Aguayo 1974b; Branch et al. 2006; Chandler and Calambokidis 2004; Donovan 1984; Mate et al. 1999; Palacios 1999; Palacios et al. 2005; Reilly and Thayer 1990; Wade and Friedrichsen 1979). Reilly and Thayer (1990) suggested that blue whales that occur in the CRD may be migrant animals from the northern or southern hemispheres or they may be a resident population (Mate et al. 1999; Palacios 1999). It should be noted that blue whales have not been sighted during four NSF-funded seismic surveys in the region over the past decade (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a). Stafford et al. (1999a) and Chandler and Calambokidis (2004) found that blue whales feeding off California have call similarities to those over the CRD, meaning that they may be from the same population. This is supported by satellite tracking data showing blue whales moving from California to a region near the CRD (Bailey et al. 2009; Mate et al. 1999).

Indian Ocean. Blue whale sightings have occurred in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Clapham et al. 1999; Mikhalev 1997; Mizroch et al. 1984).

Southern Hemisphere. Blue whales range from the edge of the Antarctic pack ice (40°-78°S) during the austral summer north to Ecuador, Brazil, South Africa, Australia, and New Zealand during the austral winter (Shirihai 2002). Occurrence in Antarctic waters appears to be highest from February-May as well as in November (Sirovic et al. 2009). Blue whales are occasionally sighted in pelagic waters off the western coast of Costa Rica and Nicaragua, near the Galápagos Islands, and along the coasts of Ecuador and northern Peru (Aguayo 1974a; Clarke 1980b; Donovan 1984; LGL Ltd. 2007; Mate et al. 1999; Palacios 1999; Reilly and Thayer 1990). Individuals here may represent to populations; the true and pygmy blue whales of the Southern Hemisphere (Gilpatrick and Perryman. 2009).

Age. Blue whales may reach 70–80 years of age (COSEWIC 2002; Yochem and Leatherwood 1985).

Reproduction. Gestation takes 10-12 months, followed by a 6-7 month nursing period. Sexual maturity occurs at 5-15 years of age and calves are born at 2-3 year intervals (COSEWIC 2002; NMFS 1998; Yochem and Leatherwood 1985). Recent data from illegal Russian whaling for Antarctic and pygmy blue whales support sexual maturity at 23 m and 19-20 m, respectively (Branch and Mikhalev 2008).

Movement. Satellite tagging indicates that, for blue whales tagged off Southern California, movement is more linear and faster (3.7 km/h) while traveling versus while foraging (1.7 km/h) (Bailey et al. 2009). Residency times in what are likely prey patches averages 21 days and constituted 29% of an individual's time overall, although foraging could apparently occur at any time of year for tagged individuals (Bailey et al. 2009). Broad scale movements also varied greatly, likely in response to oceanographic conditions influencing prey abundance and distribution (Bailey et al. 2009).

Feeding. Data indicate that some summer feeding takes place at low latitudes in upwelling-

modified waters, and that some whales remain year-round at either low or high latitudes (Clarke and Charif 1998; Hucke-Gaete et al. 2004; Reilly and Thayer 1990; Yochem and Leatherwood 1985). One population feeds in California waters from June to November and migrates south in winter/spring (Calambokidis et al. 1990; Mate et al. 1999). Prey availability likely dictates blue whale distribution for most of the year (Burtenshaw et al. 2004; Clapham et al. 1999; Sears 2002 as cited in NMFS 2006b). The large size of blue whales requires higher energy requirements than smaller whales and potentially prohibits fasting (Mate et al. 1999). Krill are the primary prey of blue whales in the North Pacific (Kawamura 1980; Yochem and Leatherwood 1985).

While feeding, blue whales show slowed and less obvious avoidance behavior then when not feeding (Sears et al. 1983 as cited in NMFS 2005b).

Diving. Blue whales spend greater than 94% of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 sec intervals before a deep dive of 3-30 min (Croll et al. 1999; Leatherwood et al. 1976; Mackintosh 1965; Maser et al. 1981; Strong 1990; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001). Deep dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

Blue whales typically occur alone or in groups of up to five animals, although larger foraging aggregations of up to 50 have been reported including aggregations mixed with other rorquals such as fin whales (Aguayo 1974a; Corkeron et al. 1999; Fiedler et al. 1998; Mackintosh 1965; Nemoto 1964; Pike and MacAskie 1969; Ruud 1956; Schoenherr 1991; Shirihai 2002; Slijper 1962).

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

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources; (Edds-Walton 1997; Payne and Webb 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure.

Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

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

Status and trends. Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973.

Table 3 contains historic and current estimates of blue whales by region. Globally, blue whale abundance has been estimated at between 5,000-13,000 animals (COSEWIC 2002; Yochem and Leatherwood 1985); a fraction of the 200,000 or more that are estimated to have populated the oceans prior to whaling (Maser et al. 1981; U.S. Department of Commerce 1983).

North Atlantic. Commercial hunting had a severe effect on blue whales, such that they remain rare in some formerly important habitats, notably in the northern and northeastern North Atlantic (Sigurjónsson and Gunnlaugsson 1990). Sigurjónsson and Gunnlaugsson (1990) estimated that at least 11,000 blue whales were harvested from all whaling areas from the late nineteenth to mid-twentieth centuries. The actual size of the blue whale population in the North Atlantic is uncertain, but estimates range from a few hundred individuals to about 2,000 (Allen 1970; Mitchell 1974; Sigurjónsson 1995; Sigurjónsson and Gunnlaugsson 1990). Current trends are unknown, although an increasing annual trend of 4.9% annually was reported for 1969–1988 off western and southwestern Iceland (Sigurjónsson and Gunnlaugsson 1990). Sigurjónsson and Gunnlaugsson (1990) concluded that the blue whale population had been increasing since the late 1950s.

North Pacific. Estimates of blue whale abundance are uncertain. Prior to whaling, Gambell (1976) reported there may have been as many as 4,900 blue whales. Blue whales were hunted in the Pacific Ocean, where approximately 5,761 killed from 1889–1965 (Perry et al. 1999). The IWC banned commercial whaling in the North Pacific in 1966, although Soviet whaling continued after the ban. In the eastern North Pacific, the minimum population (based upon surveys in U.S. EEZ waters) is thought to be 1,384 whales, but no minimum estimate has been established (Carretta et al. 2006). Although blue whale abundance has likely increased since its protection in 1966, the possibility of unauthorized harvest by Soviet whaling vessel, incidental shipstrikes, and gillnet mortalities make this uncertain.

Calambokidis and Barlow (2004) estimated roughly 3,000 blue whales inhabit waters off California, Oregon, and Washington based on line-transect surveys and 2,000 based on capture-recapture methods. Carretta et al.(2006) noted that the best estimate of abundance off California, Oregon, and Washington is an average of line-transect and capture-recapture estimates (1,744).

Southern Hemisphere. Estimates of 4-5% for an average rate of population growth have been proposed (Yochem and Leatherwood 1985). A recent estimate of population growth for Antarctic blue whales was a robust 7.3% (Branch et al. 2007). Branch et al. (2007) also included an estimate of 1,700 individuals south of 60º. Blue whales in the region remain severely depleted with the 1996 estimate only 0.7% of pre-whaling levels (IWC 2005a).

Blue whales were the mainstay of whaling in the region once the explosive harpoon was developed in the late nineteenth century (Shirihai 2002). During the early 1900s, the species became a principal target of the whaling industry throughout the world, with the majority killed in the Southern Hemisphere. Approximately 330,000–360,000 blue whales were harvested from 1904 to 1967 in the Antarctic alone, reducing their abundance to <3% of their original numbers (Perry et al. 1999; Reeves et al. 2003). Blue whales were protected in portions of the Southern Hemisphere beginning in 1939, and received full protection in the Antarctic in 1966.

Natural threats. As the world's largest animals, blue whales are only occasionally known to be

killed by killer whales (Sears et al. 1990; Tarpy 1979). Blue 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). Blue whales are known to become infected with the nematode *Carricauda boopis*, which are believed to have caused mortality in fin whale due to renal failure (Lambertsen 1986).

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

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	200,000	--	11,200-13,000	--	(DOC 1983; Maser et al. 1981)
				5,000-12,000		(COSEWIC 2002)
North Atlantic	Basinwide	1,100-1,500	--	100-555	--	(Braham 1991; Gambell 1976)
	NMFS - Western North Atlantic stock	--	--	308	--	(Sears et al. 1987)
North Pacific	Basinwide	4,900	--	1,400-1,900	--	(Gambell 1976)
				3,300	--	(Wade and Gerrodette 1993a) and (Barlow 1997a) as combined in (Perry et al. 1999)
	Eastern Tropical Pacific	--	--	1,415	1,078-2,501	(Wade and Gerrodette 1993a)
	EEZ of Costa Rica	--	--	48	22-102*	(Gerrodette and Palacios 1996)
	EEZs of Central America north of Costa Rica	--	--	94	34-257*	(Gerrodette and Palacios 1996)
	Eastern North Pacific	--	--	2,997	2,175-3,819*	(Calambokidis and Barlow 2004)
	NMFS - western North Pacific stock	--	--	n/a	--	(Carretta et al. 2006)
	NMFS - eastern North Pacific stock	--	--	2,842	CV=0.41	(Carretta et al. 2009b)
Southern Hemisphere	Basinwide	150,000-210,000	--	5,000-6,000	--	(Gambell 1976; Yochem and Leatherwood 1985)
		300,000	--	--	--	(COSEWIC 2002)
		--	--	400-1,400	400-1,400	IWC, for years 1980-2000
		--	--	1,700	860-2,900	(IWC 2005b), point estimate for 1996
	Within IWC survey areas	--	--	1,255	--	(IWC 1996)
	Pygmy blue whale population	10,000	--	5,000	--	(Gambell 1976)
		13,000	--	6,500	--	(Zemsky and Sazhinov 1982)

*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).

Anthropogenic threats. Blue whales have faced threats from several historical and current sources. Blue whale populations are severely depleted originally due to historical whaling activity.

Shipstrike is presently a concern for blue whale recovery. Shipstrikes have recently averaged roughly one every other year (eight shipstrike incidents are known Jensen and Silber (2004), but in September 2007, ships struck five blue whales within a few-day period off southern California (Calambokidis pers. comm. 2008). Dive data support a surface-oriented behavior during nighttime that would make blue whales particularly vulnerable to shipstrikes. There are concerns that, like right whales, blue whales may surface when approached by large vessels; a behavior that would increase their likelihood of being struck. Protective measures are not currently in place. In the California/Mexico stock, annual incidental mortality due to shipstrikes averaged one whale every 5 years, but we cannot determine if this reflects the actual number of blue whales struck and killed by ships (i.e., individuals not observed when struck and those who do not strand; Barlow et al. (1997a). It is believed that the vast majority of shipstrike mortalities are never identified, and that actual mortality is higher than currently documented.

Increasing oceanic noise may impair blue whale behavior. Although available data do not presently support traumatic injury from sonar, the general trend in increasing ambient low-frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006).

There is a paucity of contaminant data regarding blue whales. Available information indicates that organochlorines, including dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCB), benzene hexachloride (HCH), hexachlorobenzene (HCB), chlordane, dieldrin, methoxychlor, and mirex have been isolated from blue whale blubber and liver samples (Gauthier et al. 1997b; Metcalfe et al. 2004). Contaminants transfer between mother and calf meaning that young often start life with concentrations of contaminants equal to their mothers, before accumulating additional contaminant loads during life and passing higher loads to the next generation (Gauthier et al. 1997a; Metcalfe et al. 2004).

Humpback whale

Distribution. Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they 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. Migrations, though, are undertaken through deep, pelagic waters (Winn and Reichley 1985).

Population designations. Populations are have been relatively well defined for humpback whales. Individuals (particularly males) are known to move between breeding areas; trans-equatorial movement and genetic exchange have been found (Rizzo and Schulte 2009).

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 (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). 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; genetic exchange has been identified between individuals along the west coast of the U.S. and humpbacks off Japan (Baker et al. 1998). 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. 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. 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; Mori et al. 1998; Rice 1998). During summer, whales from this population migrate to the Aleutian and Kuril Islands, Okhotsk and Bering Sea, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2007; Calambokidis 1997; Calambokidis et al. 2001; Nishiwaki 1966b; Ohsumi and Masaki 1975).

The timeframe of the proposed seismic survey (April through June) is a period when humpback whales are observed in the region, but this period is likely in between the peak occurrences for Northern and Southern Hemisphere individuals (Acevedo and Smultea 1995; Calambokidis et al.

2010; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001; May-Collado et al. 2005; Rasmussen et al. 2004; Rasmussen et al. 2007a; Smultea and Holst 2003b). Individuals encountered during this time would likely be early migrants from the Southern Hemisphere leaving the breeding grounds, which occur along Costa Rica from June to October, peaking in abundance between August and early October (May-Collado et al. 2005; Rasmussen et al. 2004; Rasmussen et al. 2007a). Most of these individuals would be mothers with accompanying calves (Jay Barlow, NOAA-SWFSC, pers. comm.). Previous seismic surveys in the region have encountered humpback whales previously, particularly a survey in the region during November and December timeframe (Holst and Smultea 2008b; Holst et al. 2005c). Mean group sizes in the eastern tropical Pacific during winter have been found to range between 1.6 and 2.5 over the past decade (Félix and Haase 2001; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001). Although sightings are frequent, occurrence tends to be limited to neritic environments; this is a trait consistent with humpback breeding areas elsewhere in the world. Fewer sightings have been documented in offshore regions of the action area.

Southern Hemisphere. Eight proposed stocks, or populations, of humpback whales occur in waters off Antarctica (Fig. 2). Individuals from these stocks winter and breed in separate areas and are known to return to the same areas. 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 we known little of the movements of this group (Mikhalev 1997; Rasmussen et al. 2007b). 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). In addition, females appear in this area in large numbers well before their male counterparts, frequently accompanied by calves (Barendse et al. 2010).

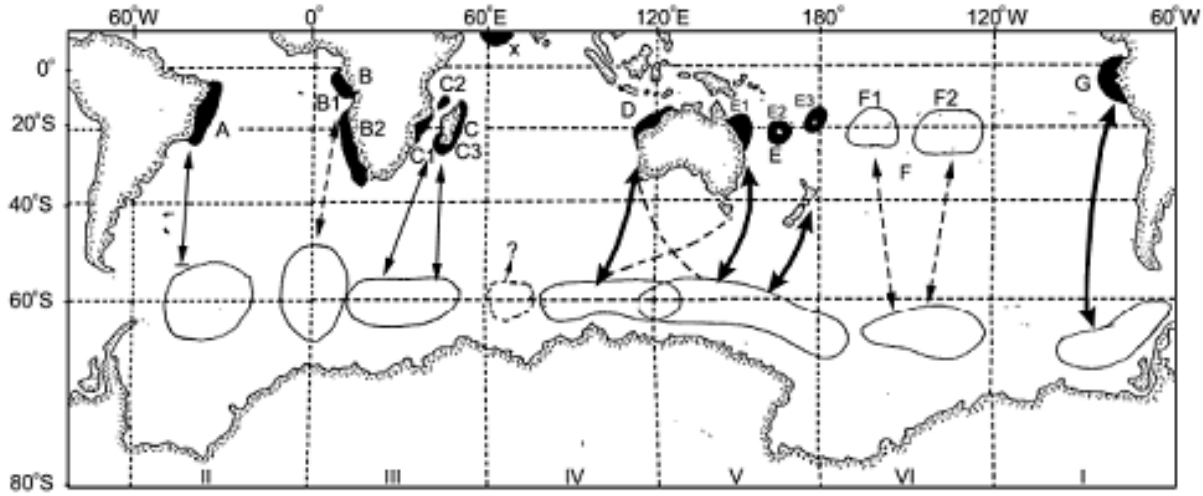

Figure 2. Southern Hemisphere humpback stocks (populations) (IWC 2005a).

Geographical overlap between Northern and Southern Hemisphere populations has been documented only off the Pacific coast of Central America (Acevedo and Smultea 1995; Rasmussen et al. 2004; Rasmussen et al. 2007a). Humpback whales are one of the most abundant cetaceans off the Pacific coast of Costa Rica (Northern Hemisphere humpbacks) and off the coasts of Ecuador, Columbia, and Panama (Southern Hemisphere humpbacks), where the population calves and breeds (Best 2008; Denkinger et al. 1997; Felix and Haase. 2005; May-Collado et al. 2005; Rasmussen et al. 2004).

Diving. In Hawaiian waters, humpback whales remain almost exclusively within the 1,800 m isobath and usually within waters 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).

Vocalization and hearing. We understand humpback whale vocalization much better than we do hearing. Humpback whales produce different sounds 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. 1995a; 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. 1995a; 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. 1995a; Thompson et al. 1986)). Humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995a).

Recently, humpback whales were reported to use echolocation-type clicks that were associated with feeding (Stimpert et al. 2009). The authors suggest that a primitive echoranging capability may exist.

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. The maximum possible growth rate for populations of this species is likely to be 7.3-8.6% annually (Zerbini et al. 2010).

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). Estimates of animals in 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, conclusions supported by increased sightings within the Gulf of Maine feeding aggregation (Barlow 1997b; 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 1997b; 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 went so far as to suggest that humpback whales in the area had probably recovered from whaling.

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	--	--	847	CV=0.55	(Waring et al. 2009)
	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	--	--	5,833	CV=0.30	(Angliss and Outlaw 2009)
	NMFS - Eastern North Pacific stock	--	--	1,391	1,331-1,451*	(Carretta et al. 2009b)
Indian Ocean	Arabian Sea	--	--	56	35-255	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 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 1978). From 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whales 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 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). 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. 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). Felix et al. (2005) estimated abundance for the southeast Pacific stock is at about 2,900 individuals. Group G (the population believed to breed in or near the action area) is thought to number 3,851 individuals (Stevick et al. 2006).

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 populations 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).

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. Three human activities widely and significantly threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Humpback whales are also killed or injured during interactions with commercial fishing gear. Fishing gear entangles humpback whales off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Several humpback whales are also known to have become entangled in the North Pacific (Angliss and Outlaw 2007; Hill et al. 1997).

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific coast, a humpback whale is known to be killed about every other year by shipstrikes (Barlow et al. 1997a). 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 shipstrikes and in seven cases, shipstrike was determined to be the cause of death. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale shipstrike appear to be largely ignored (Vanderlaan et al. 2008). 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%.

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997a). 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.

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.

Stock 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). 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 2003a). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003a; 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 50° N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974; Whitehead 2003b), with males exhibiting a somewhat broader latitudinal range. 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-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 1993a) 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 Galápagos Islands, mainland Ecuador, and northern Peru may be distinct from other sperm whales in the Southern Hemisphere, as well as from one another (Dufault and Whitehead 1995; Rice 1977; Wade and Gerrodette 1993a). 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). 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 Galápagos 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. 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 1989b). 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).

Mean school sizes have ranged from 5.1 to 11.5 over several years of cetacean surveys through the eastern tropical Pacific (Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001; May-Collado et al. 2005; Smultea and Holst 2003b). In the Galápagos Islands, sperm whales usually occur in mixed groups of females and immature individuals; mature males occur from April through June in the Galápagos Islands, corresponding to one of two mating peaks in the area; the other is from September through October (Christal and Whitehead 1997; Lettevall 1997; Whitehead and Arnbom 1987).

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. 1989b; 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 2003a). 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. Sperm whales in the Galápagos Islands forage at depths of about 400 m (Papastavrou et al. 1989a; Smith and Whitehead 2000; Whitehead 1989).

Feeding. Sperm whales appear to feed regularly throughout the year (NMFS 2006f). 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 1989b). 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 1989b). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989b). 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).

Growth and reproduction. Sperm whales in waters near the Galapagos Islands appear to have somewhat unique traits of size and fertility. Waters and Whitehead (1990) found that sperm whales here have low pregnancy rates (2-4%), but that females reach sexual maturity at smaller sizes than individuals in other locations. Mortality of this population also may be low (Waters and Whitehead. 1990).

Vocalization and hearing. We understand **s**ound 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 2006e; 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). 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. 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 2003a).

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)
	--	1,100,000	670,000-1,512,000	360,000	105,984-614,016*	(Whitehead 2002a)
North Atlantic	Basinwide	224,800	--	22,000	--	(Gosho et al. 1984; Würsig et al. 2000)
	Northeast Atlantic, Faroes-Iceland, and U.S. East coast	--	--	13,190	--	(Whitehead 2002a)
	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	(Waring et al. 2009)
	Northern Gulf of Mexico – off the Mississippi River Delta between 86º and 91º 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 1989b)
	Eastern tropical Pacific	--	--	26,053	13,797-38,309*	(Whitehead 2003a)
	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-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)
	Western North Pacific	--	--	102,000	75,000-148,000	Kato and Miyashita (2000)
Southern Hemisphere	Basinwide	547,600	--	299,400	--	(Gosho et al. 1984; IWC 1988; Perry et al. 1999)
	South of 60ºS	--	--	14,000	8,786-19,214	(Butterworth et al. 1995) as cited in (Perry et al. 1999)
	South of 30ºS	--	--	128,000	17,613-238,687	(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).

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 sperm whale fishery operated during the late 1700s to the early 1900s (NMFS 2006f; Townsend 1935).

North Pacific. There are approximately 76,803 sperm whales in the eastern tropical Pacific, eastern North Pacific, Hawaii, and western North Pacific (Whitehead 2002a). Minimum estimates in the eastern North Pacific are 1,719 individuals and 5,531 in the Hawaiian Islands (Carretta et al. 2007). The tropical Pacific is home to approximately 26,053 sperm whales and

the western North Pacific has approximately 29,674 (Whitehead 2002a). There was a dramatic decline in the number of females around the Galápagos Islands during 1985-1999 versus 1978-1992 levels, likely due to migration to nearshore waters of South and Central America (Whitehead 2003a).

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 hunted 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 2003a). Whitehead (2002b) estimated 12,069 sperm whales south of 60° S. Sightings of sperm whales in the eastern tropical Pacific are common during the proposed seismic survey timeframe (Ferguson and Barlow 2001; Jackson et al. 2003; Jackson et al. 2008; Kinzey et al. 2000; Kinzey et al. 1999; Kinzey et al. 2001; Polacheck 1987; Smultea and Holst 2003b; Wade and Gerrodette 1993b). May-Collado et al. (2005) reported that sperm whales were particularly abundant off southeastern Costa Rica and near Isla del Cocos. Sperm whales also strand with some frequency along Ecuador and Costa Rica (Haase and Felix. 1994; Rodríguez-Fonseca and Cubero-Pardo 2001). Only one of four NSF-funded seismic surveys has detected sperm whales in the region over the past decade (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a). Whitehead et al. (1992) estimated a population of approximately 200 individuals in the Galápagos Islands.

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 1989a; 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). Other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). All of these estimates are likely underestimates due to illegal and inaccurate killings by Soviet whaling fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov 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.

Following a moratorium on whaling by the IWC, large-scale commercial whaling pressures on sperm whales ended. Sperm whales are also 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 also killed incidentally by gill nets at a rate of roughly nine per year (data from 1991 to 1995) in U.S. Pacific waters (Barlow et al. 1997a). Sperm whales interact with (remove fish from) longline fisheries in the Gulf of Alaska and entanglement has rarely been recorded (Hill and DeMaster 1999; Rice 1989b; Sigler et al. 2008).

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) (Yasunaga and Fujise 2009). 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; Yasunaga and Fujise 2009). Chromium levels from sperm whale skin samples worldwide have varied from undetectable to 122.6 µg Cr/g tissue, with the mean (8.8 µg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals did not appear to accumulate chromium at higher levels.

Sea turtles

Green sea turtle

Distribution. Green sea turtles have a circumglobal distribution, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters.

Population designation. Populations are distinguished generally by ocean basin and more specifically by nesting location (Table 6).

Based upon genetic differences, two or three distinct regional clades may exist in the Pacific: western Pacific and South Pacific islands, eastern Pacific, and central Pacific, including the rookery at French Frigate Shoals, Hawaii (Dutton and Balazs In review; Dutton et al. 1996). In the eastern Pacific, green sea turtles forage from San Diego Bay, California to Mejillones, Chile. Individuals along the southern foraging area originate from Galápagos Islands nesting beaches, while those in the Gulf of California originate primarily from Michoacán. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003a).

Green sea turtles are found year-round along the Pacific coast of Central America (Eckert 1993b; Govan 1998; NMFS and USFWS 1998a; Ocean Resource Foundation 1998). The east Pacific green is the second-most sighted turtle in the east Pacific during tuna fishing cruises; they have been frequently seen along a north-south band from 15°N to 5°S along 90°W, and between the

Galápagos Islands and Central American Coast (NMFS and USFWS 1998a). Although considered primarily neritic, green sea turtles can occur 3,200 km from shore and can travel long distances (Eckert 1993b). Roughly 10% of sea turtles sighted during NSF-funded seismic surveys in the region have been green sea turtles (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a). Based on tag-recovery information, the feeding grounds of the Mexican breeding population are restricted to Mexico and Central America, whereas green sea turtles from the Galápagos forage from Costa Rica south to Peru (NMFS and USFWS 1998a). Algal beds around the Islands of Ferdinanda e Isabel in the Galápagos are an important foraging habitat for this population (Green and Ortiz-Crespo 1995).

Table 6. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF), annual nests (AN), annual egg production (EP), and annual egg harvest (EH).

Location	Most recent abundance	Reference
Western Atlantic Ocean		
Tortuguero, Costa Rica	17,402-37,290 AF	(Troëng and Rankin 2005)
Aves Island, Venezuela	335-443 AF	(Vera 2007)
Galibi Reserve, Suriname	1,803 AF	(Weijerman et al. 1998)
Isla Trindade, Brazil	1,500-2,000 AF	(Moreira and Bjorndal 2006)
Central Atlantic Ocean		
Ascension Island, UK	3,500 AF	(Broderick et al. 2006)
Eastern Atlantic Ocean		
Poilao Island, Guinea-Bissau	7,000-29,000 AN	(Catry et al. 2009)
Bioko Island, Equatorial Guinea	1,255-1,681 AN	(Tomas et al. 1999)
Mediterranean Sea		
Turkey	214-231 AF	(Broderick et al. 2002)
Cyprus	121-127 AF	(Broderick et al. 2002)
Israel / Palestine	1-3 AF	(Kuller 1999)
Syria	100 AN	(Rees et al. 2005)
Western Indian Ocean		
Eparces Islands	2,000-11,000 AF	(Le Gall et al. 1986)
Comoros Islands	5,000 AF	S. Ahamada, pers. comm. 2001
Seychelles Islands	3,535-4,755 AF	J. Mortimer, pers. comm. 2002
Kenya	200-300 AF	(Okemwa and Wamukota 2006)
Northern Indian Ocean		
Ras al Hadd, Oman	44,000 AN	S. Al-Saady, pers. comm. 2007
Sharma, Yemen	15 AF	(Saad 1999)
Karan Island, Saudi Arabia	408-559 AF	(Pilcher 2000)
Jana and Juraid Islands, Saudi Arabia	643 AN	(Pilcher 2000)
Hawkes Bay and Sandspit, Pakistan	600 AN	(Asrar 1999)
Gujarat, India	461 AN	(Sunderraj et al. 2006)
Sri Lanka	184 AF	(Kapurisinghe 2006)
Eastern Indian Ocean		
Thamihla Kyun, Myanmar	<250,000 EH	(Thorbjarnarson et al. 2000)
Pangumbahan, Indonesia	400,000 EH	(Schulz 1987)
Suka Made, Indonesia	395 AN	C. Limpus, pers. comm. 2002
Western Australia	3,000-30,000 AN	R. Prince, pers. comm. 2001
Southeast Asia		
Gulf of Thailand	250 AN	Charuchinda pers. comm. 2001
Vietnam	239 AF	(Hamann et al. 2006a)
Berau Islands, Indonesia	4,000-5,000 AF	(Schulz 1984)
Turtle Islands, Philippines	1.4 million EP	(Cruz 2002)
Sabah Turtle Islands, Malaysia	8,000 AN	(Chan 2006)
Sipadan, Malaysia	800 AN	(Chan 2006)

Sarawak, Malaysia	2,000 AN	(Liew 2002)
Enu Island (Aru Islands)	540 AF	Dethmers, in preparation
Terengganu, Malaysia	2,200 AN	(Chan 2006)
Western Pacific Ocean		
Heron Island, Australia	560 AF	(Limpus et al. 2002)
Raine Island, Australia	25,000 AF	(Limpus et al. 2003)
Guam	45 AF	(Cummings 2002)
Ogasawara Islands, Japan	500 AF	(Chaloupka et al. 2007)
Central and Eastern Pacific Ocean		
French Frigate Shoals, Hawaii	400 AF	(Balazs and Chaloupka 2006)
Michoacán, Mexico	1,395 AF	C. Delgado, pers. comm. 2006
Central American Coast	184-344 AN	(López and Arauz 2003)
Galápagos Islands, Ecuador	1,650 AF	(Zárate et al. 2006)

Mitochondrial DNA analyses have indicated major nesting populations in the eastern Pacific at Michoacán, Mexico; Galápagos Islands, Ecuador; and Islas Revillagigedos, Mexico (Dutton 2003b). Nesting occurs in Michoacán between August and January (peaking in October–November) and on the Galápagos Islands between December and May (peaking in February–March) (Alvarado and Figueroa 1995; Green and Ortiz-Crespo 1995). Galápagos nesting has been stable or slightly increasing since the late 1970s; turtles nesting here are highly specific to their nesting beaches, unlike green turtles in other areas (NMFS and USFWS 2007b; Zárate et al. 2010b). Green sea turtles nesting peaks at Rio Oro on the Osa Peninsula peaks between November and December (Govan 1998). The species also nests in very small numbers in El Salvador, Nicaragua, and Costa Rica (Hasbún and Vásquez 1999; NMFS and USFWS 1998a; Ocean Resource Foundation 1998).

Growth and reproduction. Most green sea turtles exhibit particularly slow growth rates, which have been attributed to their largely plant-eating diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka et al. 2004), and density of turtles in foraging areas (Balazs and Chaloupka 2004; Bjorndal et al. 2000; Seminoff et al. 2002b). If individuals do not feed sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark et al. 2009). In general, there is a tendency for green sea turtles to exhibit monotonic growth (declining growth rate with size) in the Atlantic and non-monotonic growth (growth spurt in mid size classes) in the Pacific, although this is not always the case (Balazs and Chaloupka 2004; Chaloupka and Musick 1997; Seminoff et al. 2002b). It is estimated that green sea turtles reach a maximum size just under 100 cm in carapace length (Tanaka 2009). A female-bias has been identified from studies of green sea turtles (Wibbels 2003); bycatch data support a ration of three females for every one male along Costa Rica's Pacific coast (Arauz 2001).

Consistent with slow growth, age-to-maturity for green sea turtles appears to be the longest of any sea turtle species and ranges from ~20-40 years or more (Chaloupka et al. 2004; Chaloupka and Musick 1997; Hirth 1997; Limpus and Chaloupka 1997; Seminoff et al. 2002b; Zug et al. 2002; Zug and Glor 1998). Estimates of reproductive longevity range from 17 to 23 years (Carr et al. 1978; Chaloupka et al. 2004; Fitzsimmons et al. 1995). Considering that mean duration between females returning to nest ranges from 2 to 5 years (Hirth 1997), these reproductive longevity estimates suggest that a female may nest 3 to 11 seasons over the course of her life.

Based on reasonable means of three nests per season and 100 eggs per nest (Hirth 1997), a female may deposit 9 to 33 clutches, or about 900 to 3,300 eggs, during her lifetime.

Once hatched, sea turtles emerge and orient towards a light source, such as light shining off the ocean. They enter the sea in a "frenzy" of swimming activity, which decreases rapidly in the first few hours and gradually over the first several weeks (Ischer et al. 2009; Okuyama et al. 2009). Factors in the ocean environment have a major influence on reproduction (Chaloupka 2001; Limpus and Nicholls 1988; Solow et al. 2002). It is also apparent that during years of heavy nesting activity, density dependent factors (beach crowding and digging up of eggs by nesting females) may impact hatchling production (Tiwari et al. 2005; Tiwari et al. 2006). Precipitation, proximity to the high tide line, and nest depth can also significantly affect nesting success (Cheng et al. 2009). Precipitation can also be significant in sex determination, with greater nest moisture resulting in a higher proportion of males (Leblanc and Wibbels 2009). Green sea turtles often return to the same foraging areas following nesting migrations (Broderick et al. 2006; Godley et al. 2002). Once there, they move within specific areas, or home ranges, where they routinely visit specific localities to forage and rest (Godley et al. 2003; Makowski et al. 2006; Seminoff and Jones 2006; Seminoff et al. 2002a; Taquet et al. 2006). It is also apparent that some green sea turtles remain in pelagic habitats for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier et al. 2003).

In general, survivorship tends to be lower for juveniles and subadults than for adults. Adult survivorship has been calculated to range from 0.82-0.97 versus 0.58-0.89 for juveniles (Chaloupka and Limpus 2005; Seminoff et al. 2003a; Troëng and Chaloupka 2007), with lower values coinciding with areas of human impact on green sea turtles and their habitats (Bjorndal et al. 2003; Campbell and Lagueux 2005).

Migration and movement. Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. After departing as hatchlings and residing in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), green sea turtles make their way back to the same beach from which they hatched (Carr et al. 1978; Meylan et al. 1990). Green sea turtles spend the majority of their lives in coastal foraging grounds. These areas include both open coastline and protected bays and lagoons. While in these areas, green sea turtles rely on marine algae and seagrass as their primary dietary constituents, although some populations also forage heavily on invertebrates. There is some evidence that individuals move from shallow seagrass beds during the day to deeper areas at night (Hazel 2009).

Habitat. Green turtles appear to prefer waters that usually remain around 20º C in the coldest month, but may occur considerably north of these regions during warm-water events, such as El Niño. Stinson (1984a) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18º C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998a). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal

and Bolten 2000). Strong site fidelity appears to be a characteristic of juveniles green sea turtles along the Pacific Baja coast (Senko et al. 2010).

Feeding. While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley et al. 1998; Hatase et al. 2006; Heithaus et al. 2002; Parker and Balazs in press; Seminoff et al. 2002a). A shift to a more herbivorous diet occurs when individuals move into neritic habitats, as vegetable mater replaces an omnivorous diet at around 59 cm in carapace length off Mauritania (Cardona et al. 2009). However, green sea turtles still rely on animal prey for growth following recruitment into nearshore areas and a primarily-herbivorous diet (Cardone et al. 2010).

Eastern Pacific green sea turtles apparently have a more varied diet than in other areas, with mollusks, polychaetes, and (to a lesser extent) fish, fish eggs, jellyfish and commensal amphipods making up a significant portion of a turtles' diet (Bjorndal 1997).

Diving. Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, we presume that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (Hazel et al. 2009; NMFS and USFWS 1998a). Recent data from Australia indicate green sea turtles rarely dive deep, staying in upper 8 m of the water column (Hazel et al. 2009). Here and in Hawaii, daytime dives were shorter and shallower than were nighttime dives (Rice and Balazs 2010). In addition, time spent resting and dive duration increased significantly with decreases in seasonal water temperatures. The maximum recorded dive depth for an adult green turtle was just over 106 m (Berkson 1967), while subadults routinely dive to 20 m for 9-23 min, with a maximum recorded dive of over 1 h (Brill et al. 1995; I-Jiunn 2009). Green sea turtles along Taiwan may rest during long, shallow dives (I-Jiunn 2009). Dives by females may be shorter in the period leading up to nesting (I-Jiunn 2009).

Vocalization and hearing. Although very limited information is available regarding green turtle hearing, it is one of the few sea turtle species that have been studied. Based upon auditory brainstem responses green sea turtles have been measured to hear in the 50-1600 Hz range (Dow et al. 2008) and 100-800 Hz (Bartol and Ketten 2006) , although cochlear potential suggest a range between 60 and 1000 Hz (Ridgway et al. 1969). Maximum sensitivity has been found to be 200-400 Hz for subadults and 600-700 for juveniles (Bartol and Ketten 2006; Ketten and Bartol 2006). This is supported by cochlear potential estimates of 300-500 Hz from Ridgway et al. (1969). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz. Outside of this limited range, green turtles are much less sensitive to sound (Ridgway et al. 1969). This is similar to estimates for loggerhead sea turtles, which have most sensitive hearing between 250-1,000 Hz, with rapid decline above 1,000 Hz (Moein Bartol et al. 1999).

Status and trends. Federal listing of the green sea turtle occurred on July 28, 1978, with all populations listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are endangered (43 FR 32800). The International Union for Conservation of Nature (IUCN) has classified the green turtle as "endangered."

No trend data are available for almost half of the important nesting sites, where numbers are based on recent trends and do not span a full green sea turtle generation, and impacts occurring over four decades ago that caused a change in juvenile recruitment rates may have yet to be manifested as a change in nesting abundance. The numbers also only reflect one segment of the

population (nesting females), who are the only segment of the population for which reasonably good data are available and are cautiously used as one measure of the possible trend of populations.

Table 6 summarizes nesting abundance for 46 nesting sites worldwide. These include both large and small rookeries believed to be representative of the overall trends for their respective regions. Based on the mean annual reproductive effort, 108,761-150,521 females nest each year among the 46 sites. Overall, of the 26 sites for which data enable an assessment of current trends, 12 nesting populations are increasing, 10 are stable, and four are decreasing. Long-term continuous datasets of 20 years are available for 11 sites, all of which are either increasing or stable. Despite the apparent global increase in numbers, the positive overall trend should be viewed cautiously because trend data are available for just over half of all sites examined and very few data sets span a full green sea turtle generation (Seminoff 2004).

Pacific Ocean. Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, from a combination of overexploitation and habitat loss (Eckert 1993b; Seminoff et al. 2002a). In the western Pacific, the only major (>2,000 nesting females) populations of green turtles occur in Australia and Malaysia, with smaller colonies throughout the area. Indonesian nesting is widely distributed, but has experienced large declines over the past 50 years. Hawaii green turtles are genetically distinct and geographically isolated, and the population appears to be increasing in size despite the prevalence of fibropapillomatosis and spirochidiasis (Aguirre et al. 1998). The nesting population at the two main nesting beaches in Michoacán decreased from 5,585 females in 1982 to 940 in 1984 (Alvarado and Figueroa 1990).

All other areas. Nesting populations are doing relatively well in the western Atlantic and central Atlantic Ocean. In contrast, populations are doing relatively poorly in Southeast Asia, the eastern Indian Ocean, and perhaps the Mediterranean.

Natural threats. Herons, gulls, dogfish, and sharks prey upon hatchlings. Predators (primarily of eggs and hatchlings) also include dogs, pigs, rats, crabs, sea birds, reef fishes, and groupers (Bell et al. 1994; Witzell 1981). Adults face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can be lethal. For unknown reasons, the frequency of a disease called fibropapillomatosis is much higher in green sea turtles than in other species and threatens a large number of existing subpopulations. Extremely high incidence has been reported in Hawaii, where affliction rates peaked at 47-69% in some foraging areas (Murakawa et al. 2000). A to-date unidentified virus may aid in the development of fibropapillomatosis (Work et al. 2009). The incidence of fibropapillomatosis has declined since a peak in the mid 1990s, however (Chaloupka et al. 2009). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint et al. 2009).

Anthropogenic threats. Major anthropogenic impacts to the nesting and marine environment affect green sea turtle survival and recovery. At nesting beaches, green sea turtles rely on intact dune structures, native vegetation, and normal beach temperatures for nesting (Ackerman 1997). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to nesting

females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington et al. 2003; Witherington et al. 2007). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, particularly areas rich in seagrass and marine algae. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005). Ingestion of plastic and other marine debris is another source of morbidity and mortality (Stamper et al. 2009). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n=34), although mortality appears to have results in three cases (Tourinho et al. 2009). Low-level bycatch has also been documented in longline fisheries (Petersen et al. 2009). Further, the introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996).

Sea level rise may have significant impacts upon green turtle nesting on Pacific atolls. These low-lying, isolated locations could be inundated by rising water levels associated with global warming, eliminating nesting habitat (Baker et al. 2006; Fuentes et al. 2010). Fuentes et al. (2010) predicted that rising temperatures would be a much greater threat in the long term to the hatching success of sea turtle turtles in general and green sea turtles along northeastern Australia particularly. Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). Predicted temperature rises may approach or exceed the upper thermal tolerance limit of sea turtle incubation, causing widespread failure of nests (Fuentes et al. 2010). Although the timing of loggerhead nesting depends upon sea-surface temperature, green sea turtles do not appear to be affected (Pike 2009).

Green sea turtles have been found to contain the organochlorines chlordane, lindane, endrin, endosulfan, dieldrin, DDT and PCB (Gardner et al. 2003; Miao et al. 2001). Levels of PCBs found in eggs are considered far higher than what is fit for human consumption (van de Merwe et al. 2009). The heavy metals copper, lead, manganese, cadmium, and nickel have also been found in various tissues and life stages (Barbieri 2009). Arsenic also occurs in very high levels in green sea turtle eggs (van de Merwe et al. 2009). These contaminants have the potential to cause deficiencies in endocrine, developmental, and reproductive health, and depress immune function in loggerhead sea turtles (Keller et al. 2006; Storelli et al. 2007). Andreani et al. (2008) detected concentrations of Zn, Cu, Fe, Mn and Cd in green sea turtles from Tortuguero National Park in Costa Rica; however, the impact of these heavy metal pollutants on these turtles remains unknown. Exposure to sewage effluent may also result in green sea turtle eggs harboring antibiotic-resistant strains of bacteria (Al-Bahry et al. 2009). DDE has not been found to influence sex determination at levels below cytotoxicity (Keller and McClellan-Green 2004; Podreka et al. 1998). To date, no tie has been found between pesticide concentration and susceptibility to fibropapillomatosis, although degraded habitat and pollution have been tied to the incidence of the disease (Aguirre et al. 1994; Foley et al. 2005). Flame retardants have been measured from healthy individuals (Hermanussen et al. 2008). It has been theorized that exposure to tumor-promoting compounds produced by the cyanobacteria *Lyngbya majuscule* could promote the development of fibropapillomatosis (Arthur et al. 2008). It has also been theorized that dinoflagellates of the genus *Prorocentrum* that produce the tumorogenic

compound okadoic acid may influence the development of fibropapillomatosis (Landsberg et al. 1999).

Hawksbill sea turtle

Distribution. The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific oceans. Satellite tagged turtles have shown significant variation in movement and migration patterns. In the Caribbean, distance traveled between nesting and foraging locations ranges from a few kilometers to a few hundred kilometers (Byles and Swimmer 1994; Hillis-Starr et al. 2000; Horrocks et al. 2001; Lagueux et al. 2003; Miller et al. 1998; Prieto et al. 2001).

Population designation. Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. For example, genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the Western Atlantic, where the vast majority of nesting has been documented (McClellan et al. 2010; Monzon-Arguello et al. 2010).

Hawksbill sea turtles do not nest in significant numbers along the Pacific coast of Central America (Euroturtle 2009), although a few hawksbills nest at the La Flor National Wildlife Refuge in Nicaragua (Ocean Resource Foundation 1998) and at Punta Banco, Caña Blanca, and Playa Caletas in Costa Rica (Gaos et al. 2006). Chiriqui Beach in western Panama was host to a massive nesting colony, but was greatly depleted by 1990 due to overharvesting; a recent recovery to several hundred nests has occurred (Spotila 2004a).

Migration and movement. Upon first entering the sea, neonatal hawksbills in the Caribbean are believed to enter an oceanic phase that may involve long distance travel and eventual recruitment to nearshore foraging habitat (Boulon 1994). In the marine environment, the oceanic phase of juveniles (i.e., the "lost years") remains one of the most poorly understood aspects of hawksbill life history, both in terms of where turtles occur and how long they remain oceanic. Offshore waters associated with major current systems, which may be nursery habitat for hawksbills (NMFS and USFWS 1998d; Seminoff et al. 2003b). Along Central and South America, hawksbills appear to limit their movements to nearshore waters (Seaturtle.org 2010).

Habitat. Hawksbill sea turtles are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Small juvenile hawksbills (5-21 cm straight carapace length) have been found in association with *Sargassum* spp. in both the Atlantic and Pacific oceans (Musick and Limpus 1997) and observations of newly hatched hawksbills attracted to floating weed have been made (Hornell 1927; Mellgren and Mann 1996; Mellgren et al. 1994). Post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997), and mud flats (R. von Brandis, unpublished data in NMFS and USFWS 2007c). Individuals of multiple breeding locations can occupy the same foraging habitat (Bass 1999; Bowen et al. 1996; Bowen et al. 2007; Diaz-Fernandez et al. 1999; Velez-Zuazo et al. 2008). As larger juveniles, some individuals may associate with the same feeding locality for more than a decade, while others apparently migrate from one site to another (Blumenthal et al. 2009a; Mortimer et al. 2003; Musick and Limpus 1997). Larger individuals may prefer deeper habitats than their smaller counterparts (Blumenthal et al. 2009a).

Feeding. Dietary data from oceanic stage hawksbills are limited, but indicate a combination of plant and animal material (Bjorndal 1997).

Diving. Hawksbill diving ability varies with age and body size. As individuals increase with age, diving ability in terms of duration and depth increases (Blumenthal et al. 2009b). Studies of hawksbills in the Caribbean have found diurnal diving behavior, with dive duration nearly twice as long during nighttime (35-47 min) compared to daytime (19-26 min Blumenthal et al. 2009b; Van Dam and Diez 1997). Daytime dives averaged 5 m, while nighttime dives averaged 43 m (Blumenthal et al. 2009b)

Hawksbills have long dive durations, although dive depths are not particularly deep. Adult females along St. Croix reportedly have average dive times of 56 min, with a maximum time of 73.5 min (Starbird et al. 1999). Average day and night dive times were 34–65 and 42–74 min, respectively. Immature individuals have much shorter dives of 8.6–14 min to a mean depth of 4.7 m while foraging (Van Dam and Diez 1997).

Vocalization and hearing. Although information is not available regarding hawksbill sea turtle vocalizations or auditory capabilities, green and loggerhead sea turtles have been studied and are likely similar in capacity to their close relative, the hawksbill. The frequency range at which these species hear best is 50-700 Hz, with rapid diminishment of sensitivity outside of this range (Bartol and Ketten 2006; Dow et al. 2008; Ketten and Bartol 2006; Ridgway et al. 1969). Green and loggerhead sea turtles are likely incapable of hearing frequencies >1,600 Hz (Moein Bartol et al. 1999; Ridgway et al. 1969) (Dow et al. 2008).

Status and trends. Hawksbill sea turtles received protection on June 2, 1970 (35 FR 8495) under the Endangered Species Conservation Act and since 1973 have been listed as endangered under the ESA. Although no historical records of abundance are known, hawksbill sea turtles are considered to be severely depleted due to the fragmentation and low use of current nesting beaches (NMFS and USFWS 2007c). Worldwide, an estimated 21,212-28,138 hawksbills nest each year among 83 sites. Among the 58 sites for with historic trends, all show a decline during the past 20 to 100 years. Among 42 sites for which recent trend data are available, 10 (24%) are increasing, three (7%) are stable and 29 (69%) are decreasing.

In the eastern Pacific Ocean, hawksbills were apparently common or abundant as recently as 50 years ago in nearshore waters from Mexico to Ecuador, particularly the east coast of Baja California Sur in Mexico (Cliffton et al. 1982a; NMFS and USFWS 1998b). Hawksbill turtles commonly occur along the Galápagos (Zárate et al. 2010a). This species was the second most commonly sighted sea turtles during NSF-funded seismic surveys in the eastern tropical Pacific (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a), although they are infrequently caught as part of the shrimping industry along Costa Rica (Kelez et al. 2010).

Atlantic Ocean. Atlantic nesting sites include: Antigua (Jumby Bay), the Turks and Caicos, Barbados, the Bahamas, Puerto Rico (Mona Island), the U.S. Virgin Islands, the Dominican Republic, Sao Tome, Guadeloupe, Trinidad and Tobago, Jamaica, Martinique, Cuba (Doce Leguas Cays), Mexico (Yucatan Peninsula), Costa Rica (Tortuguero National Park), Guatemala, Venezuela, Bijagos Archipelago, Guinea-Bissau, and Brazil.

Population increase has been greater in the Insular Caribbean than along the Western Caribbean Mainland or the eastern Atlantic (including Sao Tomé and Equatorial Guinea). Nesting

populations of Puerto Rico appeared to be in decline until the early 1990s, but have universally increased during the survey periods. Mona Island now hosts 199-332 nesting females annually, and the other sites combined host 51-85 nesting females annually (R.P. van Dam and C.E. Diez, unpublished data in NMFS and USFWS 2007c) C.E. Diez, Chelonia, Inc., in litt. to J. Mortimer 2006). The U.S. Virgin Islands have a long history of tortoiseshell trade (Schmidt 1916). At Buck Island Reef National Monument, protection has been in force since 1988, and during that time, hawksbill nesting has increased by 143% to 56 nesting females annually, with apparent spill over to beaches on adjacent St. Croix (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). However, St. John populations did not increase, perhaps due to the proximity of the legal turtle harvest in the British Virgin Islands (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). Populations have also been identified in Belize and Brazil as genetically unique (Hutchinson and Dutton 2007). An estimated 50-200 nests are laid per year in the Guinea-Bissau (Catry et al. 2009). Sea turtle nesting on Cousin Island, Seychelles, which was decimated by harvesting in the 1970s has rebounded to hundreds of individuals nesting annually, with the increasing trend continuing (Allen et al. 2010).

Pacific Ocean. American Samoa and Western Samoa host fewer than 30 females annually (Grant et al. 1997; Tuato'o-Bartley et al. 1993). In Guam, only 5-10 females are estimated to nest annually (G. Balazs, NMFS, in litt. to J. Mortimer 2007; G. Davis, NMFS, in litt. to J. Mortimer 2007) and the same is true for Hawaii, but there are indications that this population is increasing (G. Balazs, pers. comm. in NMFS and USFWS 2007c). Additional populations are known from the eastern Pacific (potentially extending from Mexico through Panama), northeastern Australia, and Malaysia (Hutchinson and Dutton 2007).

Indian Ocean. The Indian Ocean hosts several populations of hawksbill sea turtles (Hutchinson and Dutton 2007; Spotila 2004a). These include western Australian, Andaman and Nicobar Islands, Maldives, Seychelles, Burma, East Africa, Egypt, Oman, Saudi Arabia, Sudan, and Yemen.

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can be lethal. The only other significant natural threat to hawksbill sea turtles is from hybridization of hawksbills with other species of sea turtles. This is especially problematic at certain sites where hawksbill numbers are particularly low (Mortimer and Donnelly in review). Predators (primarily of eggs and hatchlings) include dogs, pigs, rats, crabs, sea birds, reef fishes, groupers, feral cats, and foxes (Bell et al. 1994; Ficetola 2008). In some areas, nesting beaches can be almost completely destroyed and all nests can sustain some level of depredation (Ficetola 2008).

Anthropogenic threats. Threats to hawksbill sea turtles are largely anthropogenic, both historically and currently. Impacts to nesting beaches include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). Because hawksbills prefer to nest under vegetation (Horrocks and Scott 1991; Mortimer 1982), they are particularly impacted by beachfront development and clearing of dune vegetation (Mortimer and Donnelly in review). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). One of the most detrimental human threats to hawksbill sea turtles is the intensive harvest of eggs from nesting beaches. Surprisingly, human presence can

also aid sea turtles by decreasing predation of hawksbill nests by displacing predators, such as mongoose, from nesting areas (Leighton et al. 2010).

In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005). Hawksbills are typically associated with coral reefs, which are among the world's most endangered marine ecosystems (Wilkinson 2000). Although primarily spongivorous, bycatch of hawksbill sea turtles in the swordfish fishery off South Africa occurs (Petersen et al. 2009).

Future impacts from climate change and global warming may result in significant changes in hatchling sex ratios. The fact that hawksbill turtles exhibit temperature-dependent sex determination (Wibbels 2003) suggests that there may be a skewing of future hawksbill cohorts toward strong female bias (since warmer temperatures produce more female embryos).

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. 2006b). 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 2001b). 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 2006a). Guiana nesting may have increased again in the early 2000s (NMFS 2006a). 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. 2006b).

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 1984b; 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.

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 (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).

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 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. 2010a).

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 1984b).

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 if 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 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. 2005d; Smultea and Holst 2003a).

Declines in the western Pacific is equally severe. Nesting at Terengganu, Malaysia is 1% of that in 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. 2006b; Hernández 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. 2007b; 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.

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).

Loggerhead Sea Turtle

Distribution. Loggerheads are circumglobal occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian oceans. Loggerheads are the most abundant species of sea turtle found in U.S. coastal waters.

Population designations. Five groupings represent loggerhead sea turtles by major sea or ocean basin: Atlantic, Pacific, and Indian oceans, as well as Caribbean and Mediterranean seas. As with other sea turtles, populations are frequently divided by nesting aggregation (Hutchinson and Dutton 2007).

On March 16, 2010, the NMFS proposed to reclassify loggerhead sea turtles into nine distinct population segments throughout the world based upon physical, ecological, behavioral, and genetic data. These include North and South Pacific Ocean segments, northern, southeastern, and southwestern Indian Ocean segments, northeastern, northwestern, and South Atlantic Ocean segments, and Mediterranean Sea segment. These segments do not constitute populations, but are structured for better species management.

Atlantic Ocean. Western Atlantic nesting locations include The Bahamas, Brazil, and numerous locations from the Yucatán Peninsula to North Carolina (Addison 1997; Addison and Morford 1996; Marcovaldi and Chaloupka 2007). This group comprises five nesting subpopulations: Northern, Southern, Dry Tortugas, Florida Panhandle, and Yucatán. Additional nesting occurs on Cay Sal Bank (Bahamas), Cuba, the Bahamian Archipelago, Quintana Roo (Yucatan Peninsula), Colombia, Brazil, Caribbean Central America, Venezuela, and the eastern Caribbean Islands. Genetic studies indicate that, although females routinely return to natal beaches, males may breed with females from multiple populations and facilitate gene flow Bowen et al. (2005). In the eastern Atlantic, we know of five rookeries from Cape Verde, Greece, Libya, Turkey, and the western Africa coast.

Indian Ocean. Loggerhead sea turtles nest along the Indian Ocean in Oman, Yemen, Sri Lanka, Madagascar, South Africa, and possibly Mozambique.

Pacific Ocean. Pacific Ocean rookeries are limited to the western portion of the basin. These sites include Australia, New Caledonia, New Zealand, Indonesia, Japan, and the Solomon

Islands.

Population structure in the Pacific is comprised of a northwestern Pacific nesting aggregation in Japan and a smaller southwestern nesting aggregation in Australia and New Caledonia (NMFS 2006e). Genetics of Japanese nesters suggest that this population is comprised of genetically distinct nesting colonies (Hatase et al. 2002a). Almost all loggerheads in the North Pacific seem to stem from Japanese nesting beaches (Bowen et al. 1995; Resendiz et al. 1998). The fidelity of nesting females to their nesting beach allowed differentiation of these subpopulations and the loss of nesting at a beach means a significant loss of diversity and the beach is unlikely to be recolonized (NMFS 2006e).

Loggerheads are rare in Chilean waters (Donoso et al. 2000), but are relatively common in the waters off southern Peru (Alfaro-Shigueto et al. 2004b). Satellite-tagged juvenile loggerheads caught along central or southern Peru all moved offshore beyond the continental shelf, although most remained within 100 km of the Peruvian coast, suggesting year-round residency (Mangel et al. 2010). Loggerheads are less abundant off Ecuador, and there were a considerable number of observations made by Inter-American Tropical Tuna Commission (IATTC) observers during 1993–2002 along the northwest coast of Ecuador and in international waters between 3º N and 10º N in July–September (Alava 2008). Of the four NSF-funded seismic surveys in the eastern tropical Pacific over the past decade, only one survey has identified a single loggerhead sea turtle of out hundreds of sea turtles observed (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a).

Reproduction and growth. Loggerhead nesting is confined to lower latitudes temperate and subtropic zones but absent from tropical areas (NMFS and USFWS 1991b; NRC 1990; Witherington et al. 2006b). The life cycle of loggerhead sea turtles can be divided into seven stages: eggs and hatchlings, small juveniles, large juveniles, subadults, novice breeders, first year emigrants, and mature breeders (Crouse et al. 1987). Hatchling loggerheads migrate to the ocean (to which they are drawn by near ultraviolet light Kawamura et al. 2009), where they are generally believed to lead a pelagic existence for as long as 7-12 years (NMFS 2005a). Loggerheads in the Mediterranean, similar to those in the Atlantic, grow at roughly 11.8 cm/yr for the first six months and slow to roughly 3.6 cm/yr at age 2.5-3.5. As adults, individuals may experience a secondary growth pulse associated with shifting into neritic habitats, although growth is generally monotypic (declines with age Casale et al. 2009a; Casale et al. 2009b). Individually-based variables likely have a high impact on individual-to-individual growth rates (Casale et al. 2009b). At 15-38 years, loggerhead sea turtles become sexually mature, although the age at which they reach maturity varies widely among populations (Casale et al. 2009b; Frazer and Ehrhart 1985; NMFS 2001a; Witherington et al. 2006).

Loggerhead mating likely occurs along migration routes to nesting beaches, as well as in offshore from nesting beaches several weeks prior to the onset of nesting (Dodd 1988; NMFS and USFWS 1998d). Females usually breed every 2-3 years, but can vary from 1-7 years (Dodd 1988; Richardson et al. 1978). Females lay an average of 4.1 nests per season (Murphy and Hopkins 1984) , although recent satellite telemetry from nesting females along southwest Florida support 5.4 nests per female per season, with increasing numbers of eggs per nest during the course of the season (Tucker 2009). The authors suggest that this finding warrants revision of the number of females nesting in the region. The western Atlantic breeding season is March-August.

The Japanese rookeries are the most significant nesting sites for loggerheads in the North Pacific, with nesting occurring on the Japanese mainland, except for Hokkaido, as well as the Ryukyu Islands to the south (Kamezaki 1989; Kamezaki et al. 2003; Sea Turtle Association of Japan 2010; Uchida and Nishiwaki 1995). Nesting generally occurs through summer and fall (April-August, peaking in July), with females returning every two to three years (Iwamoto et al. 1985). Nesting females lay at least three nests of 60-115 eggs per nest each season, with roughly two weeks between nests (Eckert 1993b; Iwamoto et al. 1985; Nishimura 1994). Between nests, females appear to swim offshore into the Kuroshio Current, possibly to speed egg development (NMFS and USFWS 1998e; Sato et al. 1998).

Migration and movement. Loggerhead hatchlings migrate offshore and become associated with *Sargassum* spp. habitats, driftlines, and other convergence zones (Carr 1986). After 14-32 years of age, they shift to a benthic habitat, where immature individuals forage in the open ocean and coastal areas along continental shelves, bays, lagoons, and estuaries (Bowen et al. 2004; NMFS 2001a). Adult loggerheads make lengthy migrations from nesting beaches to foraging grounds (TEWG 1998b). In the Gulf of Mexico, larger females tend to disperse more broadly after nesting than smaller individuals, which tend to stay closer the nesting location (Girard et al. 2009). In the North Atlantic, loggerheads travel north during spring and summer as water temperatures warm and return south in fall and winter, but occur offshore year-round assuming adequate temperature. For immature individuals, this movement occurs in two patterns: a north-south movement over the continental shelf with migration south of Cape Hatteras in winter and movement north along Virginia for summer foraging, and a not-so-seasonal oceanic dispersal into the Gulf Stream as far north as the 10-15˚ C isotherm (Mansfield et al. 2009). Wallace et al. (2009) suggested differences in growth rate based upon these foraging strategies. There is conflicting evidence that immature loggerheads roam the oceans in currents and eddies and mix from different natal origins or distribute on a latitudinal basis that corresponds with their natal beaches (Monzon-Arguello et al. 2009; Wallace et al. 2009).

Individuals in the western Pacific also show wide-ranging movements. Loggerheads hatched on beaches in the southwest Pacific travel have been found to range widely in the southern portion of the basin, with individuals from populations nesting in Australia found as far east as Peruvian coast foraging areas still in the juvenile stage (Boyle et al. 2009). Individuals hatched along Japanese coasts have been found to migrate to waters off Baja California via the North Pacific Subtropical Gyre (and the Kuroshio Extension) to feed for several years before migrating back to western Pacific waters to breed (Bowen et al. 1995; Nichols 2005; Polovina et al. 2006; Polovina et al. 2000; Resendiz et al. 1998).

Some data are available regarding fine scale movement in the North Atlantic; loggerheads appear to move more randomly in areas of cooler, shallower surface waters with high chlorophyll a concentrations, as well as areas of faster moving currents, possibly as a result of foraging opportunities in these areas (McCarthy et al. 2010).

Gender, age, and survivorship. Although information on males is limited, several studies identified a female bias, although a single study has found a strong male bias to be possible (Dodd 1988; NMFS 2001a; Rees and Margaritoulis 2004).

Additionally, little is known about longevity, although Dodd (1988) estimated the maximum female life span at 47-62 years. Heppell et al. (2003) estimated annual survivorship to be 0.81 (southeast U.S. adult females), 0.78-0.91 (Australia adult females), 0.68-0.89 (southeast U.S.

benthic juveniles, and 0.92 (Australia benthic juveniles). Survival rates for hatchlings during their first year are likely very low (Heppell et al. 2003).

Feeding. Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker et al. 2005). Hatchling loggerheads feed on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991b). Pelagic and benthic juveniles forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988; Wallace et al. 2009). Loggerheads in the deep, offshore waters of the western North Pacific feed on jellyfish, salps, and other gelatinous animals (Dodd Jr. 1988; Hatase et al. 2002b). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998d). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich et al. 2010; Vander Zanden et al. 2010).

Diving. Loggerhead diving behavior varies based upon habitat, with longer surface stays in deeper habitats than in coastal ones. Off Japan, dives were shallower than 30 m (Sakamoto et al. 1993). Routine dives can last 4–172 min (Byles 1988; Renaud and Carpenter 1994; Sakamoto et al. 1990). The maximum-recorded dive depth for a post-nesting female was over 230 m, although most dives are far shallower (9-21 m (Sakamoto et al. 1990). Loggerheads tagged in the Pacific over the course of 5 months showed that about 70% of dives are very shallow (<5 m) and 40% of their time was spent within 1 m of the surface (Polovina et al. 2003; Spotila 2004a). During these dives, there were also several strong surface temperature fronts that individuals were associated with, one of 20° C at 28° N latitude and another of 17° C at 32° N latitude. Small juvenile loggerheads live at or near the surface; for the 6–12 years spent at sea as juveniles, they spend 75% of their time in the top 5 m of water (Spotila 2004a).

Vocalization and hearing. Information on the hearing capabilities of sea turtles is limited, but available information 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). Bartol et al. (1999) measured loggerhead hearing thresholds between 250 and 1,000 Hz, with best sensitivity at 200 Hz. There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz (L-DEO 2006).

Status and trends. Loggerhead sea turtles were listed as threatened under the ESA of 1973 on July 28, 1978 (43 FR 32800). The NMFS recently determined that a petition to reclassify loggerhead turtles in the western North Atlantic Ocean as endangered might be warranted due to the substantial scientific and commercial information presented. Consequently, NMFS has published a proposed rule to list 9 Distinct Population Segments (DPSs) of Loggerhead Sea Turtles under the ESA, , as well as areas that may qualify as critical habitat (76 FR 15932; March 22,2011).

There is general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are doubts about the ability to estimate the overall population size (Bjorndal et al. 2005). An important caveat for population trends analysis based on nesting beach data is that this may reflect trends in adult nesting females, but it may not reflect overall population growth rates well. Adult nesting females often account for less than 1% of total population numbers. The global abundance of

nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004b).

Atlantic Ocean. In the eastern Atlantic, the Cape Verde Islands support the only known loggerhead nesting assemblage, which is of at least intermediate size (Fretey 2001a). In 2000, researchers tagged over 1,000 nesting females (Erhart et al. 2003). Annual data from monitoring projects in Cyprus, Greece, Israel, Tunisia, and Turkey reveal total annual nesting in the Mediterranean ranging of 3,375-7,085 nests per season (Margaritoulis et al. 2003). Libya and the West African coast host genetically-unique breeding populations of loggerhead sea turtles as well (Hutchinson and Dutton 2007). A recently discovered nesting site along the southern Italian shores of the Ionian Sea found particularly high genetic diversity amongst nesting females (Garofalo et al. 2009). Nesting at Dalyan Beach, Turkey does not have an apparent trend, with between 50 and 286 nests laid annually for the past 19 years (Turkozan and Yilmaz 2008).

The greatest concentration of loggerheads occurs in the Atlantic Ocean and the adjacent Caribbean Sea, primarily on the Atlantic coast of Florida, with other major nesting areas located on the Yucatán Peninsula of Mexico, Columbia, Cuba, South Africa (EuroTurtle 2006 as cited in LGL Ltd. 2007; Márquez 1990).

Among the five subpopulations, loggerhead females lay 53,000-92,000 nests per year in the southeastern U.S. and the Gulf of Mexico, and the total number of nesting females is 32,000-56,000. All of these are currently in decline or data are insufficient to access trends (NMFS 2001a; TEWG 1998a). Loggerheads from western North Atlantic nesting aggregations may or may not feed in the same regions from which they hatch. Loggerhead sea turtles from the northern nesting aggregation, which represents about 9% of the loggerhead nests in the western North Atlantic, comprise 25-59% of individuals foraging from Georgia up to the northeast U.S. (Bass et al. 1998; Norrgard 1995; Rankin-Baransky 1997; Sears 1994; Sears et al. 1995). Loggerheads associated with the South Florida nesting aggregation occur in higher frequencies in the Gulf of Mexico (where they represent ~10% of the loggerhead captures) and the Mediterranean Sea (where they represent ~45% of loggerhead sea turtles captured). About 4,000 nests per year are laid along the Brazilian coast (Ehrhart et al. 2003).

Because of its size, the south Florida subpopulation of loggerheads may be critical to the survival of the species in the Atlantic, and in the past it was considered second in size only to the Oman nesting aggregation (NMFS 2006e; NMFS and USFWS 1991b). The South Florida population increased at ~5.3% per year from 1978-1990, and was initially increasing at 3.9-4.2% after 1990. An analysis of nesting data from 1989-2005, a period of more consistent and accurate surveys than in previous years, showed a detectable trend and, more recently (1998-2005), has shown evidence of a declining trend of approximately 22.3% (FFWCC 2007a; FFWCC 2007b; Witherington et al. 2009). This is likely due to a decline in the number of nesting females within the population (Witherington et al. 2009). Nesting data from the Archie Carr Refuge (one of the most important nesting locations in southeast Florida) over the last 6 years shows nests declined from approximately 17,629 in 1998 to 7,599 in 2004, also suggesting a decrease in population size[2]. Loggerhead nesting is thought to consist of just 60 nesting females in the Caribbean and Gulf of Mexico (NMFS 2006f). Based upon the small sizes of almost all nesting aggregations in

2 While this is a long period of decline relative to the past observed nesting pattern at this location, aberrant ocean surface temperatures complicate the analysis and interpretation of these data. Although caution is warranted in interpreting the decreasing nesting trend given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, the recent nesting decline at this nesting beach is reason for concern.

the Atlantic, the large numbers of individuals killed in fisheries, and the decline of the only large nesting aggregation, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic are only slightly lower than those of populations in the Pacific.

Pacific Ocean. Abundance has declined dramatically over the past 10-20 years, although loggerheads range widely from Alaska to Chile (NMFS and USFWS 1998d). Pacific nesting is limited to two major locations, Australia and Japan. Eastern Australia supported one of the major global loggerhead nesting assemblages until recently (Limpus 1985). Now, less than 500 females nest annually, an 86% reduction in the size of the annual nesting population in 23 years (Limpus and Limpus 2003). The status of loggerhead nesting colonies in southern Japan and the surrounding region is uncertain, but approximately 1,000 female loggerhead turtles may nest there; a 50-90% decline compared to historical estimates (Bolten et al. 1996; Dodd Jr. 1988; Kamezaki et al. 2003; STAJ 2002). In addition, loggerheads uncommonly occur in U.S. Pacific waters, and there have been no documented strandings of loggerheads on the Hawaiian Islands in nearly 20 years (1982-1999 stranding data). There are very few records of loggerheads nesting on any of the many islands of the central Pacific, and the species is considered rare or vagrant in this region (USFWS 1998). Overall, Gilman (2009) estimated that the number of loggerheads nesting the Pacific has declined by 80% in the past 20 years.

Indian Ocean. The largest known nesting aggregation occurs on Masirah and Kuria Muria Islands in Oman (Ross and Barwani 1982). Extrapolations resulting from partial surveys and tagging in 1977-1978 provided broad estimates of 19,000-60,000 females nesting annually at Masirah Island, while a more recent partial survey in 1991 provided an estimate of 23,000 nesting females (Baldwin 1992; Ross 1979; Ross 1998; Ross and Barwani 1982). Over 3,000 nests per year have been recorded on the Al-Halaniyat Islands, while along the Oman mainland of the Arabian Sea, about 2,000 nests are deposited per year (Salm 1991; Salm et al. 1993). Based upon genetic analyses, additional populations nest in Yemen, Sri Lanka, and Madagascar (Hutchinson and Dutton 2007). In the southwestern Indian Ocean, the highest concentration of nesting occurs on the coast of Tongaland, South Africa (Baldwin et al. 2003). The total number of females nesting annually in South Africa is estimated to be between 500-2,000 (Baldwin et al. 2003). An estimated 800-1,500 loggerheads nest annually on Dirk Hartog Island beaches along Western Australia (Baldwin et al. 2003).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can pose lethal effects. Eggs are commonly eaten by raccoons and ghost crabs along the eastern U.S. (Barton and Roth 2008). In the water, hatchlings are hunted by herons, gulls, dogfish, and sharks. Heavy loads of barnacles are associated with unhealthy or dead stranded loggerheads (Deem et al. 2009).

Anthropogenic threats. Anthropogenic threats impacting loggerhead nesting habitat are numerous: coastal development and construction, placement of erosion control structures, beachfront lighting, vehicular and pedestrian traffic, sand extraction, beach erosion, beach nourishment, beach pollution, removal of native vegetation, and planting of non-native vegetation (Baldwin 1992; Margaritoulis et al. 2003; Mazaris et al. 2009b; USFWS 1998). Surprisingly, beach nourishment also hampers nesting success, but only in the first year post-nourishment before hatching success increases (Brock et al. 2009). Loggerhead sea turtles face numerous threats in the marine environment as well, including oil and gas exploration, marine pollution, trawl, purse seine, hook and line, gill net, pound net, longline, and trap fisheries,

underwater explosions, dredging, offshore artificial lighting, power plant entrapment, entanglement in debris, ingestion of marine debris, marina and dock construction and operation, boat collisions, and poaching.

The major factors inhibiting their recovery include mortalities caused by fishery interactions and degradation of the beaches on which they nest. Shrimp trawl fisheries account for the highest number of captured and killed loggerhead sea turtles. Along the Atlantic coast of the U.S., the NMFS estimated that shrimp trawls capture almost 163,000 loggerhead sea turtles each year in the Gulf of Mexico, of which 3,948 die. Each year, various fisheries capture about 2,000 loggerhead sea turtles in Pamlico Sound, of which almost 700 die. Along Baja California, it is estimated that 1,500-2,950 loggerheads are killed annually by local fishing fleets (Peckham et al. 2008). Offshore longline tuna and swordfish longline fisheries are also a serious concern for the survival and recovery of loggerhead sea turtles and appear to affect the largest individuals more than younger age classes (Aguilar et al. 1995; Bolten et al. 1994; Carruthers et al. 2009; Howell et al. 2008; Marshall et al. 2009; Petersen et al. 2009; Tomás et al. 2008). Deliberate hunting of loggerheads for their meat, shells, and eggs has declined from previous exploitation levels, but still exists and hampers recovery efforts. In the Pacific, loggerhead turtles are captured, injured, or killed in numerous Pacific fisheries including

- Japanese longline fisheries in the western Pacific Ocean and South China Seas
- direct harvest and commercial fisheries off Baja California, Mexico
- commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru
- purse seine fisheries for tuna in the eastern tropical Pacific Ocean
- California/Oregon drift gillnet fisheries (NMFS 2006e)

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 are expected to be loggerhead sea turtles. Donoso and Dutton (2010) found that 59 loggerheads were bycaught between 2001 and 2005 as part of the Chilean longline fishery, with no mortalities and all individuals released.

Climate change may also have significant implications on loggerhead populations worldwide. In addition to potential loss of nesting habitat due to sea level rise, loggerhead sea turtles are very sensitive to temperature as a determinant of sex while incubating. Ambient temperature increase by just 1º-2º C can potentially change hatchling sex ratios to all or nearly all female in tropical and subtropical areas (Hawkes et al. 2007a). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin et al. 2009). Sea surface temperatures on loggerhead foraging grounds correlate to the timing of nesting, with higher temperatures leading to earlier nesting (Mazaris et al. 2009a; Schofield et al. 2009). Increasing ocean temperatures may also lead to reduced primary productivity and eventual food availability. This has been proposed as partial support for reduced nesting abundance for loggerhead sea turtles in Japan; a finding that could have broader implications for other populations in the future if individuals do not shift feeding habitat (Chaloupka et al. 2008). Warmer temperatures may also decrease the energy needs of a developing embryo (Reid et al. 2009).

Tissues taken from loggerheads sometimes contain very high levels of organochlorines chlorobiphenyl, chlordanes, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT, and PCB (Alava et al. 2006; Corsolini et al. 2000; Gardner et al. 2003; Keller et al. 2005; Keller et al. 2004a; Keller et al. 2004b; McKenzie et al. 1999; Monagas et al. 2008; Oros et al. 2009; Perugini et al. 2006; Rybitski et al. 1995; Storelli et al. 2007). It appears that levels of organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2004c; Keller et al. 2006; Oros et al. 2009). These contaminants could cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007). It is likely that the omnivorous nature of loggerheads makes them more prone to bioaccumulating toxins than other sea turtle species (Godley et al. 1999; McKenzie et al. 1999). Loggerheads foraging near areas of high human urbanization have been found to have significantly higher PFOS levels than in other, less urbanized regions (O'Connell et al. 2010).

Heavy metals, including arsenic, barium, cadmium, chromium, iron, lead, nickel, selenium, silver, copper, zinc, and manganese, have also been found in a variety of tissues in levels that increase with turtle size (Anan et al. 2001; Fujihara et al. 2003; Garcia-Fernandez et al. 2009; Gardner et al. 2006; Godley et al. 1999; Saeki et al. 2000; Storelli et al. 2008). These metals likely originate from plants and seem to have high transfer coefficients (Anan et al. 2001; Celik et al. 2006; Talavera-Saenz et al. 2007).

Loggerhead sea turtles have higher mercury levels than any other sea turtle studied, but concentrations are an order of magnitude less than many toothed whales (Godley et al. 1999; Pugh and Becker 2001). Arsenic occurs at levels several fold more concentrated in loggerhead sea turtles than marine mammals or seabirds.

Also of concern is the spread of antimicrobial agents from human society into the marine environment. Loggerhead sea turtles may harbor antibiotic-resistant bacteria, which may have developed and thrived as a result of high use and discharge of antimicrobial agents into freshwater and marine ecosystems (Foti et al. 2009).

Olive ridley sea turtle

Distribution. Olive ridleys are globally distributed in tropical regions (>20º C) of the Pacific (southern California to Peru, and rarely in the Gulf of Alaska Hodge and Wing 2000), Indian (eastern Africa and the Bay of Bengal), and Atlantic oceans (Grand Banks to Uruguay and Mauritania to South Africa Foley et al. 2003; Fretey 1999; Fretey et al. 2005; Stokes and Epperly 2006). Olive ridleys are uncommon in the western Pacific and western Indian Oceans, and most of the North Atlantic (Spotila 2004b).

Population designations. Population designations are poorly known. Populations likely correspond somewhat to nesting beach location (Tables 7 and 8). Most olive ridleys nest synchronously in huge events called "arribadas", with hundreds to thousands of females nesting over the course of three to seven days; other individuals nest alone, out of sequence with the arribada (Aprill 1994a; Kalb and Owens 1994).

Table 7. Recent estimates of olive ridley arribada size.

Country	Beach	Estimates of arribada size from one-time, most recent counts	References
Western Atlantic Ocean			

Suriname	Galibi Nature Reserve*	335 nests	(Hoekert et al. 1996)
French Guiana		1,716-3,257 females	(Kelle et al. 2009)
Eastern Pacific Ocean			
Nicaragua	Chacocente	42,541 nests	(López Carcache et al. in press)
Nicaragua	La Flor	1,300-9,000 turtles per arribada	(Ruiz 1994)
Nicaragua	Masachapa	No estimate available	(Cornelius 1982; Margaritoulis and Demetropoulos 2003)
Nicaragua	Pochomil	No estimate available	(Cornelius 1982; Margaritoulis and Demetropoulos 2003)
Nicaragua	Boquita	No estimate available	(Cornelius 1982)***
Costa Rica	Nancite	200-20,000 turtles per arribada	(Fonseca et al. 2009)
Costa Rica	Ostional	Average 50,000-200,000 turtles per arribada	(Chaves et al. 2005)
Panama	Isla Cañas	5,000-12,000 turtles per arribada	(Evans and Vargas 1998)
Northern Indian Ocean			
India	Gahirmatha	1,000-100,000+ turtles per arribada	(Shanker et al. 2003)
India	Devi River	No estimate available	(Shanker et al. 2003)
India	Rushikulya	10,000-200,000 turtles per arribada	(Shanker et al. 2003)

* Large arribadas once occurred at these beaches but no longer do (Cliffton et al. 1982b; Hoekert et al. 1996).
** These data represent total nests per season.
*** Masachapa, Pochomil, and Boquita were extant at the time of the Cornelius (1982) article. The status for Boquita is unknown.

Table 8. Locations of olive ridley arribada and solitary nesting beaches in the eastern Pacific and estimates of arribada sizes.

Country	Beach	Estimates of arribada size from one-time, most recent counts	References
Arribada			
Mexico	Mismaloya*	1,000-5,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007a)
Mexico	Tlacoyunque*	500-1,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007a)
Mexico	Chacahua*	10,000-100,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007a)
Mexico	La Escobilla	1,000,000+ nests	(Márquez et al. 2005)
Mexico	Moro Ayuta*	10,000-100,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007a)
Solitary			
Mexico	Entire Pacific coast		(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007a)

* Large arribadas once occurred at these beaches but no longer do (Cliffton et al. 1982b; Hoekert et al. 1996).

Atlantic Ocean. Olive ridley distribution in the western North Atlantic occurs mostly along the northern coast of South America and adjacent waters. In the Caribbean, non-nesting individuals occur regularly near Isla Margarita, Trinidad, and Curacao, but are rare further west, such as in Puerto Rico, the Dominican Republic, and Cuba. In rare cases, olive ridleys are known to occur as far north as Puerto Rico, the Dominican Republic, and Cuba and as far south as Brazil (Moncada-G. 2000 as cited in NMFS 2004a). Regular nesting occurs only in Guyana, Suriname, and French Guiana, with most foraging grounds likely nearby (Reichart 1989 as cited in LGL Ltd. 2007). Nesting occurs along the north coast of Venezuela (Sternberg 1981). Olive ridleys likely occur in low numbers along western Africa.

Pacific Ocean. Typical distribution is from Peru to California, with rare Alaskan sightings. Peak arribada nesting in the eastern Pacific occurs at several beaches in Mexico, Nicaragua, Costa Rica, and Panama (NMFS and USFWS 2007f). In Peru, they can be found along the entire coast but are most common in the north, although they are rare in the Galápagos (Kelez et al. 2009; Zárate et al. 2010a). Olive ridley sea turtles were the most commonly sighted sea turtle during regional seismic surveys funded by the NSF (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a). Tagged Costa Rican nesters have been recovered as far south as Peru, as far north as Oaxaca, Mexico, and offshore to a distance of 2,000 km. Olive ridleys are the most common sea turtle in oceanic waters of the eastern tropical Pacific but move into nearshore waters prior to breeding (Pitman 1990). This species frequently basks at the surface, is accompanied by seabirds, and associates with floating debris, from logs to

plastic debris to dead whales (Arenas and Hall 1991a; Pitman 1992 as cited in NMFS 2004a).

Eastern Pacific nests are most concentrated in southern Mexico and northern Costa Rica, with secondary nesting as far north as southern Baja California (Fritts et al. 1982) and as far south as Peru (Brown and Brown 1982; Kelez et al. 2009). Nesting occurs year-round, but tends to peak from September through December (NMFS and USFWS 1998b). Most females lay two clutches of 100-107 eggs with an inter-nesting period of 1–2 months and incubation lasting 50-60 days (Eckert 1993b; NMFS and USFWS 1998b; Plotkin et al. 1994a). Internesting females tend to stay within 5 km of shore (Kalb and Owens 1994).

Southern Hemisphere. Distribution is poorly known, but nesting colonies occur in the Philippines, Papua New Guinea, and northern Australia (Euroturtle 2009; Spring 1982). Solitary nesting beaches occur in Australia, Brunei, Malaysia, Indonesia, and Vietnam (Spotila 2004a). Olive ridleys have been sighted in Fiji, Vanuatu, French Polynesia, the Solomon and Marshall islands, and Palau (SPREP 2007). The occurrence of olive ridleys in Tonga and Kiribati is suspected but unconfirmed (SPREP 2007).

Reproduction and growth. Little is known about olive ridley growth or reproduction. However, some beaches, such as Ostional Beach on the Pacific coast of Costa Rica, is known to have extremely low hatching success, particularly at the onset of the dry season onward, at least partly due to the high temperatures of nests (Valverde et al. 2010).

Migration and movement. Olive ridleys are highly migratory and may spend most of their non-breeding life cycle in deep-ocean waters, but occupy the continental shelf region during the breeding season (Arenas and Hall 1991b; Beavers and Cassano 1996; Cornelius and Robinson 1986; Pitman 1991; Pitman 1993; Plotkin 1994; Plotkin et al. 1994a; Plotkin et al. 1995). Reproductively active males and females migrate toward the coast and aggregate at nearshore breeding grounds near nesting beaches (Cornelius 1986; Hughes and Richard 1974; Kalb et al. 1995; Plotkin et al. 1991; Plotkin et al. 1996; Plotkin et al. 1997; Pritchard 1969). Other males and females may not migrate to nearshore breeding aggregations at all (Kopitsky et al. 2000; Pitman 1991). Some males appear to remain in oceanic waters, are non-aggregated, and mate opportunistically as they intercept females *en route* to near shore breeding grounds and nesting beaches (Kopitsky et al. 2000; Plotkin 1994; Plotkin et al. 1994b; Plotkin et al. 1996). Their migratory pathways vary annually (Plotkin 1994), there is no spatial and temporal overlap in migratory pathways among groups or cohorts of turtles (Plotkin et al. 1994a; Plotkin et al. 1995), and no apparent migration corridors exist. Olive ridleys may use water temperature more than any other environmental cue during migrations (Spotila 2004b). Post-nesting migration routes from Costa Rica traverse more than 3,000 km out into the central Pacific (Plotkin et al. 1993; Plotkin et al. 1994a). Olive ridleys from different populations may occupy different oceanic habitats (Polovina et al. 2004; Polovina et al. 2003). Unlike other marine turtles that migrate from a breeding ground to a single feeding area, where they reside until the next breeding season, olive ridleys are nomadic migrants that swim hundreds to thousands of kilometers over vast oceanic areas (Plotkin 1994; Plotkin et al. 1994a; Plotkin et al. 1995). Olive ridleys may associate with flotsam, which could provide food, shelter, and/or orientation cues (Arenas and Hall 1991b). In the oceanic eastern tropical Pacific, olive ridley sea turtles are far more common than any other cheloniid (Pitman 1990).

Feeding. Olive ridleys typically forage offshore and feed on a variety of benthic and pelagic species, such as jellyfish, squid, salps, red crabs, acorn and gooseneck barnacles, mollusks, and

algae (Márquez 1990; Deraniyagala 1939, Carr 1961, Caldwell 1969, Fritts 1981, Cornelius and Robinson 1986, Mortimer 1982 - as cited in NMFS 2004a).

Diving. Diving behavior remains somewhat of a mystery, but several studies have highlighted general insights. The average dive length for an adult female and male were reported to be 54.3 and 28.5 min, respectively (Plotkin 1994 in Lutcavage and Lutz 1997, as cited in NMFS and USFWS 2007f). McMahon et al. (2007) reported a maximum dive duration of 200 min (± 20 min) in northern Australia. In the eastern tropical Pacific, diving rate is greater during daytime than at night (Beavers and Cassano 1996; Parker et al. 2003). During nighttime however, dives are longer (up to 95 min). In the eastern tropical Pacific, at least 25% of olive ridley total dive time is spent in the permanent thermocline, located at 20–100 m (Parker et al. 2003).

Olive ridleys can dive and feed at considerable depths (80–300 m), although ~90% of their time is spent at depths <100 m (Polovina et al. 2003). At least 25% of their total dive time is spent in the permanent thermocline, located at 20–100 m (Parker et al. 2003). In the North Pacific Ocean, two olive ridleys tagged with satellite-linked depth recorders spent about 20% of their time in the top meter and about 10% of their time deeper than 100 m; 70% of the dives were no deeper than 5 m (Polovina et al. 2003).

Vocalization and hearing. Information on the hearing capabilities of sea turtles is limited, but available information supports low-frequency hearing centered below 1 kHz and a hearing threshold at 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).

Status and trends. Except for the Mexico breeding stock, olive ridley sea turtles were listed as threatened under the ESA on July 28, 1978 (43 FR 32800). The olive ridley is the most abundant sea turtle in the world (Pritchard 1997). Worldwide, abundance of nesting female olive ridleys is estimated at two million (Spotila 2004b).

Atlantic Ocean. Nesting centers, such as around Surinam, have declined more than 80% since 1967. However, nesting along Brazil, Nicaragua, and Costa Rica appear to be increasing, although long-term data are lacking (NMFS and USFWS 2007e).

Pacific Ocean. The eastern Pacific population is believed to number roughly 1.39 million (Eguchi et al. in preperation). Abundance estimates in recent years indicate that the Mismaloya and Moro Ayuta nesting populations appear to be stable and the nesting population at La Escobilla is increasing, although less than historical levels, which was roughly 10 million adults prior to 1950 (Cliffton et al. 1982b; NMFS and USFWS 2007a). By 1969, after years of adult harvest, the estimate was just over one million (Cliffton et al. 1982b). Olive ridley nesting at La Escobilla rebounded from approximately 50,000 nests in 1988 to over 700,000 nests in 1994, and more than a million nests by 2000 (Márquez et al. 2005; Márquez et al. 1996). The largest known arribadas in the eastern Pacific are on the coast of Costa Rica (~475,000-650,000 females estimated nesting annually) and in southern Mexico (~800,000 nests per year at La Escobilla, in Oaxaca, Mexico). Along Costa Rica, 25,000-50,000 olive ridleys nest at Playa Nancite and 450,000-600,000 turtles nest at Playa Ostional annually (NMFS and USFWS 1998b). At a nesting site in Costa Rica, an estimated 0.2% of 11.5 million eggs laid during a single arribada produced hatchlings (NMFS and USFWS 1998b). Two of the five arribada beaches in Nicaragua have available estimates – Chacocente at over 42,000 nests and La Flor at 1,300 to 9,000 turtles per arribada (NMFS 2004a; NMFS 2004b). Analysis of bycatch data off Costa Rica suggest a female-biased sex ration of roughly two females for every male (Arauz

2001).

Indian Ocean. Arribada nesting populations are still large but are either in or near decline. Solitary nesting declines have been reported from Bangladesh, Myanmar, Malaysia, Pakistan, and southwest India (NMFS and USFWS 2007e). However, solitary nesting in Indonesia may be increasing (Asrar 1999; Dermawan 2002; Islam 2002; Krishna 2005; Limpus 1995; Thorbjarnarson et al. 2000).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. Natural predators of olive ridleys also include crabs, garrabos, iguanas, crocodiles, black vultures, coyotes, raccoons, and coatis (Aprill 1994b). All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can pose lethal effects.

Anthropogenic threats. Collection of eggs as well as adult turtles has historically led to species decline (NMFS and USFWS 2007a). Harvests remain a concern for olive ridley recovery. In some locations, takes are now regulated or banned (with varying compliance), while harvests remain uncontrolled in other areas. Adult harvests are now largely banned, except along African coasts.

High levels of adult mortality due to harvesting are believed to be the reason why rapid and large nesting population declines occurred in Mexico (Cornelius et al. 2007). The nationwide ban on commercial sea turtles harvest in Mexico, enacted in 1990, has greatly aided olive ridley conservation, but the population is still seriously decremented and threatened with extinction (Groombridge 1982). Several solitary and arribada nesting beaches experience (although banned) egg harvesting, which is causing declines (Cornelius et al. 2007). Approximately 300,000-600,000 eggs were seized each year from 1995-1998 (Trinidad and Wilson 2000).

In India, uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large-scale mortality of adult olive ridley turtles during the last two decades. Since 1993, more than 50,000 olive ridleys have stranded along the coast, at least partially because of near-shore shrimp fishing (Shanker and Mohanty 1999). In 2008, several hundred olive ridleys stranded dead along Orissa beaches coincident with trawl fisheries operating in the area (Das 2008). Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. However, mortality due to shrimp trawling reached a record high of 13,575 ridleys during the 1997 to 1998 season and none of the approximately 3,000 trawlers operating off the Orissa coast use turtle excluder devices in their nets despite mandatory requirements passed in 1997 (Pandav and Choudhury 1999). Shrimp trawls off of Central America are estimated capture over 60,000 sea turtles annually, most of which are olive ridleys (Arauz 1996 as cited in NMFS and USFWS 2007f). Olive ridleys in the eastern Pacific are also incidentally caught by purse seine fisheries and gillnet fisheries (Frazier et al. 2007). 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 olive ridley sea turtles.

There are additional impacts to the nesting and marine environment that affect olive ridleys. Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997).

The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water, with up to 50% of some olive ridley hatchlings disoriented upon emergence in some years (Karnad et al. 2009; Witherington 1992; Witherington and Bjorndal 1991). At sea, there are numerous potential threats including marine pollution, oil and gas exploration, lost and discarded fishing gear, changes in prey abundance and distribution due to commercial fishing, habitat alteration and destruction caused by fishing gear and practices, agricultural runoff, and sewage discharge (Frazier et al. 2007; Lutcavage et al. 1997).

Olive ridley tissues have been found to contain the organochlorines chlordanes, lindane, endrin, endosulfan, dieldrin, DDT, and PCB (Gardner et al. 2003). These contaminants have the potential to cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007), and are known to depress immune function in loggerhead sea turtles (Keller et al. 2006). Heavy metals, including cadmium, iron, nickel, copper, zinc, and manganese, have been found in a variety of tissues in levels that increase with turtle size (Gardner et al. 2006). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because females offload contaminants to their eggs. Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996).

Environmental baseline

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, and ecosystem, within the action area. Individuals found in an action area can potentially be affected by activities anywhere within this wide range.

By regulation, environmental baselines for Opinions include the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities which will occur contemporaneously with this consultation (50 CFR §402.02). Unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultation are also part of the environmental baseline, as are Federal and other actions within the action area that may benefit listed species or critical habitat. It clearly identifies how actions affect the status and trend of the listed species or critical habitat of the opinion. To provide the reader with a more comprehensive discussion of the all the activities affecting the species found in the action area, we have included activities occurring in areas to which these species could migrate during the course of their life cycle.

A number of human activities have contributed to the current status of listed species in the action area. Some of those activities, (e.g. commercial harvesting of individuals as well as sea turtle eggs) no longer occur in the U.S., yet are still a problem in other countries. Other human activities are ongoing and appear to be directly or indirectly affecting these species. Additionally, unrelated factors may be acting together to affect listed species, such as global warming.

Taken together, the components of the environmental baseline for the action area include sources of natural mortality as well as influences from natural oceanographic and climatic features in the action areas. Circulation and productivity patterns influence food distribution and habitat quality

for listed species. The effects of climatic variability on these species in the action areas and the availability of food remain largely undetermined; however, it is likely that any changes in weather and oceanographic conditions resulting in effects on population dynamics (i.e. sex-ratios) as well as food availability would have dire consequences for listed species.

Physical and oceanographic features

The presence of key habitat features, such as shelter or foraging opportunities, are the primary reasons why individuals occur where they do. In the marine environment, this is fundamentally built upon local physical and oceanographic features that influence the marine environment. The eastern tropical Pacific is bounded by two westward-flowing currents, the North and South Equatorial currents, which take their origins from the California and Peru Currents, respectively (Reilly and Fiedler 1994). In between these is the eastward-flowing North Equatorial Countercurrent (NECC), which results from Ekman transport in the region, and becomes the Costa Rica Current off that country's coast (Lavın et al. 2006). These current regions form the fundamental habitats of the eastern tropical Pacific (Fiedler and Lavın 2006). The NECC's flow is particularly strong from September through December, a period associated with highest productivity (Pennington et al. 2006; Reilly and Fiedler 1994). As one might expect, the eastern tropical Pacific is a warm, tropical body. Cooler waters occur in the Peru and California Currents as well as in the NECC (Reilly and Fiedler 1994). A relatively shallow, though strong thermocline exists throughout and is considered a defining feature of the region, limiting nutrient and oxygen exchange (Au and Perryman 1976; Fiedler and Talley 2006; Lavın et al. 2006; Perrin et al. 1976). Major fluctuations in eastern tropical Pacific oceanography are also associated with El Niño Southern Oscillation (ENSO) cycles, more so year-to-year than any other area in the world (Fiedler and Talley 2006).

A prominent physical feature of the region is the CRD, which is a shoaling of the strong, shallow thermocline present within the eastern tropical Pacific. The CRD is generally centered near 9° N, 90° W, and is normally 300-500 km in diameter. Due to upwelling within the CRD, productivity generally increases within the region of upwelling (Fiedler 2002; Fiedler et al. 1991; Rodríguez-Fonseca 2001; Wyrtki 1964). As the largest concentration of plankton in the eastern tropical Pacific, this feature draws numerous species for available foraging opportunities, including listed whales and turtles (Fiedler et al. 1991; Reilly and Thayer 1990; Volkov and Moroz 1977; Wade and Friedrichsen 1979; Wade and Gerrodette 1993b; Wyrtki 1964; Wyrtki 1967). Although sea surface temperature and productivity within the CRD is stable, seasonal variation in extent is relatively large, with upwelling occurring near the continental shelf in February and March, but extending westward up to 600 km from summer through fall (Fiedler and Talley 2006; Kessler 2006; Pennington et al. 2006).

Productivity within the eastern tropical Pacific is moderately high, with a mean productivity of 544 $mgC/m^2/day$ in coastal regions and less so (129–291 $mgC/m^2/day$) in oceanic realms (Sea Around Us 2009). Productivity is changed significantly by rainfall patterns associated with converging trade winds at the Intertropical Convergence Zone (ITCZ). Although near the equator, the ITCZ is generally north of it (particularly in January and July). Increased rainfall associated with the ITCZ is associated with increased productivity and influences species distribution (LGL Ltd. 2010). However, because the ITCZ occurs well offshore, a "shadow" zone occurs in areas closer to the Mexican and Central American coastlines, which results in greater heat input to the ocean (greater sea surface temperatures) and a shallower, stronger thermocline (Fiedler and Talley 2006). This region is distinct biologically because, along with

being iron limited like the rest of the eastern tropical Pacific, nitrates are also limiting, resulting in a dominance of picoplankton (Pennington et al. 2006). Dolphins, tuna, and seabirds are also prevalent through this region and in particular the area where the NECC bisects the "shadow" zone (Ballance et al. 2006). Overall seasonal variability in the "shadow" zone is fairly small, but large in extent; seasonal biological changes are not apparent (Fiedler and Talley 2006; Wang and Fiedler 2006). The NECC is also associated with higher productivity, particularly in summer and autumn when phyto-and zooplankton biomass is large (Fernandez-Alamo and Farber-Lorda 2006; Kessler 2006; Pennington et al. 2006).

Coastal upwelling is widespread along the coast of Peru, which has supported the largest fishery in the world. However, productivity can vary widely based upon ENSO conditions (Kessler 2006; Lavın et al. 2006; Pennington et al. 2006). Chlorophyll α and phytoplankton levels are highest during the austral summer and fall, with zooplankton concentrations peaking in fall (Pennington et al. 2006). In austral winter, productivity may be bolstered by upwelling-favorable winds (Lavın et al. 2006). Three wind jets ("Nortes") blowing through Central America also affect eastern tropical Pacific productivity. The Nortes blow westerly through mountain gaps from November to April and induce thermocline lifting, mixing, and thus cool sea surface temperatures and cause upwelling in the "shadow" zone (Amador et al. 2006; Fernandez-Alamo and Farber-Lorda 2006; Pennington et al. 2006; Willett et al. 2006). This upwelling results in increases in both primary and secondary productivity (Fernandez-Alamo and Farber-Lorda 2006). These regions of high productivity then move westward and disperse.

The "Nortes" also generate eddies due to their curving circulation in the atmosphere (Willett et al. 2006). These "warm-core" or downwelling eddies are 180-500 km in diameter, can survive for several months, and travel westward up to 3,000 km from their coastally-generated origins at speeds of 11-19 cm/s to about 120˚ W and 10-15˚ N (Gonzalez-Silvera et al. 2004; Hansen and Maul 1991; Muller-Karger and Fuentes-Yaco 2000; Willett 1996; Willett et al. 2006). Although not productive themselves, large anticyclonic eddies can have cyclonic or "cold-core" downwelling eddies form on their periphery, which are shorter-lived and smaller but are associated with locally enhanced productivity (Barton et al. 1993; Gonzalez-Silvera et al. 2004; Willett et al. 2006). Phytoplankton concentrations within eddies range from 0.25 mg/m^3 (generally warm-core eddies) to greater than 10 mg/m^3 (usually cold-core eddies). In total, four to 18 eddies are formed annually in the eastern tropical Pacific (Gonzalez-Silvera et al. 2004; Muller-Karger and Fuentes-Yaco 2000; Willett 1996). Eddies are believed to be the source for relatively fertile waters in the "shadow" zone; their productivity and nutrients can be entrained for 1,000 km into the eastern tropical Pacific by westward-moving eddies (Muller-Karger and Fuentes-Yaco 2000; Willett et al. 2006).

Because of the significant levels of productivity found within them, both the warmer and cooler water bodies support cetaceans, although of different species (Au and Perryman 1985; Au et al. 1980; Ballance et al. 2006; Reilly and Thayer 1990; Volkov and Moroz 1977; Wade and Gerrodette 1993b). Au et al. (1980) found cetaceans to generally correlate their distributions with equatorial water masses in the eastern tropical Pacific.

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. 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 or 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 remain 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 low-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). For marine mammals considered in this opinion, the only available data suggest sperm whale females 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). 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). 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. 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 (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. 1990). 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. Productivity may increase in other areas, though, 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). For sea turtles, warming ocean temperatures may extend poleward the habitat which they can utilize (Poloczanska et al. 2009). Seagrass habitats have declined by 29% in the last 130 years and 19% of coral reefs have been lost due to human degradation (Poloczanska et al. 2009).

Prey availablility 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 region include ENSO and La Niña events. In the eastern tropical Pacific, ENSO events deepen the thermocline in both coastal and oceanic regions, limiting nutrients and subsequent biological productivity and subsequently the ability of top

trophic predators to survive, reproduce, and grow (Ballance et al. 2006; Fernandez-Alamo and Farber-Lorda 2006; Pennington et al. 2006). The 1982-1983 ENSO event appears to have triggered a 60% decline in marine iguana, Galápagos fur seal, and Galápagos sea lion populations (Laurie 1990). At the peak of ENSO events, the NECC strengthens (Kessler 2006). Regardless of ENSO status, upwelling continues to some extent over the CRD and Peruvian coasts, as well from Nortes, although the upwelled water is warmer and contains fewer nutrients, resulting in reduced productivity during ENSO periods (Pennington et al. 2006). Productivity in these areas is less variable over long time frames due to these alternative sources compared to other eastern tropical Pacific locals (Fiedler and Talley 2006; Pennington et al. 2006; Wang and Fiedler 2006). La Nina conditions will likely be in place during the time frame of the proposed survey (CPC 2010).

The Pacific Decadal Oscillation (PDO) is relatively poorly studied for effects in the eastern tropical Pacific versus the North Pacific, but changes do occur (Lavın et al. 2006). As with ENSO events, PDO impacts the colder, more productive waters of the NECC and coastal upwelling along Mexico and Peru (Pennington et al. 2006). Zooplankton biomass has decreased from 1964-1987, possibly in association with the PDO cycle (Fernandez-Alamo and Farber-Lorda 2006).

Habitat degradation

A number of factors may be 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). North Atlantic right whales increase the amplitude of their calls in response to increased background noise (Parks et al. 2010a; Parks et al. 2010b).

Coastal drainages along Central America deposit large amounts of sediment and pollutants from inland regions into nearshore waters of the eastern tropical Pacific (Jameson et al. 2000; Jameson et al. 2000b). In 2001, a fuel tanker struck a reef in the Galápagos Islands, spilling roughly 6,250 barrels of fuel.

Vessel traffic

Vessel noise could affect marine animals in the proposed action 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. 1995a). 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; background noise may be 20 dB higher now versus preindustrial periods (Hildebrand 2009; Jasny et al. 2005; McDonald et al. 2006; NRC 1994; NRC 2003; NRC 2005; Richardson et al. 1995b). 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). Background noise is of particular concern in the

eastern tropical Pacific, as the Panama Canal is a major transit point for worldwide commercial vessel traffic (Rodrigue et al. 2009). Reports from the Amver reporting system, which tracks commercial traffic worldwide, indicates that 15-49 commercial vessels of 100 metric tons or more can be expected to operate within the northern portion of the action area each month during the October-November time frame, while about four vessels per month can be expected in the southern half of the action area (LGL Ltd. 2010; USCG 2010). Port container traffic is high along the coastline due east of the study area. At least 10 important ports occur between 10°N and 10°S with overall port container traffic of more than 5.3 million twenty-foot equivalent units recorded in 2008. The most important ports are Balboa, Panama and Callao, Peru. 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. 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).

Oil development and extraction

Several Central and South American nations currently extract or are in the process of developing offshore oil and gas reserves. Columbia has conducted roughly 3,000 km of seismic surveys targeting 8,000 km^2 of seafloor in its EEZ; drilling will likely begin in 2010 (Offshore 2010). Ecuador authorized funding for about 10,000 km of seismic surveys in its EEZ in 2008 for oil and gas exploration (Subsea World 2008). Peru currently extracts crude oil from the Tumbes-Progresso and Talara basins on its northern coast. Currently, we know of only one well producing oil and gas in the marine environment. Production here is being ramped-up and new exploration is being conducted with the intention of drilling 500 new wells and installing 40 new extraction platforms (EcoPetrol 2010; EOE 2008; Offshore 2009). Nicaragua has undertaken seismic exploration for several decades, with thousands of kilometers of seismic surveys conducted and several exploratory wells dug in the 1970s (LGL Ltd 2007) . In 1990, 1,360 km of seismic surveys were conducted (LGL Ltd 2007; LGL Ltd. 2007). In 2003, the Nicaraguan government announced exploration and production contracts to several U.S. firms granting six-year leases to explore for resources (Alexander's Gas & Oil Connection 2003). Although historically free of oil exploration and development, Costa Rica recently agreed to begin exploration within its borders, which may include offshore locations (Jimenez 2007).

Seismic surveys

In July 2003, the Lamont-Doherty Earth Observatory (L-DEO) conducted seismic surveys in the Hess Deep area west of the Galápagos Islands using the R/V *Maurice Ewing* (Smultea and Holst 2003b). The *Maurice Ewing* deployed airgun arrays consisting of 10 and 12 airguns, with total volumes of the arrays being 3,050 and 3,705 in^3 for the 10 and 12 airgun arrays, respectively. A total of 215 hours of visual effort over 2,628 km of survey resulted in no sightings of listed whales, but eight sea turtles were sighted (two olive ridleys were the only individuals identified to species).

In November and December of 2004, L-DEO conducted a seismic survey in the Pacific Ocean off Central America using the *Maurice Ewing*, which towed 135 in^3 and 315 in^3 airgun arrays (Holst et al. 2005d; Holst et al. 2005a). A total of 288 hours of observation over 2,734 km of

seismic transect effort resulted in 16 individual humpback whales sighted as well as detecting humpback whales twice acoustically. In addition, 179 individual sea turtles were spotted, including 84 olive ridleys, one leatherback, and two possible green sea turtles. The remaining 92 individuals were unidentified to species. Sea turtles were sighted farther from airguns during firing than during non-seismic conditions, although the lower proportion of sightings during non-seismic periods limits conclusions from such a comparison.

From April through August, 2008, L-DEO conducted seismic surveys in two locations of the eastern tropical Pacific >2,000 km west of Central and South America using the *R/V Langseth* towing a 36-airgun, 6,600 in^3 seismic array and operated a multibeam echosounder and sub bottom profiler (one of the locations only utilized half of the array; (Hauser et al. 2008a)). A total of 6,097 km of seismic transect was run using the full array, while an additional 8,337 km was run with 3,300 in^3 of the array. Visual monitoring occurred for 707 hours, with an additional 758 hours of passive acoustic monitoring. Cetaceans were spotted 2.5 times more frequently during non-seismic periods compared to when airguns were operational. However, sightings occurred at a closer distance on average during seismic periods than during non-seismic periods. Although several unidentified large whales were sighted, the only confirmed sightings of listed species were five groups of sperm whales totaling 12 individuals. A total of 171 sea turtles were spotted and, like cetaceans, the sighting rate was higher (1.5x) during non-seismic periods than during airgun operations. Of turtles identified, four were greens and 33 were olive ridleys.

In March and April, 2008, L-DEO conducted a seismic survey in the eastern tropical Pacific (generally within the EEZ of Nicaragua and Costa Rica) aboard the *R/V Langseth* towing a 36-airgun, 6,600 in^3 seismic array and operated a multibeam echosounder and subbottom profiler (Holst and Beland 2008). A total of 4,257 km of seismic transect was run. Visual monitoring occurred for 592 hours, with an additional 836 hours of passive acoustic monitoring. In all, 345 sea turtles were spotted: 204 olive ridleys, five greens, and 136 unidentified sea turtles, resulting in 60 power downs and 26 shut downs. Sea turtles were spotted at a significantly longer distance from the *Langseth* during seismic operations than during non-seismic periods. Turtles were also spotted 50% more often during non-seismic periods compared to when airguns were firing. Although not statistically significant, delphinids were also seen at a slightly longer distance during seismic operations than when airguns were shutdown. Three individual humpback whales were detected.

Whale watching

Whale watching is a popular activity in Costa Rica. In 2001, there were 25 tour operators in the country, with humpback whales one of the main target species (Hoyt 2001; LGL Ltd 2007; LGL Ltd. 2007). From just 1991 to 1994, the number of people participating in whale watching increased from 2,034 to 90,720 (Hoyt 1991). Swimming with cetaceans is prohibited in Costa Rica; however, it does occur for scientific purposes and filming (May-Collado 2006).

Entrapment and entanglement in fishing gear

Fisheries interactions are a significant problem for several marine mammals 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 shipstrikes, by restricting agility and

swimming speed. Between 1998 and 2005, observers identified 12 humpback whales and six sperm whales injured or killed by fisheries off the U.S. west coast (NMFS, unpublished data). An additional nine sperm whales were incidentally killed by the gillnet fishery between 1991 and 1995 (Barlow et al. 1997a). There are no reports of fisheries-related mortality or serious injury in any of the blue whale populations. Blue whale interaction with fisheries may go undetected because the whales are not observed after they swim away with a portion of the net. However, fishers report that large blue whales usually swim through their nets without entangling and with very little damage to the net (Barlow et al. 1997b).

Sea turtle entanglement and bycatch is a major mortality factor for sea turtles in the eastern tropical Pacific. Among longline fisheries in the ETP, olive ridleys were the most frequent bycatch off northern Peru, Ecuador, and Central America; bycatch rates there were higher than that further south, but lower than those off Mexico. For shrimp trawl operations along the Pacific coast of Costa Rica, the annual incidental catch is estimated at over 15,600 turtles (LGL Ltd 2007; LGL Ltd. 2007), and Arauz et al. (1998) estimated mortality rates from shrimp nets to be 37.6% for olive ridley turtles and 50% for green turtles. Roughly 90% of the sea turtles caught were olive ridleys while almost all of the rest were green sea turtles. Among gillnet fisheries, olive ridleys were rare in the bycatch of the Chilean gillnet swordfish fishery and were the species most frequently captured during shrimp trawling off Costa Rica (Kelez et al. 2010). An estimated 37 sea turtles died between 2001 and 2008 as a result of offshore purse-seine activities (IATTC 2008). Data from the U.S. fleet indicate four deaths and 91% of bycaught turtles were released unharmed. However, data from 1993-1997 show 860 sea turtle deaths resulting from bycatch in the purse-seine industry in the eastern tropical Pacific, most of which were olive ridleys, with lesser numbers of greens and loggerheads (IATTC 1999). Another 31 sea turtles (29 of which were olive ridleys; 2 were green sea turtles) were caught while monitoring half of the longline deployments in the region, with a 10% mortality rate (Segura and Arauz 1995). Although Arauz (2001) found hundreds of olive ridleys to be hooked by longlines in Costa Rica's EEZ, no mortality was documented. Swimmer et al. (2005) found olive ridleys off the coast of Costa Rica to be captured at a rate of roughly eight turtles per 1,000 hooks. Olive ridleys are also the most frequently bycaught sea turtles off Peru, Ecuador, and other parts of Central America, although loggerheads and greens become predominant off central and southern Peru (Alfaro-Shigueto et al. 2004a; Kelez et al. 2010).

Among longline fisheries in the ETP, leatherbacks were the most frequent bycatch only in the Chilean swordfish fishery, which had the lowest bycatch rate of longline fisheries from Chile to Baja California (Kelez et al. 2010). Among gillnet fisheries, leatherbacks were virtually the only species in the bycatch of the Chilean gillnet swordfish fishery, and are caught with other species in the bycatch of driftnets targeting sharks and rays off Peru (Kelez et al. 2010). Leatherbacks recovered from Chilean fishing vessels are from populations nesting both in the eastern and western Pacific Ocean (Donoso et al. 2000). Leatherback bycatch also occurs in drift gillnets set for sharks and rays along southern Peru; mortality is believed to be 200 individuals annually (de Paz et al. 2006).

Commercial and subsistence harvest

In Nicaragua, harvest of olive ridley adults and eggs led to the loss of two arribada beaches by the 1970s and Ostional in Costa Rica has been the major source of turtle eggs for at least the past 30 years (Cornelius et al. 1991). Costa Rica authorizes a legal harvest of a small percentage of olive ridley eggs on the Ostional arribada site, with the suggestion these eggs can be harvested

without impacting total hatching success (Sea Turtle Restoration Project 2008). From 1987–89, between 3.7 to 6.7% of eggs were harvested at this location (Alvarado 1990); and currently around 11% of eggs on average may be harvested in return for local communities providing rangers to protect the majority of olive ridley eggs at Ostional (Sea Turtle Restoration Project 2008). In Ecuador, up to 148,000 olive ridleys were killed each year during the late 1970s (Spotila 2004a).

More than 165,000 green sea turtles were harvested from 1965 to 1977 in the Mexican Pacific. In the early 1970s nearly 100,000 eggs per night were collected from these nesting beaches (NMFS and USFWS 1998c).

Shipstrike

Shipstrike is a significant concern for the recovery of baleen whales in the region. We believe the vast majority of shipstrike mortalities go unnoticed, and that actual mortality is higher than currently documented. More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific U.S. coast, a humpback whale is known to be killed about every other year by shipstrikes (Barlow et al. 1997a).

There have not been any recent documented shipstrikes involving sperm whales in the eastern North Pacific, although there are a few records of shipstrikes 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. 1997a). More recently in the Pacific, two sperm whales were struck by a ship in 2005, but it is not known if these shipstrikes resulted in injury or mortality (NMFS 2009). The lack of recent evidence should not lead to the assumption that no mortality or injury from collisions with vessels occurs as carcasses that do not drift ashore may go unreported, and those that do strand may show no obvious signs of having been struck by a ship (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 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 shipstrikes are a significant threat to sperm whales (Whitehead 2003a).

Blue whales off California have also been killed due to shipstrike, particularly in and around the Santa Barbara Channel. Strikes in 1980, 1986, 1987, 1988, 1993, 2002, and 2007 are believed to have resulted in blue whales deaths, with additional individuals showing large scars likely associated with non-lethal shipstrike (Barlow et al. 1997b; Berman-Kowalewski et al. 2010). Although the long-term average of strikes is low (0.2 annually between 1991 and 1995), a recent rash of shipstrikes to multiple blue whales has heightened concerns over the vulnerability of blue whales to shipstrikes (Barlow et al. 1997b; Berman-Kowalewski et al. 2010; Carretta et al. 2009a).

Scientific and research activities

Scientific research permits issued by the NMFS currently authorize studies on listed species in the Pacific and Southern Oceans, 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, and exposure to acoustic activities, and breath sampling. Research activities involve non-lethal "takes" of these whales by harassment, with none resulting in mortality. Since these "takes" have been authorized, we must assume that they

will actually occur. However, monitoring of prior research activities suggests that only a fraction of the potential "takes" will actually occur. In addition, we expect that most of the individuals which will be exposed to authorized research activities will not occur in the action area, as the number of individuals likely to co-occur in the action area with the proposed actions will be a small fraction of the total number of individuals which may be exposed to authorized research activities.

Tables 9-16 describe the cumulative number of takes for each listed species in the action area authorized in scientific research permits. Although most research will take individuals in the Northern Hemisphere, some takes may include individuals from Southern Hemisphere populations.

Table 9. Blue whale takes in the Pacific and Southern Oceans.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Acoustic playback
2009	13,044	1,075	338	115	0
2010	16,346	1,485	563	190	21
2011	8,706	525	508	120	21
2012	4,211	415	438	120	21
2013	3,312	415	225	75	21
Total	45,619	3,915	2,072	620	84

Permit numbers: 1127-1921, 1071-1770, 540-1811, 731-1774, 781-1824, 1058-1733, 774-1714, 782-1719, 808-1735, 14097, 14122, 14296, 14451, 14534, and 727-1915.

Table 10. Humpback whale takes in the Pacific and Southern Oceans.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Acoustic playback	Exhale sample	Ultrasound
2009	44,823+unl.[1]	4,790	555	82	280	10	5
2010	58,920+unl.[1]	5,530	1,350	212	670	10	5
2011	27,886	1,295	1,158	155	390	10	5
2012	18,111	1,170	988	135	390	0	0
2013	16,142	1,170	835	135	390	0	0
Total	165,882	13,955	4,886	719	2,120	30	15

Permit numbers: 1127-1921, 1071-1770, 473-1700, 540-1811, 731-1774, 781-1824, 782-1719, 1058-1733, 1000-1617, 10018, 1120-1898, 393-1772, 532-1822, 545-1761, 587-1767, 945-1776, 965-1821, 716-1705, 0642-1536, 1049-1718, 774-1714, 808-1735, 14097, 14122, 14296, 14451, 14534, 727-1915, 14353, and 14599.

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

Table 11. Sperm whale takes in the Pacific and Southern Oceans.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Acoustic playback
2009	23,280	840	110	55	0
2010	27,261	1,450	420	185	120
2011	6,451	810	350	145	120
2012	4,616	690	330	135	120
2013	4,616	690	330	135	120
Total	66,224	4,480	1,540	655	480

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, and 727-1915.

Table 12. Green sea turtle takes in the Pacific Ocean.

Year	Approach	Capture/ handling/ restraint	Satellite/ sonic/ flipper tagging	Blood/tissue collection	Lavage	Ultrasound	Tetra-cycline injection
2009	1,066	1,066	1,060	766	345	0	85
2010	1,123	1,123	1,117	823	380	45	120
2011	1,048	1,048	1,042	748	380	45	120
2012	348	348	342	348	180	45	120
2013	263	263	257	263	95	45	35
Total	3,848	3,848	3,818	2,948	1,380	180	480

Permit numbers: 14097, 1514, 1591, 10027, 1537, 1556, 14381, 14510, and 1581.

Table 13. Hawksbill sea turtle takes in the Pacific Ocean.

Year	Approach	Capture/ handling/ restraint	Satellite/ sonic/ flipper tagging	Blood/tissue collection	Lavage
2009	122	122	120	122	10
2010	122	122	120	122	10
2011	92	92	90	92	10
2012	42	42	40	42	10
2013	42	42	40	42	10
Total	420	420	410	420	50

Permit numbers: 14097, 10027, 1537, 1556, and 1581.

Table 14. Leatherback sea turtle takes in the Pacific Ocean.

Year	Approach	Capture/ handling/ restraint	Satellite/ sonic/ flipper tagging	Blood/tissue collection	Ultrasound
2009	191	191	191	191	38
2010	222	222	222	222	38
2011	188	188	188	188	38
2012	188	188	188	188	38
2013	112	112	112	112	0
Total	901	901	901	901	152

Permit numbers: 14097, 1514, 1596, 14381, and 14510.

Table 15. Loggerhead sea turtle takes in the Pacific Ocean.

Year	Approach	Capture/ handling/ restraint	Satellite/ sonic/ flipper tagging	Blood/tissue collection	Lavage	Ultrasound	Tetra-cycline injection
2009	49	49	49	49	18	0	8
2010	111	111	111	111	24	9	14
2011	90	90	90	90	24	9	14
2012	90	90	90	90	24	9	14
2013	82	82	82	82	16	9	6
Total	422	422	422	422	106	36	56

Permit numbers: 14097, 1514, 1591, 14381, and 14510.

Table 16. Olive ridley sea turtle takes in the Pacific Ocean.

Year	Approach	Capture/ handling/ restraint	Satellite/ sonic/ flipper tagging	Blood/tissue collection	Lavage	Ultrasound	Tetra-cycline injection
2009	351	351	351	351	58	0	8
2010	404	404	404	404	64	7	8
2011	361	361	361	361	64	7	8
2012	361	361	361	361	64	7	8
2013	353	353	353	353	56	7	0
Total	1,830	1,830	1,830	1,830	306	28	32

Permit numbers: 14097, 1514, 1591, 14381, 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" 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. 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 substantially similar to the U.S. Fish and Wildlife Service's regulatory definition of "harass"[3] 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 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 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

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

consequences than others. For example, evasion from 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. shipstrikes
4. sound fields produced by engine noise and machinery
5. entanglement in towed hydrophone streamer
6. sound fields produced by airguns, 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 shipstrikes resulting from the proposed action in the action area 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.

The risk of collision of seismic vessels or towed/deployed equipment with marine mammals exists but is extremely unlikely. This is based on the relatively slow operating speed (typically 4-5 kt or 7-9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. Although a seismic vessel would travel faster during transits to and from seismic survey sites (approximately 10 kt or 18 km/h), movement would be predominantly in a straight line, with typically gradual changes in orientation. Theoretically, this should make the vessel tracks more predictable for whales than vessels engaged in erratic changes in headings and speeds, thereby allowing time for whales to move out of the vessel‘s path.

In addition, studies indicate that vessels traveling at higher speeds than those typical of the proposed seismic vessels are more likely to collide with whales (Laist et al. 2001; Jensen and Silber 2003). The presence of trained on-board observers to alert ship crew of nearby cetaceans significantly minimizes the risk of ship strikes and other equipment collisions with whales.

The chances of the seismic vessel or towed/deployed equipment striking a sea turtle are considered highly unlikely. While vessel collisions with sea turtles are known to occur, the project vessel(s) will be moving relatively slowly (4-5 kt [7.4-9.3 km/hr]) and in a straight line at most times,particularly during seismic acquisition. In general, the risk of collision or

entanglement by sea turtles with seismic vessel gear is considered low relative to the many more miles of seismic surveys conducted with no such known occurrences reported.

We therefore do not expect a significant probability of shipstrike due to low whale density (except blue and sperm whales) and general expected movement away or parallel to the *Langseth* (Hauser and Holst 2009; Holst 2009; Holst 2010; Holst and Smultea 2008a). Thus, we feel the potential for a shipstrike and oil spill is discountable.

We expect that the *Langseth* will not add significantly to the local noise environment in its operating area due to the propulsion and other noise characteristics of the vessel's machinery. Any contribution is likely small in the overall regional sound field (particularly considering the amount of large vessel traffic prevalent in shipping lanes associated with the Panama Canal near the action area). 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 and the probability of a shipstrike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Thus, we feel the potential for shipstrike or acoustic interference from propulsion and mechanical noise is discountable.

Although the towed hydrophone streamers could come in direct contact with a listed species and sea turtle entanglements have occurred in towed seismic gear, 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 no entanglements occurring (Hauser et al. 2008b; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). Entanglement is therefore considered discountable.

Accordingly, this consultation focused on the following stressors likely to occur from the proposed seismic activities and 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 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 blue, humpback, and sperm whales, as well as green, hawksbill, leatherback, loggerhead, and olive ridley 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 whales and sea turtles. 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 Division believed they represent the best available information and methods to evaluate exposure to listed species.

L-DEO and the Permits Division provided density estimates for listed whales in the action area. Review of the local survey data as well as knowledge of listed species life history and local oceanographic conditions supports these estimates as the best available information. L-DEO and Permits Division used two different methods to obtain density estimates, but both are based upon sighting data from NOAA's annual marine mammal and seabird surveys through the eastern tropical Pacific from July through December from 1986 to at least 1996. The preferred method utilized sightings along with a habitat-based model in a geographic information system to predict marine mammal densities (SeaMap project; http://seamap.env.duke.edu/prod/serdp/serdp_map.php). This model utilizes known sightings from 1986-2006, correlates them with environmental variables such as sea surface temperature, chlorophyll levels, and other factors, and then predicts the densities of marine mammals in areas where, based upon these environmental variables (as well as survey effort, sightings, and other variables), species are likely to occur but significant survey effort has not been undertaken. Within the geographic information system, L-DEO drew the box around the area where the seismic survey would be conducted, as well as within one degree on either side of the tracklines on which seismic surveys would be conducted. The geographic information system calculated blue whale densities within this region, which were multiplied by the area expected to be ensonified up to 160 dB re 1 μPa_{rms} (4,030 km^2). This calculation produced the expected number of blue whale exposures (Table 17).

This approach requires that a significant number of sightings be made in order for density estimates to be reasonably accurate. For listed species, only blue whales were identified frequently enough during annual surveys to allow for this approach. For sperm and humpback whales, densities were calculated based upon raw data only (no modeling) as presented in Ferguson and Barlow (2003). Here, the eastern tropical Pacific where surveys have been conducted over the years 1986-1996 was divided into blocks. Densities from Ferguson and Barlow (2003) calculated each block, but only select blocks in which the proposed survey would take place was analyzed here. The relative contribution of each block to overall density was determined by dividing the block's area by the total area of all analyzed blocks and the density of the block multiplied by that proportion. This was done for each block, yielding an expected density within the analyzed blocks as a whole for humpback and sperm whales, respectively. This overall density was multiplied by the total area expected to be ensonified up to 160 dB re 1 μPa_{rms} (4,030 km^2) to produce the number of expected exposures to humpback and sperm whales (Table 17).

Marine mammals are expected to be abundant in the action area. This is particularly true for regions of high productivity, such as the CRD and off Peru (Fiedler 2002; Fiedler et al. 1991; Kessler 2006; Lavın et al. 2006; Pennington et al. 2006; Reilly and Thayer 1990; Rodríguez-Fonseca 2001; Volkov and Moroz 1977; Wade and Friedrichsen 1979; Wade and Gerrodette

1993b; Wyrtki 1964; Wyrtki 1967). However, the presence of eddies and upwelling features can increase local productivity at points throughout the eastern tropical Pacific (Amador et al. 2006; Barton et al. 1993; Fernandez-Alamo and Farber-Lorda 2006; Gonzalez-Silvera et al. 2004; Pennington et al. 2006; Willett et al. 2006). These findings are supported by concentrations of blue whales around the CRD, but diffuse occurrences of blue and sperm whales throughout the eastern tropical Pacific.

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 are provided in Table 1 on page 5. The maximum distance from airguns where received levels might reach 160 dB re 1 μPa_{rms} at 2,000 m depth (maximum depth at which listed species are expected to occur) is 3800 m with a 7 m tow depth. A thorough review of available literature (see *Response analysis*) supports this level as a general point at which baleen whales tend to show some avoidance response to received seismic sound. 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 *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. 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.

A major mitigation factor proposed by the NSF is visual monitoring, especially for marine mammals, which should reduce exposure of listed whales and sea turtles. 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. Shut-down procedures are unlikely to be completely effective at eliminating the co-occurrence of listed individuals within the sound field $\geq$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 4,030 km^2 along survey track lines.

NSF's exposure estimates (Table 17) were calculated by using the density per 1,000 km^2 multiplied by the total survey track area (4,030 km^2) to obtain the total number of exposures. If this number was smaller than the average group size observed in the eastern tropical Pacific, the number of individuals in an average group was used (rounded to the next whole number). Multiple exposure to individuals is not expected because of a lack of overlap in sound fields along the trackline. 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, 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 NSF's approach pending better information.

Table 17. Estimated exposure of ESA-listed whales to sound levels ≥160 dB re 1 μPa_{rms} during the proposed seismic activities.

Whale density per 1,000 km^2	# of whales exposed to proposed activities	# of exposures to listed whales	Population size	% of population exposed	Population/location
Blue -0.13	8	8	1,415	0.56	Eastern tropical Pacific[1]
Humpback - 0.25	18	18	3,851	0.47	Group G-Southern Hemisphere[2]
Sperm -4.19	40	40	25,053	0.16	Eastern tropical Pacific[3]
Total	66	66	--	--	--

[1]Read et al. (2009)

[2&3]Ferguson and Barlow (2003)

Whales of all age classes are likely to be exposed. Female humpback whales are likely to be migrating south with their recently-born calves at this time, although any age or sex class may be exposed (Denkinger et al. 1997). Blue whales are expected to be feeding in the area and some females may have young-of-the-year accompanying them; all other age and sex classes are also expected to be present foraging. It is assumed that sex distribution is even for whales and sexes are exposed at a relatively equal level. Although sperm whale males are known to migrate to some extent between higher-latitude foraging areas and low-latitude breeding areas (whereas females and their family groups tend to be less migratory), this does not appear to be the case in the eastern tropical Pacific, where adult males can be found year-round (Whitehead 2003b).

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 airguns (10.5-13 kHz for the multibeam echosounder and 3.5 kHz for the sub-bottom profiler) and this mitigates effects; 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 shipstrike, simultaneously mitigating exposure to very high source levels. As shipstrike has already been ruled out as a discountable 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). 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 within 10 m of the vessel to experience a single multibeam echosounder pulse that could result in TTS (LGL Ltd. 2010). 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 0.8-20 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. 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. Green sea turtles, hawksbill sea turtles, leatherback sea turtle, loggerhead sea turtles, and olive ridley sea turtles may occur in the action area and, therefore, be exposed to airgun sound during the cruise. A combination of factors leads us to believe that each of these species will be present. These factors include bycatch from fisheries, sightings from NSF-funded surveys, satellite tracks suggesting potential migratory corridors, nesting habitat for leatherback and olive ridley sea turtles, and observations of breeding in oceanic waters.

Green sea turtles are frequently seen by tuna fishers (NMFS and USFWS 1998a) and are known to be present along Central America year round (Eckert 1993b; Govan 1998; NMFS and USFWS 1998a; Ocean Resource Foundation 1998). Sightings are particularly numerous between the Galápagos Islands (where the largest nesting concentration in the eastern or central Pacific is located and runs from December through May; (Zárate et al. 2006)) and Central America (NMFS and USFWS 1998a). Additional nesting occurs along Central America on the Osa Peninsula and north in Mexico during the proposed seismic survey timeframe. Green sea turtles encountered during the proposed seismic cruise would likely be immature individuals who maintain an oceanic habitat or adults moving between nesting and foraging habitats (NMFS and USFWS 1998a). The former situation may not be as likely because young green sea turtles seem to prefer frontal and convergence zones in the oceanic environment; habitat characteristics which are not readily found in the action area. Individuals exposed during the proposed seismic survey may be moving between Galápagos and mainland American locations. Females are more likely to be exposed than males, as a 3:1 female bias has been identified off Costa Rica (Arauz 2001).

Few data exist on recent hawksbill occurrence in the eastern tropical Pacific. Although massive levels of nesting formerly occurred along western Panama, nesting was believed to have collapsed along Central America due to overharvesting (Cliffton et al. 1982a; Euroturtle 2009; Gaos et al. 2006; NMFS and USFWS 1998b; Ocean Resource Foundation 1998; Spotila 2004a). However, formerly unknown use of estuaries by hawksbills of the eastern Pacific may have lead

to significant underestimation of hawksbill foraging and nesting along Central and South America (Gaos et al. 2010). Regional satellite tagging of juvenile and adult hawksbills show that individuals tend to remain in nearshore waters even over several month periods (Seaturtle.org 2010). This species has been the second most commonly sighted sea turtle during NSF-funded seismic surveys in the eastern tropical Pacific (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a; Zárate et al. 2010a). The age and sex structure of hawksbills in the eastern tropical Pacific is unknown.

Leatherback nesting along Central America occurs from September through March, with peaks along Costa Rica in April through May, including the largest nesting colony of leatherbacks in the Pacific Ocean (Chacón-Chaverri and Eckert 2007; LGL Ltd. 2007; Spotila 2004a; Yañez et al. 2010). Satellite tracking data reveal that leatherback females leaving Mexican and Central American nesting beaches migrate towards the equator and into Southern Hemisphere waters, some of which pass 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. 2010a). Females nesting are likely to be the individuals exposed to proposed seismic activities. Nesting is expected to be at peak levels during April through June, so we expect individuals to be exposed to the proposed seismic activities. However, we expect that most females should remain closer to shore or avoid the action area while seismic activities are ongoing.

Loggerheads are frequently encountered by observers on tuna fishers in the eastern tropical Pacific, particularly between 3º N and 10º N in July–September, but no other sources have found loggerheads to be particularly common to the region (Alava 2008). Loggerhead satellite tracks along Peru seem to suggest individual residency as well as limited distribution to within 100 km of shore (Mangel et al. 2010). Only one loggerhead has been seen during NSF-funded seismic surveys. Loggerhead sea turtles may be exposed in small numbers and we expect that those that are exposed are more likely to be female due to a general female bias (Dodd 1988; NMFS 2001a; Rees and Margaritoulis 2004).

We expect more exposure to olive ridleys during the proposed seismic survey than any other sea turtle. The abundance of olive ridley sea turtles in the eastern tropical Pacific may be partly due to the presence of several large nesting concentrations along the Pacific coast of Central America (Table 7 on page 56) as well as the large number of individuals alive relative to other sea turtle species (Pitman 1990; Pritchard 1997; Spotila 2004b). Olive ridleys are common along the Peruvian coast but are rare in the Galápagos Islands, although individuals may travel up to 2,000 km from the mainland Americas (Kelez et al. 2009; Zárate et al. 2010a). Olive ridleys were by far the most commonly sighted sea turtle species during NSF-funded seismic surveys in the eastern tropical Pacific (Hauser et al. 2008a; Holst and Smultea 2008b; Holst et al. 2005d; Smultea and Holst 2003a). In the eastern Pacific, nesting occurs from June through December on certain beaches on the coasts of Mexico, Nicaragua, and Costa Rica and on a single beach in Panama (Brown and Brown 1982; Fritts et al. 1982; Kelez et al. 2009; NMFS and USFWS 1998b). During this time, nesting females stay close to shore during internesting periods of one to two months. Breeding males also tend to occur near shore during these times (Cornelius 1986; Hughes and Richard 1974; Kalb et al. 1995; Plotkin et al. 1991; Plotkin et al. 1996; Plotkin et al. 1997; Pritchard 1969). However, males may also remain offshore and breed with females on their way to beaches (Kopitsky et al. 2000; Plotkin 1994; Plotkin et al. 1994b; Plotkin et al. 1996). Migratory routes are highly variable and generally unknown (Plotkin et al. 1994a; Plotkin

et al. 1995). However, turtles dispersing from nesting sites along Costa Rica appear to travel more than 3,000 km into the central Pacific (Plotkin et al. 1994a). We expect significant numbers of olive ridley sea turtles to be exposed to seismic sound by the proposed survey. This is because we expect tens or hundreds of thousands of adult male and female olive ridleys to be migrating to nesting beaches along the Central American coast.

Based upon this information, we expect exposure to all five sea turtle species. Hawksbill and loggerhead sea turtles, although reported in significant concentrations or frequency, are not expected to be particularly widespread in the action area during the time of the proposed seismic survey. Infrequent exposure of green sea turtles may also occur as individuals travel between the Galápagos Islands and mainland Americas. Although we lack data to quantify the number of individuals exposed to the proposed action, we expect a few individuals of these species may be exposed. However, we expect far higher numbers of olive ridleys will be exposed based upon the greater number of individuals composing regional population(s), the expected movement of adults moving into and through the action area at the time of the proposed survey, and the large number of individuals spotted during prior seismic surveys in the eastern tropical Pacific (204 out of 345 sea turtles spotted during a 2008 NSF-funded seismic survey along Nicaragua and Costa Rica were identified as olive ridleys).

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 and sea turtles 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 and sea turtles 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. TTSs can last minutes to days. Full recovery is expected and this condition is not considered a physical injury. However, a recent mouse study has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). 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 450 m of the *Langseth's* airgun array to be within the 180 dB re 1 μPa_{rms} isopleth and risk a TTS in deep water. 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 shut-down if individuals enter or are about to enter the 180dB 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. Some reduction in communication due to masking may still occur between seismic pulses, as airgun pulses tend to reverberate, increasing the background noise level in the marine environment (Guerra et al.

2009). 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 (<500 Hz for the *Langseth's* 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. 1995c). The *Langseth's* airguns will emit a 0.1 s pulse when fired every 8-10 s. Therefore, pulses will not "cover up" the vocalizations of listed whales to a significant extent and reverberation should be small enough so as not to increase background noise levels for significant periods of time between pulses (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. 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 survey 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. Although some studies are available which address responses of listed whales considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-listed or species outside the action area are also considered here.

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). Some blue 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). 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). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re 1 $\mu Pa_{p\text{-}p}$ (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 the responses of some baleen whale to airguns, although responses to lower-amplitude sounds are known, most studies seem to support a threshold of ~160 dB re 1 μPa_{rms} as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995a). 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. 1995a; Richardson et al. 1999). Migrating bowhead whales show strong avoidance reactions to received 120–130 dB re 1 μPa_{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_{rms}; (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995a; 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). Bowheads feeding during late summer and autumn did not show overt large-scale distribution shifts when exposed to seismic operations (Christie et al. 2009; Koski et al. 2009). We do not know whether the individuals exposed in these ensonified areas are the same returning 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_{rms} (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007b; 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). 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_{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. (2007a) 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). 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). 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).

Observational data are sparse for specific baleen whale life history data (breeding and feeding grounds) are less well known. 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). Castellote et al. (2009) found that migrating fin whales in the Mediterranean Sea likely vacated a wintering area during ten days of seismic airgun activity as well as ten days following the end of survey activity. Acoustically, fin whales in the Mediterranean Sea shortened their pulse durations, decreased the bandwidth, center, and peak frequencies of their calls (Castellote et al. 2010).

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. 2009b; Moulton et al. 2006a; Moulton and Miller 2005; Stone 2003; Stone and Tasker 2006; Weir 2008). Detailed study of Gulf of Mexico sperm whales suggests some alteration in foraging from 111-147 dB re 1 μPa_{rms}, 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), including changes in vocalization rate associated with prey capture (Miller et al. 2009a; Tyack 2009). 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. (2009b) 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. 1995a). 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 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. 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. 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 it to be unlikely that breeding may be temporarily disrupted if avoidance or displacement occurs, since in the southern hemisphere, the peak breeding season occurs between October and December (Best *et al.* 1984), therefore 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. 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; NMFS 2006c)(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). 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). When considering hormones as indicators of stress, one must consider that glucocorticoids do not change linearly with the stressor or in close synchrony with it; high levels may not even indicate a stressed individual (Busch and Hayward 2009). Further, cortisol levels are not necessarily indicative of reproductive success or survival (Busch and Hayward 2009). Stress hormones in captive belugas vary by time of day, with some being relatively low when others are relatively high (Schmitt et al. 2010). However, all measured stress hormones (aldostrone, cortisol, and plasma adrenocorticotropic hormone) were significantly higher during out-of-water exams versus in-water exams, indicating that these procedures involved a consistent stress response by these hormonal measures (Schmitt et al. 2010).

Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re 1 μPa · 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. 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 2006c). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NMFS 2006c; NRC 2003). As we do not expect individuals to experience TTS or PTS, (see *Marine mammals and threshold shifts*) or be exposed to other similarly stressful stimuli, 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 stressors) transects away without significant or long-term harm to the individual via the stress response.

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 limited to within a few meters of the airgun array (Buchanan et al. 2004). 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 μPa^2·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}. Capelin and monkfish larvae exposed to 199 to 205 dB re 1 μPa_{p-p} did not show increased mortality, even when exposed multiple times (Payne et al. 2009).

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 μPa_{p-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 μPa_{0-p} (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163–191 dB re 1 μPa_{0-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. Auditory brainstem responses of the squid *Sepioteuthis lessoniana* and the octopus *Octopus vulgaris* showed hearing ranges of 400-1,500 Hz and 400-1,000 Hz, respectively (Hu et al. 2009). 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. 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. 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. 1995a). Thus, if blue 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. 1995a; 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. 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 navigational sonars are operated routinely by thousands of vessels around the world, stranding incidence has not been correlated to 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 one 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 2003a). 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 became 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 to within 10 m (Holst et al. 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006a; NMFS 2006d).

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). Loggerhead sea turtles

in the Mediterranean Sea have been observed to almost universally startle and dive in response to airgun ensonification when they are close enough to be tracked (within 100 m); roughly 20% dove immediately following an airgun shot (DeRuiter and Doukara 2010). 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 or breeding 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. Therefore, 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, shipstrikes, bycatch, entanglements, oil development and extraction, scientific research, high vessel traffic, 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. Many central and south American countries have look at increasing their oil development, which may pose additional threats to marine mammal and sea turtle habitat, as well as potential direct threats through seismic or drilling noise and chemical pollution.

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 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 several listed whale species. These species include: blue whales, humpback whales, and sperm whales, 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 (Tables 3-5). 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: altered prey base and habitat quality as a result of global warming, shipstrike, entanglement in fishing gear, toxic chemical burden and biotoxins, ship noise, competition with commercial fisheries, and killer whale predation. Populations of whales inhabiting the eastern tropical Pacific face area-specific threats identified in the *Environmental baseline*, including significant vessel noise and habitat change resulting from naturally-occurring ENSO and anthropogenic climate change.

Despite these pressures, available trend information indicates most local populations of listed whales are stable or increasing (Tables 3-5). 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 listed whales by proposed seismic activities. We expect individuals and exposure to be 8blue (8total exposures), 18 humpback (18 total exposures), and 40 sperm whales (40 total exposures) 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 (not in excess of 0.14%; Table 17) 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 blue 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 irrevocable 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.

Listed turtles. Listed turtles that are expected to occur within the action area include green sea turtles, hawksbill sea turtles, leatherback sea turtle, loggerhead sea turtles, and olive ridley sea turtles, which are either threatened or endangered. 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 green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles could experience exposure to airgun sounds and be harassed by these sounds, with far more olive ridleys being exposed than individuals of any other species. These sounds may induce a temporary effect in low-level stress levels, swimming patterns, and movement out of range of the seismic survey (hundreds of meters). 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 reduction.

Conclusion

After reviewing the current status of blue, humpback, and sperm whales, as well as green, hawksbill, leatherback, loggerhead, and olive ridley 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 a seismic survey in the eastern tropical Pacific) are 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 agencies 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 blue, 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.

Amount or extent of take

The NMFS anticipates the proposed seismic survey in the eastern tropical Pacific Ocean might result in the incidental take of listed species. The proposed action is expected to take 8 blue (8 exposures), 18 humpback (18 exposures), and 40 sperm whales (40 exposures) 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. Death or injury of any individuals that are exposed is not expected.

We expect the proposed action will also take individual 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 blue, humpback, and sperm whales exposed to seismic studies at levels less than 160 dB re 1 μPa, or of green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles at levels less than 166 dB re 1 μPa, is not expected. If overt adverse reactions (for example, startle responses, dive reactions, or rapid departures from the area) by listed whales or sea turtles 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 Division to determine whether reinitiation of consultation is required because of such operations.

Any incidental take of blue whales, humpback whales, sperm whales, or green sea turtles, hawksbill sea turtles, leatherback sea turtles, loggerhead sea turtles, and olive ridley 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 as specified in the environmental assessment; 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 shut-down procedures; and emergency shutdown procedures in the event of an injury or mortality of a listed marine mammal or sea turtle. 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 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 the 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 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 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 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 eastern tropical Pacific, 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, 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

Aburto, A. D., J. Rountry, and J. L. Danzer. 1997. Behavioral response of blue whales to active signals. Naval Command, Control, and Ocean Surveillance Center, RDT&E Division, San Diego, CA.

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.

Acevedo, A., and M. A. Smultea. 1995. First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of Northern and Southern Hemisphere populations. Marine Mammal Science 11(4):554-560.

Ackerman, R. A. 1997. The nest environment, and the embryonic development of sea turtles. Pages 83-106 *in* P. L. Lutz, and J. A. Musick, editors. The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Addison, D. S. 1997. Sea turtle nesting on Cay Sal, Bahamas, recorded June 2-4, 1996. Bahamas Journal of Science 5:34-35.

Addison, D. S., and B. Morford. 1996. Sea turtle nesting activity on the Cay Sal Bank, Bahamas. Bahamas Journal of Science 3:31-36.

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

Aguayo, L. A. 1974b. Baleen whales off continental Chile. Pages 209-217 *in* W. E. Schevill, editor. The Whale Problem: A Status Report. Harvard University Press, Cambridge, Massachusetts.

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

Aguilar, R., J. Mas, and X. Pastor. 1995. Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the western Mediterranean. J. I. Richardson, and T. H. Richardson, editors. Proceedings of the Twelfth Annual Workshop on Sea Turtle Biology and Conservation. U.S. Department of Commerce, Jekyll Island, Georgia.

Aguirre, A. A., G. H. Balazs, B. Zimmerman, and F. D. Galey. 1994. Organic contaminants and trace metals in the tissues of green turtles (*Chelonia mydas*) afflicted with fibropapillomas in the Hawaiian Islands. Marine Pollution Bulletin 28(2):109-114.

Aguirre, A. A., T. R. Spraker, G. H. Balazs, and B. Zimmerman. 1998. Spirochidiasis and fibropapillomatosis in green turtles of the Hawaiian Islands. Journal of Wildlife Diseases 34:91-98.

Al-Bahry, S., and coauthors. 2009. Bacterial flora and antibiotic resistance from eggs of green turtles Chelonia mydas: An indication of polluted effluents. Marine Pollution Bulletin 58(5):720-725.

Alava, J. J. 2008. Loggerhead sea turtles (Caretta caretta) in marine waters off Ecuador:

occurrence, distribution and bycatch from the eastern Pacific Ocean. Marine Turtle Newsletter 119(8-11).

Alava, J. J., and coauthors. 2006. Loggerhead sea turtle (*Caretta caretta*) egg yolk concentrations of persistent organic pollutants and lipid increase during the last stage of embryonic development. Science of the Total Environment 367(1):170-181.

Alexander's Gas & Oil Connection. 2003. Nicaragua awards exploration and production contracts to US firms. Available at: http://www.gasandoil.com/goc/company/cnl32415.htm. Accessed 9/25/2007.

Alfaro-Shigueto, J., and coauthors. 2004a. Records of leatherback turtle bycatch from Peru. 25th Annual Symposium on Sea Turtle Conservation and Biology, San Jose, Costa Rica.

Alfaro-Shigueto, J., P. H. Dutton, J. Mangel, and D. Vega. 2004b. First confirmed occurrence of loggerhead turtles in Peru. Marine Turtle Newsletter 103:7-11.

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

Alvarado, J., and A. Figueroa. 1990. The ecological recovery of sea turtles of Michoacan, Mexico. Special Attention: the black turtle (Chelonia agassizi), U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Alvarado, J., and A. Figueroa. 1995. East Pacific green turtle, Chelonia mydas. Pages 24-36 *in* P. T. Plotkin, editor. Status reviews for sea turtles listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.

Alvarado, M. A. 1990. The results of more than two years of turtle egg harvests at Ostional, Costa Rica. Pp.175-178 *In*: T.H. Richardson, J.I. Richardson, and M. Donnelly (Compilers), Proceedings of the Tenth Annual Worksho pon Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFC-278 286p.

Amador, J. A., E. J. Alfaro, O. G. Lizano, and V. O. Magana. 2006. Atmospheric forcing of the eastern tropical Pacific: a review. Progress in Oceanography 69(2-4):101-142.

Anan, Y., T. Kunito, I. Watanabe, H. Sakai, and S. Tanabe. 2001. Trace element accumulation in hawksbill turtles (Eretmochelys imbricata) and green turtles (Chelonia mydas) from Yaeyama Islands, Japan. Environmental Toxicology and Chemistry 20(12):2802-2814.

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

Andreani, G., and coauthors. 2008. Metal distribution and metallothionein in loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles. Science of the Total Environment 390(2008):287-294.

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.

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 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.

Angliss, R. P., and R. B. Outlaw. 2009. Alaska marine mammal stock assessments, 2009. U.S. Department of Commerce, NMFS-TM-AFSC-206.

Anonmyous. 2009. Blue whales re-establishing former migration patterns. Marine Pollution Bulletin 58(7):949.

Aprill, M. L. 1994a. Visitation and predation of the olive ridley sea turtle, *Lepidochelys olivacea*, at nest sites in Ostional, Costa Rica. Pages 3-6 *in* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazer, editors. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce.

Aprill, M. L. 1994b. Visitation and predation of the olive ridley sea turtle, *Lepidochelys olivacea*, at nest sites in Ostional, Costa Rica. Pp.3-6 *In*: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazer (Compilers), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-351 323p.

Arauz, R. 2001. Impact of high seas longline fishery operations on sea turtle populations in the Exclusive Economic Zone (EEZ) of Costa Rica - a second look. 21st Annual Symposium on Sea Turtle Biology and Conservation, Philadelphia, PA.

Arauz, R. M., R. Vargas, I. Naranjo, and C. Gamboa. 1998. Analysis of the incidental capture and mortality of sea turtles in the shrimp fleet of Pacific Costa Rica. Pp.1-3 *In*: S.P. Epperly and J. Braun (Compilers), Proceedings of the Seventeenth Symposium on Sea Turlte Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-415. 294p.

Arenas, P., and M. Hall. 1991a. The association of sea turtles and other pelagic fauna with floating objects in teh eastern tropical Pacific Ocean. Pp.7-10 *In*: M. Salmon and J. Wyneken (Compilers), Proceedings of the Eleventh Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-302. 195p.

Arenas, P., and M. Hall. 1991b. The association of sea turtles, and other pelagic fauna with floating objects in the eastern tropical Pacific Ocean. Pages 7-10 *in* M. Salmon, and J. Wyneken, editors. The Eleventh Annual Workshop on Sea Turtle Biology and Conservation.

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.

Arthur, K., and coauthors. 2008. The exposure of green turtles (Chelonia mydas) to tumour promoting compounds produced by the cyanobacterium Lyngbya majuscula and their potential role in the aetiology of fibropapillomatosis. Harmful Algae 7(1):114-125.

Asrar, F. F. 1999. Decline of marine turtle nesting populations in Pakistan. Marine Turtle Newsletter 83:13-14.

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, D. W. K., and W. L. Perryman. 1976. Dolphin habitats in the eastern tropical Pacific. Fishery Bulletin 83:623-643.

Au, D. W. K., and W. L. Perryman. 1985. Dolphin habitats in the eastern tropical Pacific. Fishery Bulletin 83(4):623-643.

Au, D. W. K., W. L. Perryman, R. L. Pitman, and M. S. Sinclair. 1980. Cetaceans and equatorial oceanography. Tropical Ocean-Atmosphere Newsletter Oct. P.6,10.

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.

Bailey, H., and coauthors. 2009. Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. Endangered Species Research 10:93-106.

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 coauthors. 1998. Mitochondrial DNA variation and maternal gene flow among humpback whales of the Southern Hemisphere. Marine Mammal Science [Mar. Mamm. Sci.]. Vol. 14:no. 4.

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, J. D., C. L. Littnan, and D. W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 4:1-10.

Balazs, G. H., and M. Chaloupka. 2004. Thirty-year recovery trend in the once depleted

Hawaiian green sea turtle stock. Biological Conservation 117(5):491-498.

Balazs, G. H., and M. Chaloupka. 2006. Recovery trend over 32 years at the Hawaiian green turtle rookery of French Frigate Shoals. Atoll Research Bulletin 543:147-158.

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.

Baldwin, R., G. R. Hughes, and R. I. T. Prince. 2003. Loggerhead turtles in the Indian Ocean. Pages 218-232 *in* A. B. Bolten, and B. E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Baldwin, R. M. 1992. Nesting turtles on Masirah Island: Management issues, options, and research requirements. Ministry of Regional Municipalities and Environment, Oman.

Ballance, L. T., R. L. Pitman, and P. C. Fiedler. 2006. Oceanographic influences on seabirds and cetaceans in the eastern tropical Pacific: a review. Progress in Oceanography 69:360-390.

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.

Barbieri, E. 2009. CONCENTRATION OF HEAVY METALS IN TISSUES OF GREEN TURTLES (CHELONIA MYDAS) SAMPLED IN THE CANANEIA ESTUARY, BRAZIL. Brazilian Journal of Oceanography 57(3):243-248.

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. 1997a. Preliminary estimates of cetacean abundance off California, Oregon, and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Admin. Rept. LJ-97- 11:Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA. 25p.

Barlow, J. 1997b. 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., and coauthors. 1997a. 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 coauthors. 1997b. U.S. Pacific marine mammal stock assessment -1996. Southwest Fisheries Science Center, NMFS-SWFSC-248, 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.

Bartol, S. M., and D. R. Ketten. 2006. Turtle and tuna hearing. Y. Swimmer, and R. Brill, editors. Sea turtle and pelagic fish sensory biology: Developing techniques to reduce sea

turtle bycatch in longline fisheries, volume NOAA Tech. Memo. NMFS-PIFSC-7. National Marine Fisheries Service, Honolulu, HI.

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

Barton, B. T., and J. D. Roth. 2008. Implications of intraguild predation for sea turtle nest protection. Biological Conservation 181(8):2139-2145.

Barton, E. D., and coauthors. 1993. Supersquirt: dynamics of the Gulf of Tehuantepec, Mexico. Oceanography 6:23-30.

Bass, A. L. 1999. Genetic analysis to elucidate the natural history and behavior of hawksbill turtles (Eretmochelys imbricata) in the wider Caribbean: a review and re-analysis. Chelonian Conservation and Biology 3:195-199.

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

Beavers, S. C., and E. R. Cassano. 1996. Movements and dive behavior of a male sea turtle (Lepidochelys olivacea) in the eastern tropical Pacific. Journal of Herpetology 30(1):97-104.

Bell, L. A. J., U. Fa'Anunu, and T. Koloa. 1994. Fisheries resources profiles: Kingdom of Tonga, Honiara, Solomon Islands.

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. 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.

Berchok, C. L., D. L. Bradley, and T. B. Gabrielson. 2006. St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. Journal of the Acoustical Society of America 120(4):2340-2354.

Berkson, H. 1967. Physiological adjustments to deep diving in the Pacific green turtle (Chelonia mydas agassizi). Comparative Biochemistry and Physiology 21:507-524.

Berman-Kowalewski, M., and coauthors. 2010. Association between blue whale (Balaenoptera musculus) mortality and ship strikes along the California coast. Aquatic Mammals 36(1):59-66.

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. 2008. Nineteenth-century evidence for the Golfo de Panama as a migratory destination for southern humpback whales, including the first mention of singing. Marine Mammal Science 24(3):737-742.

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. 1982. The consequences of herbivory for the life history pattern of the Caribbean green turtle, Chelonia mydas. Pages 111-116 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

Bjorndal, K. A. 1997. Foraging ecology, and nutrition of sea turtles. Pages 199-232 *in* P. L. Lutz, and J. A. Musick, editors. The biology of sea turtles. CRC Press, Boca Raton, Florida.

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.

Bjorndal, K. A., A. B. Bolten, and M. Y. Chaloupka. 2000. Green turtle somatic growth model: evidence for density dependence. Ecological Applications 10(1):269-282.

Bjorndal, K. A., A. B. Bolten, and M. Y. Chaloupka. 2003. Survival probability estimates for immature green turtles Chelonia mydas in the Bahamas. Marine Ecology Progress Series 252:273-281.

Bjorndal, K. A., A. B. Bolten, and M. Y. Chaloupka. 2005. Evaluating trends in abundance of immature green turtles, *Chelonia mydas*, in the greater Caribbean. Ecological Applications 15(1):304-314.

Blumenthal, J. M., and coauthors. 2009a. Ecology of Hawksbill Turtles, Eretmochelys imbricata, on a Western Caribbean Foraging Ground. Chelonian Conservation and Biology 8(1):1-10.

Blumenthal, J. M., and coauthors. 2009b. Diving behavior and movements of juvenile hawksbill turtles Eretmochelys imbricata on a Caribbean coral reef. Coral Reefs 28(1):55-65.

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

Bolten, A. B., K.A. Bjorndal, and H. R. Martins. 1994. Life history model for the loggerhead sea

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

Bolten, A. B., J. A. Wetherall, G. H. Balazs, and S. J. Pooley. 1996. Status of marine turtles in the Pacific Ocean relevant to incidental take in the Hawaii-based pelagic longline fishery, NOAA-TM-NMFS-SWFSC-230.

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

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.

Boulon, R. H., Jr. 1994. Growth rates of wild juvenile hawksbill turtles, *Eretmochelys imbricata*, in St. Thomas, United States Virgin Islands. Copeia 1994(3):811-814.

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.

Bowen, B. W., and coauthors. 1995. TransPacific migrations of the loggerhead turtle (Caretta caretta) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences USA 92:3731-3734.

Bowen, B. W., and coauthors. 2004. Natal homing in juvenile loggerhead turtles (*Caretta caretta*). Molecular Ecology 13:3797–3808.

Bowen, B. W., and coauthors. 1996. Origin of hawksbill turtles in a Caribbean feeding area as indicated by genetic markers. Ecological Applications 6:566-572.

Bowen, B. W., A. L. Bass, L. Soares, and R. J. Toonen. 2005. Conservation implications of complex population structure lessons from the loggerhead turtle (*Caretta caretta*). Molecular Ecology 14:2389-2402.

Bowen, B. W., and coauthors. 2007. Mixed stock analysis reveals the migrations of juvenile hawksbill turtles (Eretmochelys imbricata) in the Caribbean Sea. Molecular Ecology 16:49-60.

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.

Boyle, M. C., and coauthors. 2009. Evidence for transoceanic migrations by loggerhead sea turtles in the southern Pacific Ocean. Proceedings of the Royal Society B-Biological

Sciences 276(1664):1993-1999.

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.

Branch, T. A., and Y. A. Mikhalev. 2008. Regional differences in length at sexual maturity for female blue whales based on recovered Soviet whaling data. Marine Mammal Science 24(3):690-703.

Branch, T. A., and coauthors. 2006. Past and present distribution of blue whales in the Southern Hemisphere and northern Indian Ocean. Unpublished paper to the IWC Scientific Committee. 27 pp. St Kitts and Nevis, West Indies, June (SC/58/SH16).

Branch, T. A., and coauthors. 2007. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. Mammal Review 37(2):116-175.

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.

Brill, R. W., and coauthors. 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (Chelonia mydas L.) within a foraging area in the Hawaiian Islands. Journal of Experimental Marine Biology and Ecology 185:203-218.

Brito, C., N. Vleira, E. Sa, and I. Carvalho. 2009. Cetaceans' occurrence off the west central Portugal coast: A compilation of data from whaling, observations of opportunity and boat-based surveys. Journal of Marine Animals and Their Ecology 2(1):10-13.

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. .

Brock, K. A., J. S. Reece, and L. M. Ehrhart. 2009. The Effects of Artificial Beach Nourishment on Marine Turtles: Differences between Loggerhead and Green Turtles. Restoration Ecology 17(2):297-307.

Broderick, A., and coauthors. 2006. Are green turtles globally endangered? Global Ecology and Biogeography 15:21-26.

Broderick, A., C. F. Glen, B. J. Godley, and G. C. Hays. 2002. Estimating the number of green and loggerhead turtles nesting annually in the Mediterranean. Oryx 36(3):227-235.

Brown, C. H., and W. M. Brown. 1982. Status of sea turtles in the southeastern Pacific: emphasis on Peru. K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

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.

Burtenshaw, J. C., and coauthors. 2004. Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. Deep-Sea Research II 51:967-986.

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.

Byles, R. A. 1988. The behavior and ecology of sea turtles, Caretta caretta and Lepidochelys kempi, in the Chesapeake Bay. College of William and MAry, Williamsburg, Virginia.

Byles, R. A., and Y. B. Swimmer. 1994. Post-nesting migration of *Eretmochelys imbricata* in the Yucatan Peninsula. Pages 202 *in* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.

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 J. Barlow. 2004. Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. Marine Mammal Science 20(1):63-85.

Calambokidis, J., T. Chandler, K. Rasmussen, G. H. Steiger, and L. Schlender. 1998. Humpback and blue whale photographic identification: Report of research in 1997. Final Report to Southwest Fisheries Science Center, Olympic Coast National Marine Sanctuary, University of California at Santa Cruz, and Cornell University. Cascadia Research, Olympia, WA. 41p.

Calambokidis, J., T. Chandler, L. Schlender, G. H. Steiger, and A. Douglas. 2003. Research on humpback and blue whale off California, Oregon and Washington in 2002. Final Contract

Report to Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA. 49p.

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., A. Gouglas, and F. Garita. 2010. Summary of 2010 humpback whale research along the Osa Peninsula, Costa Rica. Oceanic Society Research Expeditions, Exploritas and Cascadia Research Collective, Olympia, WA.

Calambokidis, J., and coauthors. 1990. Sightings and movements of blue whales off central California 1986-88 from photo-identification of individuals. Report of the International Whaling Commission (Special Issue 12):343-348.

Calambokidis, J., 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.

Campbell, C. L., and C. J. Lagueux. 2005. Survival probability estimates for large juvenile and adult green turtles (Chelonia mydas) exposed to an artisanal marine turtle fishery in the western Caribbean. Herpetologica 61:91-103.

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.

Carr, A., M. H. Carr, and A. B. Meylan. 1978. The ecology and migration of sea turtles, 7. the west Caribbean turtle colony. Bulletin of the American Museum of Natural History, New York 162(1):1-46.

Carr, A. F. 1986. RIPS, FADS, and little loggerheads. Bioscience 36(2):92-100.

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. 2009a. U.S. Pacific Marine Mammal Stock Assessments: 2008. U.S. Department of Commerce, NOAA.

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. 2009b. U.S. Pacific marine mammal stock assessments: 2009.

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.

Carretta, J. V., and coauthors. 2007. U.S. Pacific Marine Mammal Stock Assessments: 2006. U.S. Department of Commerce NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-398. 321p.

Carruthers, E. H., D. C. Schneider, and J. D. Neilson. 2009. Estimating the odds of survival and identifying mitigation opportunities for common bycatch in pelagic longline fisheries. Biological Conservation 142(11):2620-2630.

Casale, P., P. P. d'Astore, and R. Argano. 2009a. Age at size and growth rates of early juvenile loggerhead sea turtles (Caretta caretta) in the Mediterranean based on length frequency analysis. Herpetological Journal 19(1):29-33.

Casale, P., A. D. Mazaris, D. Freggi, C. Vallini, and R. Argano. 2009b. Growth rates and age at adult size of loggerhead sea turtles (Caretta caretta) in the Mediterranean Sea, estimated through capture-mark-recapture records. Scientia Marina 73(3):589-595.

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.

Castellote, M., C. W. Clark, F. Colmenares, and J. A. Esteban. 2009. Mediterranean fin whale migration movements altered by seismic exploration noise. Journal of the Acoustical Society of America 125(4):2519.

Castellote, M., C. W. Clark, and M. O. Lammers. 2010. Acoustic compensation to shipping and airgun noise by Mediterranean fin whales (Balaenoptera physalus). Journal of the Acoustical Society of America 127(3 Pt 2):1726.

Catry, P., and coauthors. 2009. Status, ecology, and conservation of sea turtles in Guinea-Bissau. Chelonian Conservation and Biology 8(2):150-160.

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.

Celik, A., and coauthors. 2006. Heavy metal monitoring around the nesting environment of green sea turtles in Turkey. Water Air and Soil Pollution 169(1-4):67-79.

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.

Chaloupka, M. 2001. Historical trends, seasonality, and spatial synchrony in green sea turtle egg production. Biological Conservation 101:263-279.

Chaloupka, M., and coauthors. 2007. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. Global Ecology and Biogeography Dec 2007. Available online at http://www.cccturtle.org/pdf/Chaloupka_et_alGEB2007.pdf. Accessed 12/31/2007.

Chaloupka, M., and C. Limpus. 2005. Estimates of sex- and age-class-specific survival probabilities for a southern Great Barrier Reef green sea turtle population. Marine Biology 146:1251-1261.

Chaloupka, M., C. Limpus, and J. Miller. 2004. Green turtle somatic growth dynamics in a spatially disjunct Great Barrier Reef metapopulation. Coral Reefs 23:325-335.

Chaloupka, M. Y., N. Kamezaki, and C. Limpus. 2008. Is climate change affecting the population dynamics of the endangered Pacific loggerhead sea turtle? Journal of Experimental Marine Biology and Ecology 356(1-2):136-143.

Chaloupka, M. Y., and J. A. Musick. 1997. Age, growth, and population dynamics. Pages 233-273 *in* P. L. Lutz, and J. A. Musick, editors. The biology of sea turtles. CRC Press, Boca Raton, Florida.

Chan, E. H. 2006. Marine turtles in Malaysia: on the verge of extinction? Aquatic Ecosystems Health and Management 9:175-184.

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.

Chandler, T., and J. Calambokidis. 2004. Costa Rica Dome blue whale cruise report. Cascadia Research Collective. Available online at: http://www.cascadiaresearch.org/reports/CRUISE%20REPORT.pdf.

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.

Chaves, G., R. Morera, J. R. Aviles, J. C. Castro, and M. Alvarado. 2005. Trends of the nesting activity of the “arribadas” of the olive ridley (*Lepidochelys olivacea*, Eschscholtz 1829),

in the Ostional National Wildlife Refuge (1971-2003). .

Cheng, I. J., and coauthors. 2009. Ten Years of Monitoring the Nesting Ecology of the Green Turtle, Chelonia mydas, on Lanyu (Orchid Island), Taiwan. Zoological Studies 48(1):83-94.

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.

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.

Christie, K., C. Lyons, W. R. Koski, D. S. Ireland, and D. W. Funk. 2009. Patterns of bowhead whale occurrence and distribution during marine seismic operations in the Alaskan Beaufort Sea. Pages 55 *in* 18th biennial conference on the biology of marine mammals, Quebec, Canada.

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., 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. 2006. Acoustic communication in the great whales: The medium and the message. Presentation at the 86th Annual Conference of the American Society of Mammalogists.

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

Clark, C. W., and W. T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales

for probing the environment: evidence from models and empirical measurements. Pp.564-582 In: J.A. Thomas, C.F. Moss, and M. Vater (Editors), Echolocation in Bats and Dolphins. University of Chicago Press, Chicago, Illinois.

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

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

Clarke, 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.

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

Cliffton, K. D., O. Cornejo, and R. S. Felger. 1982b. Sea turtles of the Pacific coast of Mexico. Pages 199-209 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

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.

Conway, C. A. 2005. Global population structure of blue whales, *Balaenoptera musculus* spp., based on nuclear genetic variation. University of California, Davis.

Corkeron, P., P. Ensor, and K. Matsuoka. 1999. Observations of blue whales feeding in Antarctic waters. Polar Biology 22:213-215.

Cornelius, S. E. 1982. Status of sea turtles along the Pacific coast of middle America. Pages 211-219 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

Cornelius, S. E. 1986. The sea turtles of Santa Rosa National Park. Fundacion Parques Nacionales, San José, Costa Rica.

Cornelius, S. E., and coauthors. 2007. Effect of land-based harvest of Lepidochelys. Pages 231-251 *in* P. T. Plotkin, editor. Biology and conservation of Ridley sea turtles. Johns Hopkins University Press, Baltimore, Maryland.

Cornelius, S. E., and D. C. Robinson. 1986. Post-nesting movements of female olive ridley turtles tagged in Costa Rica. Vida Silvestre Neotropical 1(11):12-23.

Cornelius, S. E., M. A. Ulloa, J. C. Castro, M. M. D. Valle, and D. C. Robinson. 1991. Management of olive ridley sea turtles Lepidochelys olivacea nesting at Playas Nancite, and Ostional, Costa Rica. Pages 111-135 *in* J. G. Robinson, and K. H. Redford, editors. Neotropical Wildlife Use and Conservation. The University of Chicago Press, Chicago, Illinois.

Corsolini, S., A. Aurigi, and S. Focardi. 2000. Presence of polychlorobiphenyls (PCBs), and coplanar congeners in the tissues of the Mediterranean loggerhead turtle Caretta caretta. Marine Pollution Bulletin 40(11):952-960.

COSEWIC. 2002. COSEWIC assessment and update status report on the blue whale *Balaenoptera musculus* (Atlantic population, Pacific population) in Canada. COSEWIC, Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 37p. Available at: www.sararegistry.gc.ca/status/status_e.cfm.

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.

CPC. 2010. ENSO cycle: Recent evolution, current status and predictions. NOAA Climate Prediction Center, Silver Spring, Maryland.

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., A. Acevedo-Gutiérrez, B. R. Tershy, and J. Urbán-Ramírez. 2001. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? Comparative Biochemistry and Physiology Part A 129:797-809.

Croll, D. A., and coauthors. 2005. From wind to whales: trophic links in a coastal upwelling system. Marine Ecology Progress Series 289:117-130.

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.

Croll, D. A., and coauthors. 1998. An integrated approach to the foraging ecology of marine birds and mammals. Deep-Sea Research II 45:1353-1371.

Crouse, O. T., L. B. Crowder, and H. Caswell. 1987. A site based population model for loggerhead sea turtles and implications for conservation. Ecology 68(5):1412-1423.

Cruz, R. D. 2002. Marine turtle distribution in the Philippines. Pages 57-66 *in* I. Kinan, editor Western Pacific Sea Turtle Cooperative Research and Management Workshop. . Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Cummings, V. 2002. Sea turtle conservation in Guam. Pages 37-38 *in* I. Kinan, editor Western Pacific Sea Turtle Cooperative Research and Management Workshop. . Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

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.

Das, S. 2008. Hundreds of sea turtles die along Odisha coast. Kalinga Times. East Coast Media, Kalinga, India.

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, 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.

de Paz, N., J. C. Reyes, M. Ormeno, H. A. Anchante, and A. J. Altamirano. 2006. Immature leatherback mortality in coastal gillnet fisheries off San Andes, Southern Peru. Pages 259 *in* M. Frick, A. Panagopoulou, A. F. Rees, and K.Williams, editors. 26th annual symposium on sea turtle biology and conservation.

De Weede, R. E. 1996. The impact of seaweed introductions on biodiversity. Global Biodiversity 6:2-9.

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.

Deem, S. L., and coauthors. 2009. COMPARISON OF BLOOD VALUES IN FORAGING, NESTING, AND STRANDED LOGGERHEAD TURTLES (CARETTA CARETTA) ALONG THE COAST OF GEORGIA, USA. Journal of Wildlife Diseases 45(1):41-56.

Denkinger, J., R. Constanza, P. Riofrio, and M. Scheidat. 1997. Humpback whales (Megaptera novaeangliae) breeding off the coast of Manabi, Ecuador. Pages 125-128 *in* P. G. H. Evans, E. C. M. Parsons, and S. L. Clark, editors. Proceedings of the Eleventh Annual Conference of the European Cetacean Society, Stralsund, Germany.

Dermawan, A. 2002. Marine turtle management, and conservation in Indonesia. Pages 67-75 *in* I. Kinan, editor Western Pacific Sea Turtle Cooperative Research and Management Workshop, Honolulu, Hawaii.

DeRuiter, S. L., and K. D. Doukara. 2010. Loggerhead turtles dive in response to airgun sound

exposure. Journal of the Acoustical Society of America 127(3 Pt 2):1726.

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.

Diaz-Fernandez, R., and coauthors. 1999. Genetic sourcing for the hawksbill turtle, Eretmochelys imbricata, in the Northern Caribbean Region. Chelonian Conservation and Biology 3:296-300.

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

DOC. 1983. Draft management plan and environmental impact statement for the proposed Hawaii Humpback Whale National Marine Sanctuary. Prepared by the NOAA Office of Ocean and Coastal Resource Management and the State of Hawaii. U.S. Department of Commerce.

Dodd, C. K. 1988. Synopsis of the biological data on the loggerhead sea turtle: *Caretta caretta* (Linnaeus 1758). Fish and Wildlife Service Biological Report 88(14):110.

Dodd Jr., C. K. 1988. Synopsis of the biological data on the loggerhead sea turtle, Caretta caretta (Linnaeus 1758).

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.

Donoso, M., P. Dutton, R. Serra, and J. L. Brito-Montero. 2000. Sea turtles found in waters off Chile. Pages 218-219 *in* H. J. Kalb, and T. Wibbels, editors. 19th Annual Symposium on Sea Turtle Biology and Conservation. NMFS.

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

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

Dow, W. E., D. A. Mann, T. T. Jones, S. A. Eckert, and C. A. Harms. 2008. In-water and in-air hearing sensitivity of the green sea turtle (Chelonia mydas). 2nd International Confernece on Acoustic Communication by Animals, Corvalis, OR.

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. 2003a. Molecular ecology of *Chelonia mydas* in the eastern Pacific Ocean. J. A. Seminoff, editor Proceedings of the 22nd annual symposium on sea turtle biology and conservation

Dutton, P. H. 2003b. Molecular ecology of the eastern Pacific green turtle. 22nd Annual Symposium on Sea Turtle Biology and Conservation.

Dutton, P. H., and G. H. Balazs. In review. Molecular ecology of the green turtle (Chelonia mydas) in the Hawaiian Archipelago: evidence for a distinct population. Endangered Species Research.

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., S. K. Davis, T. Guerra, and D. Owens. 1996. Molecular phylogeny for marine turtles based on sequences of the ND4-leucine tRNA and control regions of mitochondrial DNA. Molecular Phylogenetics and Evolution 5(3):511-521.

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.

EcoPetrol. 2010. Carta Petrolera No. 121 enero—marzo 2010.

Edds-Walton, P. L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics: The International Journal of Animal Sound and its Recording 8:47-60.

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.

Eguchi, T., T. Gerrodette, R. L. Pitman, J. A. Seminoff, and P. H. Dutton. in preperation. At-sea density and abundance estimates of the olive ridley turtle (Lepidochelys olivacea) in the Eastern Tropical Pacific.

Ehrhart, L. M., D. A. Bagley, and W. E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: Geographic distribution, abundance, and population status. Pages 157-174 *in* A. B. Bolten, and B. E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books,

Washington D.C.

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. 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.

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.

EOE. 2008. Energy profile of Peru. C. J. Cleveland, editor. The encyclopedia of earth. Environmental Information Coalition, National Council for Science and the Environment, Washington, D. C.

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

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

Euroturtle. 2009. Hawksbill Sea Turtle, Eretmochelys imbricata.

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, K. E., and A. R. Vargas. 1998. Sea turtle egg commercialization in Isla de Cañas, Panama. Pages 45 *in* R. Byles, and Y. Fernandez, editors. Sixteenth Annual Symposium on Sea Turtle Biology and Conservation.

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.

Favreau, J. M., and coauthors. 2006. Recommendations for Assessing the Effectiveness of Surrogate Species Approaches. Biodiversity and Conservation 15(12):3949-3969.

Felix, F., C. Castro, B. Haase, P. Forestell, and M. Scheidat. 2005. New estimate of the southeastern Pacific humpback whale stock. Abstr. 16th Bienn. Conf. Biol. Mar. Mamm., 12-16 Dec. 2005, San Diego, CA.

Félix, F., and B. Haase. 2001. The humpback whale off the coast of Ecuador, population parameters and behavior. Revista de Biología Marina y Oceanografía 36(1):61-74.

Felix, F., and B. Haase. 2005. Distribution of humpback whales along the coast of Ecuador and management implications. Journal of Cetacean Research and Management 7(1):21-31.

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.

Ferguson, M. C., and J. Barlow. 2003. Addendum: Spatial distribution and density of cetaceans in the Eastern Tropical Pacific Ocean based on summer/fall research vessel surveys in 1986–96. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA.

Fernandez-Alamo, M. A., and J. Farber-Lorda. 2006. Zooplankton and the oceanography of the eastern tropical Pacific: a review. Progress in Oceanography 69(2-4):318-359.

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

FFWCC. 2007a. Florida Statewide Nesting Beach Survey Data–2005 Season. Florida Fish and Wildlife Conservation Commission.

FFWCC. 2007b. Long-term monitoring program reveals a continuing loggerhead decline, increases in green turtle and leatherback nesting. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute.

Ficetola, G. F. 2008. Impacts of human activities and predators on the nest success of the hawksbill turtle, Eretmochelys imbricata, in the Arabian Gulf. Chelonian Conservation and Biology 7(2):255-257.

Fiedler, P., and coauthors. 1998. Blue whale habitat and prey in the Channel Islands. Deep-Sea Research II 45:1781-1801.

Fiedler, P. C. 2002. The annual cycle and biological effects of the Costa Rica Dome. Deep Sea Research I 49:321-338.

Fiedler, P. C., and M. F. Lavın. 2006. Introduction: A review of Eastern Tropical Pacific Oceanography. Progress in Oceanography 69(2-4):94-100.

Fiedler, P. C., V. Philbrick, and F. P. Chavez. 1991. Oceanic upwelling and productivity in the eastern tropical Pacific. Limnology and Oceanography 36:1834-1850.

Fiedler, P. C., and L. D. Talley. 2006. Hydrography of the eastern Tropical Pacific: a review. Progress in Oceanography 69(2-4):143-148.

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.

Fitzsimmons, N. N., A. D. Tucker, and C. J. Limpus. 1995. Long-term breeding histories of male green turtles and fidelity to a breeding ground. Marine Turtle Newsletter 68:2-4.

Flint, M., and coauthors. 2009. Development and application of biochemical and haematological reference intervals to identify unhealthy green sea turtles (Chelonia mydas). The Veterinary Journal.

Foley, A. M., P. H. Dutton, K. E. Singel, A. E. Redlow, and W. G. Teas. 2003. The first records of olive ridleys in Florida, USA. Marine Turtle Newsletter 101:23-25.

Foley, A. M., B. A. Schroeder, A. E. Redlow, K. J. Fick-Child, and W. G. Teas. 2005. Fibropapillomatosis in stranded green turtles (Chelonia mydas) from the eastern United States (1980-98): Trends and associations with environmental factors. Journal of Wildlife Diseases 41(1):29-41.

Fonseca, L. G., G. A. Murillo, L. Guadamuz, R. M. Spinola, and R. A. Valverde. 2009. Downward but Stable Trend in the Abundance of Arribada Olive Ridley Sea Turtles (Lepidochelys olivacea) at Nancite Beach, Costa Rica (1971-2007). Chelonian Conservation and Biology 8(1):19-27.

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.

Forney, K. A., and R. L. Brownell Jr. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. Paper SC/48/011 presented to the IWC Scientific Committee, June 1996 (unpublished). NOAA Fisheries Southwest Fisheries Science Center, La Jolla, California.

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.

Foti, M., and coauthors. 2009. Antibiotic Resistance of Gram Negatives isolates from loggerhead sea turtles (Caretta caretta) in the central Mediterranean Sea. Marine Pollution Bulletin 58(9):1363-1366.

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

Francour, P., A. Ganteaume, and M. Poulain. 1999. Effects of boat anchoring in Posidonia oceanica seagrass beds in the Port-Cros National Park (north-western Mediterranean Sea). Aquatic Conservation: Marine and Freshwater Ecosystems 9:391-400.

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.

Frazer, N. B., and L. M. Ehrhart. 1985. Preliminary growth models for green, *Chelonia mydas*, and loggerhead, *Caretta caretta*, turtles in the wild. Copeia 1985:73-79.

Frazier, J., and coauthors. 2007. Human-turtle interactions at sea. Pages 253-295 *in* P. T. Plotkin, editor. Biology and conservation of Ridley sea turtles. Johns Hopkins University Press, Baltimore, Maryland.

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. 1999. Distribution of the turtles of the genus Lepidochelys Fitzinger, 1843. I. The western Atlantic. Biogeographica 75(3):97-11.

Fretey, J. 2001a. Biogeography and conservation of marine turtles of the Atlantic coast of Africa. UNEP/CMS Secretariat, Bonn, Germany.

Fretey, J. 2001b. 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.

Fretey, J., and coauthors. 2005. Presence, nesting, and conservation of Lepidochelys olivacea in the Gulf of Guinea. Pages 172 *in* M. S. Coyne, and R. D. Clark, editors. Twenty-first Annual Symposium on Sea Turtle Biology and Conservation.

Fritts, T. H., M. L. Stinson, and R. Márquez. 1982. Status of sea turtle nesting in southern Baja California, Mexico. Bulletin of the Southern California Academy of Sciences 81:51-60.

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.

Fujihara, J., T. Kunito, R. Kubota, and S. Tanabe. 2003. Arsenic accumulation in livers of pinnipeds, seabirds and sea turtles: Subcellular distribution and interaction between arsenobetaine and glycine betaine. Comparative Biochemistry and Physiology C-Toxicology & Pharmacology 136(4):287-296.

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

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. 1979. The blue whale. Biologist 26(5):209-215.

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.

Gaos, A. R., and coauthors. 2010. Signs of hope in the eastern Pacific: international collaboration reveals encouraging status for severely depleted populations of hawksbill turtle Eretmochelys imbricata. Oryx in press.

Gaos, A. R., I. L. Yañez, and R. M. Arauz. 2006. Sea turtle conservation and research on the Pacific coast of Costa Rica.

Garcia-Fernandez, A. J., and coauthors. 2009. Heavy metals in tissues from loggerhead turtles (Caretta caretta) from the southwestern Mediterranean (Spain). Ecotoxicology and Environmental Safety 72(2):557-563.

Gardner, S. C., S. L. Fitzgerald, B. A. Vargas, and L. M. Rodriguez. 2006. Heavy metal accumulation in four species of sea turtles from the Baja California peninsula, Mexico. Biometals 19:91-99.

Gardner, S. C., M. D. Pier, R. Wesselman, and J. A. Juarez. 2003. Organochlorine contaminants in sea turtles from the Eastern Pacific. Marine Pollution Bulletin 46:1082-1089.

Garofalo, L., T. Mingozzi, A. Mico, and A. Novelletto. 2009. Loggerhead turtle (Caretta caretta) matrilines in the Mediterranean: further evidence of genetic diversity and connectivity. Marine Biology 156(10):2085-2095.

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. 1997a. 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.

Gauthier, J. M., C. D. Metcalfe, and R. Sears. 1997b. Validation of the blubber biopsy technique for monitoring of organochlorine contaminants in Balaenopterid whales. Marine Environmental Research 43(3):157-179.

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.

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.

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.

Gilpatrick, J., James W., and W. L. Perryman. 2009. Geographic variation in external morphology of North Pacific and Southern Hemisphere blue whales (Balaenoptera musculus). Journal of Cetacean Research and Management 10(1):9-21.

Girard, C., A. D. Tucker, and B. Calmettes. 2009. Post-nesting migrations of loggerhead sea turtles in the Gulf of Mexico: dispersal in highly dynamic conditions. Marine Biology 156(9):1827-1839.

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.

Godley, B., and coauthors. 2002. Long-term satellite telemetry of the movements and habitat utilization by green turtles in the Mediterranean. Ecography 25:352-362.

Godley, B. J., D. R. Thompson, and R. W. Furness. 1999. Do heavy metal concentrations pose a threat to marine turtles from the Mediterranean Sea? Marine Pollution Bulletin 38:497-502.

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.

Godley, B. J. E., and coauthors. 2003. Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging. Marine Ecology Progress

Series 253:279-288.

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.

Gonzalez-Silvera, A., E. Santamarıa-de-Angel, R. Milla´n-Nunez, and H. Manzo-Monroy. 2004. Satellite observations of mesoscale eddies in the Gulfs of Tehuantepec and Papagayo (Eastern Tropical Pacific). Deep-Sea Research II 51:587-600.

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.

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

Grant, G. S., P. Craig, and G. H. Balazs. 1997. Notes on juvenile hawksbill and green turtles in American Samoa. Pacific Science 51(1):48-53.

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, D., and F. Ortiz-Crespo. 1995. Status of sea turtle populations in the central eastern Pacific. Pages 221-233 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D. C.

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.

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.

Groombridge, B. 1982. The IUCN Amphibia - Reptilia Red Data Book. Part 1. Testudines, Crocodylia, Rhynchocephalia. International Union Conservation Nature and Natural Resources.

Guerra, M., A. M. Thode, S. B. Blackwell, C. R. Greene Jr., and M. Macrander. 2009. Quantifying masking effects of seismic survey reverberation off the Alaskan North Slope. Journal of the Acoustical Society of America 126(4):2230.

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.

Haase, B., and F. Felix. 1994. A note on the incidental mortality of sperm whales (Physeter macrocephalus) in Ecuador. Report of the International Whaling Commission Special Issue 15:481-483.-Sc/46/O6).

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.

Haley, B., and W. R. Koski. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's ADWBC seismic program in the northwest Atlantic Ocean, July-August 2004. LGL, Ltd., King City, Ontario.

Hamann, M., C. Limpus, G. Hughes, J. Mortimer, and N. Pilcher. 2006a. 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, Thailand.

Hamann, M., C. Limpus, G. Hughes, J. Mortimer, and N. Pilcher. 2006b. 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, D. V., and G. A. Maul. 1991. Anticyclonic current rings in the eastern tropical Pacific Ocean. Journal of Geophysical Research –Oceans 96:6965-6979.

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.

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.

Hasbún, C. R., and M. Vásquez. 1999. Sea turtles of El Salvador. Marine Turtle Newsletter 85:7-9.

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., and coauthors. 2002a. Population structure of loggerhead turtles, *Caretta caretta*, nesting in Japan: bottlenecks on the Pacific population. Marine Biology 141:299-305.

Hatase, H., Y. Matsuzawa, W. Sakamoto, N. Baba, and I. Miyawaki. 2002b. Pelagic habitat use of an adult Japanese male loggerhead turtle Caretta caretta examined by the Argos satellite system. Fisheries Science 68:945-947.

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., and M. Holst. 2009. Marine mammal and sea turtle monitoring during Lamont-

Doherty Earth Observatory's marine seismic program in the Gulf of Alaska, Septmerb-October 2008 LGL, Ltd., King City, Canada.

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. Broderick, M. H. Godfrey, and B. J. Godley. 2007a. The potential impact of climate change on loggerhead sex ratios in the Carolinas - how important are North Carolina's males? P.153 *in*: Frick, M.; A. Panagopoulou; A.F. Rees; K. Williams (compilers), 27th Annual Symposium on Sea Turtle Biology and Conservation [abstracts]. 22-28 February 2007, Myrtle Beach, South Carolina. 296p.

Hawkes, L. A., A. C. Broderick, M. H. Godfrey, and B. J. Godley. 2007b. 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.

Hazel, J., I. R. Lawler, and M. Hamann. 2009. Diving at the shallow end: Green turtle behaviour in near-shore foraging habitat. Journal of Experimental Marine Biology and Ecology 371(1):84-92.

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.

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.

Hermanussen, S., V. Matthews, O. Papke, C. J. Limpus, and C. Gaus. 2008. Flame retardants (PBDEs) in marine turtles, dugongs and seafood from Queensland, Australia. Marine Pollution Bulletin 57(6-12):409-418.

Hernández, R., J. Buitrago, H. Guada, H. Hernández-Hamón, 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.

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.

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.

Hill, P. S., D. P. DeMaster, and R. J. Small. 1997. Alaska stock assessments - 1996. U.S. Department of Commerce, NOAA Technical Memorandum:Alaska Fisheries Science Center; Auke Bay, Alaska. .

Hillis-Starr, Z. M. Coyne, and M. Monaco. 2000. Buck Island and back: Hawksbill turtles make their move. Pages 159 *in* H. J. Kalb, and T. Wibbels, editors. Nineteenth Annual Symposium on Sea Turtle Biology and Conservation.

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.

Hirth, H. F. 1997. Synopsis of the biological data on the green turtle, Chelonia mydas (Linnaeus 1758).

Hitt, N. P., and C. A. Frissell. 2004. A case study of surrogate species in aquatic conservation planning. Aquatic Conservation: Marine and Freshwater Ecosystems 14(6):625-633.

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

Hoekert, W. E., J. A. D. Schouten, L. H. G. V. Tienen, and M. Weijerman. 1996. Is the Suriname olive ridley on the eve of extinction? First census data for olive ridleys, green turtles, and leatherbacks since 1989. Marine Turtle Newsletter 75:1-4.

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. 2009. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's Taiger marine seismic program near Taiwan, April - July 2009 LGL, Ltd., King City, Canada.

Holst, M. 2010. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's ETOMO marine seismic program in the northeast Pacific Ocean August-September 2009 LGL, Ltd., King City, Canada.

Holst, M., and J. Beland. 2008. Marine mammal and sea turtle monitoring during Lamont-

Doherty Earth Observatory's seismic testing and calibration study in the northern Gulf of Mexico, November 2007-February 2008. Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.

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 off the northern Yucatán Peninsula in the southern Gulf of Mexico, January-February 2005. Prepared by LGL, Ltd. for the Lamont-Doherty Earth Observatory of Columbia University and the National Marine Fisheries Service, Office of Protected Resources. LGL Report TA2822-31. 110p.

Holst, M., M. A. Smultea, W. R. Koski, and B. Haley. 2005d. 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.

Holst, M., M. A. Smultea, W. R. 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 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.

Holt, M. M. 2008. Sound exposure and Southern Resident killer whales (*Orcinus orca*): A review of current knowledge and data gaps. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-89. 59p.

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

Horrocks, J. A., and N. Scott. 1991. Nest site location, and nest success in the hawksbill turtle Eretmochelys imbricata in Barbados, West Indies. Marine Ecology Progress Series 69:1-8.

Horrocks, J. A., and coauthors. 2001. Migration routes and destination characteristics of post-nesting hawksbill turtles satellite-tracked from Barbados, West Indies. Chelonian Conservation and Biology 4(1):107-114.

Howell, E. A., D. R. Kobayashi, D. M. Parker, G. H. Balazs, and J. J. Polovina. 2008. TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles Caretta caretta in the Hawaii-based pelagic longline fishery. Endangered Species Research 5:267-278.

Hoyt, E. 1991. Alle Wale der Welt. The whale watchers handbook. Conrad Stein Verlag, Kiel.

Hoyt, E. 2001. Whale Watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits. International Fund for Animal Welfare, Yarmouth Port, MA, USA, pp. i–vi; 1–158.

Hu, M. Y., H. Y. Yan, W.-S. Chung, J.-C. Shiao, and P.-P. Hwang. 2009. Acoustically evoked potentials in two cephalopods inferred using the auditory brainstem response (ABR) approach. Comparative Biochemistry and Physiology Part A 153:278-283.

Hucke-Gaete, R., L. Osman, C. Moreno, K. P. Findlay, and D. Ljungblad. 2004. Discovery of a blue whale feeding and nursing ground in southern Chile. Proceedings of the Royal Society of London, Series B: Biological Sciences 271(Suppl.):S170-S173.

Hughes, D. A., and J. D. Richard. 1974. The nesting of the Pacific ridley turtle Lepidochelys olivacea on Playa Nancite, Costa Rica. Marine Biology 24:97-107.

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.

Hulin, V., V. Delmas, M. Girondot, M. H. Godfrey, and J. M. Guillon. 2009. Temperature-dependent sex determination and global change: are some species at greater risk? Oecologia 160(3):493-506.

Hutchinson, B. J., and P. Dutton. 2007. Modern genetics reveals ancient diversity in the loggerhead.

I-Jiunn, C. 2009. Changes in diving behaviour during the internesting period by green turtles. Journal of Experimental Marine Biology and Ecology.

IATTC. 1999. Annual report of the Inter-American Tropical Tuna Commission 1997. Inter American Tropical Tuna Commission, La Jolla, CA.

IATTC. 2008. Annual report of the Inter-American Tropical Tuna Commission 2008. Inter-American Tropical Tuna Commission LA Jolla, California.

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.

Ischer, T., K. Ireland, and D. T. Booth. 2009. Locomotion performance of green turtle hatchlings from the Heron Island Rookery, Great Barrier Reef. Marine Biology 156(7):1399-1409.

Islam, M. Z. 2002. Marine turtle nesting at St. Martin's Island, Bangladesh. Marine Turtle Newsletter 96:19-21.

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

Iwamoto, T., M. Ishii, Y. Nakashima, H. Takeshita, and A. Itoh. 1985. Nesting cycles and migrations of the loggerhead sea turtle in Miyazaki, Japan. Japanese Journal of Ecology 35(4):505-511.

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. 2005a. 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. 2005b. Whale Estimates. Available from: http://www.iwcoffice.org/conservation/estimate.htm#assessment via the Internet. Accessed 7/25/2006.

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

Jackson, A., and coauthors. 2003. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships McArthur and David Starr Jordan and the UNOLS ship Endeavor July 29-December 10, 1998. NOAA-National Marine Fisheries Service.

Jackson, A., and coauthors. 2008. Marine mammal data collected during a survey in the Eastern Tropical Pacific Ocean aboard the NOAA ships David Starr Jordan and MacArthur II, July 28-December 7 2006. Southwest Fisheries Science Center, National Marine

Fisheries Service, La Jolla, CA.

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.

Jameson, S. C., V. F. Gallucci, and J. A. Robleto. 2000. Nicaragua: The Pacific Coast. Pages 531-543 *in* C. Sheppard, editor. Seas at the millenium: An environmental evaluation. , volume 1. Elsevier Science, Amsterdam.

Jameson, S. C., V. F. Gallucci, and J. A. Robleto. 2000b. Nicaragua: The Pacific Coast. Pp.531-543 In: Seas At The Millenium: An Environmental Evaluation. Volume 1. C. Sheppard (Ed.), Elsevier Science, Amsterdam.

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.

Jimenez, M. 2007. Costa Rica, China to explore for oil. Associated Press, December 7, 2007. Available online at: http://www.usatoday.com/money/economy/2007-12-07-1708783564_x.htm.

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, 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.

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 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.

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.

Kalb, H., and D. Owens. 1994. Differences between solitary and arribada nesting olive ridley females during the internesting period. Pages 68 *in* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. .

Kalb, H., R. A. Valverde, and D. Owens. 1995. What is the reproductive patch of the olive ridley sea turtle? Pages 57-60 *in* J. I. Richardson, and T. H. Richardson, editors. Twelfth Annual Workshop on Sea Turtle Biology and Conservation. .

Kamezaki, N. 1989. The nesting sites of sea turtles in the Ryukyu Archipelago and Taiwan. Pages 342-348 *in* M. Matsui, T. Hikida, and R. C. Goris, editors. Current herpetology in East Asia. Herpetological Society of Japan, Kyoto.

Kamezaki, N., and coauthors. 2003. Loggerhead turtles nesting in Japan. Pages 210-217 *in* A. B.

Bolten, and B. E. Witherington, editors. Loggerhead sea turtles. Smithsonian Books, Washington D.C.

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.

Kapurisinghe, T. 2006. Status and conservation of marine turtles in Sri Lanka. Pages 173-187 *in* K. Shanker, and B. C. Choudhury, editors. Marine Turtles of the Indian Subcontinent. Universities Press, India.

Karnad, D., K. Isvaran, C. S. Kar, and K. Shanker. 2009. Lighting the way: Towards reducing misorientation of olive ridley hatchlings due to artificial lighting at Rushikulya, India. Biological Conservation 142(10):2083-2088.

Kasamatsu, F., G. Joyce, P. Ensor, and J. Mermoz. 1996. Current occurrence of Baleen whales in Antarctic waters. Reports of the International Whaling Commission 46:293-304.

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.

Kato, H., and T. Miyashita. 2000. Current status of the North Pacific sperm whales and its preliminary abundance estimate. International Whaling commission.

Kato, H., T. Miyashita, and H. Shimada. 1995. Segregation of the two sub-species of the blue whale in the Southern Hemisphere. Reports of the International Whaling Commission 45:273-283.

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. 1980. A review of food of balaenopterid whales. Scientific Reports of the Whales Research Institute 32:155-197.

Kawamura, G., T. Naohara, Y. Tanaka, T. Nishi, and K. Anraku. 2009. Near-ultraviolet radiation guides the emerged hatchlings of loggerhead turtles Caretta caretta (Linnaeus) from a nesting beach to the sea at night. Marine and Freshwater Behaviour and Physiology 42(1):19-30.

Kelez, S., X. Velez-Zuzzo, F. Angulo, and C. Manrique. 2009. Olive ridley Lepidochelys olivacea nesting in Peru: the southernmost records in the eastern Pacific. Marine Turtle Newsletter 126:5-9.

Kelez, S., B. Wallace, D. Dunn, W. J. Nichols, and L. B. Crowder. 2010. Sea turtle bycatch in the eastern Pacific: a regional review. Pages 110 *in* K. Dean, and M. C. L. Castro, editors. 28th Annual Symposium on Sea Turtle Biology and Conservation.

Kelle, L., N. Gratiot, and B. de Thoisy. 2009. Olive ridley turtle Lepidochelys olivacea in French Guiana: back from the brink of regional extirpation? Oryx 43(2):243-246.

Keller, J. M., and coauthors. 2005. Perfluorinated compounds in the plasma of loggerhead and Kemp's ridley sea turtles from the southeastern coast of the United States. Environmental Science and Technology 39(23):9101-9108.

Keller, J. M., J. R. Kucklick, C. A. Harms, and P. D. McClellan-Green. 2004a. Organochlorine

contaminants in sea turtles: Correlations between whole blood and fat. Environmental Toxicology and Chemistry 23(3):726-738.

Keller, J. M., J. R. Kucklick, and P. D. McClellan-Green. 2004b. Organochlorine contaminants in loggerhead sea turtle blood: Extraction techniques and distribution among plasma, and red blood cells. Archives of Environmental Contamination and Toxicology 46:254-264.

Keller, J. M., J. R. Kucklick, M. A. Stamper, C. A. Harms, and P. D. McClellan-Green. 2004c. Associations between organochlorine contaminant concentrations and clinical health parameters in loggerhead sea turtles from North Carolina, USA. Environmental Health Parameters 112(10):1074-1079.

Keller, J. M., and P. McClellan-Green. 2004. Effects of organochlorine compounds on cytochrome P450 aromatase activity in an immortal sea turtle cell line. Marine Environmental Research 58(2-5):347-351.

Keller, J. M., P. D. McClellan-Green, J. R. Kucklick, D. E. Keil, and M. M. Peden-Adams. 2006. Turtle immunity: Comparison of a correlative field study and in vitro exposure experiments. Environmental Health Perspectives 114(1):70-76.

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.

Kessler, W. S. 2006. The circulation of the eastern tropical Pacific: a review. Progress in Oceanography 69(2-4):181-217.

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

Ketten, D. R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts.

Ketten, D. R., and S. M. Bartol. 2006. Functional measures of sea turtle hearing. Office of Naval Research, Arlington, VA.

Kinzey, D., and coauthors. 2000. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships McArthur and David Starr Jordan and the UNOLS ship Endeavor July 28-December 9, 1999. NOAA-National Marine Fisheries Service.

Kinzey, D., and coauthors. 1999. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships McArthur and David Starr Jordan and the UNOLS ship Endeavor July 31-December 9, 1998. NOAA-National Marine Fisheries Service.

Kinzey, D., and coauthors. 2001. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships McArthur and David Starr Jordan and the UNOLS ship Endeavor July 28-December 9, 2000. NOAA-National Marine Fisheries Service.

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.

Kite-Powell, H. L., A. Knowlton, and M. Brown. 2007. Modeling the effect of vessel speed on right whale ship strike risk. NMFS.

Kopitsky, K., R. L. Pitman, and P. Plotkin. 2000. Investigations on at-sea mating and reproductive status of olive ridleys, Lepidochelys olivacea, captured in the eastern tropical Pacific. Pages 160-162 *in* H. J. Kalb, and T. Wibbels, editors. Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. .

Koski, W. R., and coauthors. 2009. An update on feeding by bowhead whales near an offshore seismic survey in the central Beaufort Sea. International Whaling Commission, Cambridge, U.K.

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.

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.

Krishna, S. 2005. Sporadic nesting of olive ridley turtles (*Lepidochelys olivacea*) and efforts to conserve them along the coast of Karnataka (South West India). Pages 218-219 *in* M. S. Coyne, and R. D. Clark, editors. Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. .

Kujawa, S. G., and M. C. Liberman. 2009. Adding insult to injury: Cochlear nerve degeneration after “temporary” noise-induced hearing loss. The Journal of Neuroscience 29(45):14077-14085.

Kuller, Z. 1999. Current status and conservation of marine turtles on the Mediterranean coast of Israel. Marine Turtle Newsletter 86:3-5.

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.

Lagerquist, B. A., K. M. Stafford, and B. R. Mate. 2000. Dive characteristics of satellite-monitored blue whales off the Central California coast. Marine Mammal Science 16(2):375-391.

Lagueux, C. J., C. L. Campbell, and W. A. McCoy. 2003. Nesting, and conservation of the hawksbill turtle, Eretmochelys imbricata, in the Pearl Cays, Nicaragua. Chelonian Conservation and Biology 4(3):588-602.

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

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.

Landsberg, J. H., and coauthors. 1999. The potential role of natural tumor promoters in marine turtle fibropapillomatosis. Journal of Aquatic Animal Health 11(3):199-210.

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

Laurie, W. A. 1990. Population biology of marine iguanas (Amblyrhychus cristatus). I. Changes in fecundity related to a population crash. Journal of Animal Ecology 59:515-528.

Lavın, M. F., E. Beier, J. Gomez-Valdes, V. M. Godınez, and J. Garcıa. 2006. On the summer poleward coastal current off SW Mexico. Geophysical Research Letters 33:L02601.

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 Gall, J., Y. P. Bosc, D. Chateau, and M. Taquet. 1986. Estimation du nombre de tortues vertes femelles adultes Chelonia mydas par saison de ponte á Tromelin et Europa (Océan Indien) (1973-1985). Océanographie Tropicale 21:3-22.

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., D. Caldwell, and a. H. Winn. 1976. Whales, Dolphins and Porpoises of the Western North Atlantic: A Guide to Their Identification. NOAA Technical Report NMFS Circ 396:1-175.

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.

Leblanc, A. M., and T. Wibbels. 2009. Effect of Daily Water Treatment on Hatchling Sex Ratios in a Turtle With Temperature-Dependent Sex Determination. Journal of Experimental Zoology Part a-Ecological Genetics and Physiology 311A(1):68-72.

Lee Long, W. J., R. G. Coles, and L. J. McKenzie. 2000. Issues for seagrass conservation management in Queensland. Pacific Conservation Biology 5:321-328.

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

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.

Lettevall, E. 1997. Age and sex distribution of sperm whales during the breeding seasons off the Galapagos Islands. Pages 137 *in* P. G. H. Evans, E. C. M. Parsons, and S. L. Clark, editors. Proceedings of the Eleventh Annual Conference of the European Cetacean Society, Stralsund, Germany.

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. 2007. Environmental assessment of a marine geophysical survey by the R/V Marcus G. Langseth off Central America, January–March 2008.

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. 2010. Environmental Assessment of a Marine Geophysical Survey by the R/V Melville in the Pacific Ocean off Central and South America, October–November 2010. LGL, Ltd., King City, Ontario.

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.

Liew, H. C. 2002. Status of marine turtle conservation and research in Malaysia. Pages 51-56 *in* I. Kinan, editor Western Pacific Sea Turtle Cooperative Research and Management Workshop. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

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.

Limpus, C., and M. Chaloupka. 1997. Nonparametric regression modeling of green sea turtle growth rates (southern Great Barrier Reef). Marine Ecology Progress Series 149:23-34.

Limpus, C. J. 1985. A study of the loggerhead turtle, Caretta caretta, in eastern Australia. PhD thesis. University of Queensland, Brisbane, Australia.

Limpus, C. J. 1995. Global overview of the status of marine turtles: A 1995 viewpoint. Pages 605-609 *in* K. Bjorndal, editor. Biology and conservation of sea turtles, revised edition. Smithsonian Institution Press, Washington, D.C.

Limpus, C. J., and D. J. Limpus. 2003. Loggerhead turtles in the equatorial, and southern Pacific Ocean: A species in decline. Pages 199-209 *in* A. B. Bolten, and B. E. Witherington, editors. Loggerhead sea turtles. Smithsonian Books, Washington D.C.

Limpus, C. J., J. D. Miller, D. J. Limpus, and M. Hamann. 2002. The Raine Island green turtle rookery: Y2K update. Pages 132-134 *in* A. Mosier, A. Foley, and B. Brost, editors. Twentieth Annual Symposium on Sea Turtle Biology and Conservation. .

Limpus, C. J., J. D. Miller, C. J. Parmenter, and D. J. Limpus. 2003. The green turtle, Chelonia mydas, population of Raine Island and the northern Great Barrier Reef, 1843-2001. Memoirs of the Queensland Museum 49:349-440.

Limpus, C. J., and N. Nicholls. 1988. The Southern Oscillation regulates the annual numbers of green turtles (Chelonia mydas) breeding around northern Australia. Australian Journal of Wildlife Research 15:157-161.

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).

López Carcache, J., and coauthors. in press. Monitoring of isolated and arribada nests of olive ridley, Lepidochelys olivacea, in Chacocente Beach, Rio Escalante-Chacocente, Wildlife Refuge, Pacific Coast of Nicaragua (2002-2004). Twenty-fifth Annual Symposium on Sea Turtle Biology and Conservation.

López, E., and R. Arauz. 2003. Nesting records of East Pacific green turtles (*Chelonia mydas agassizii*) in south Pacific Costa Rica, including notes on incidental capture by shrimping and longline activities. Pages 84-85 *in* J. A. Seminoff, editor Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. .

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.

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

MacLean, S. A., and W. R. Koski. 2005. Marine Mammal Monitoring During Lamont-Doherty Earth Observatory's Seismic Program in the Gulf of Alaska, August-September 2004. Prepared by LGL, Ltd. - LGL Report TA2822-28 - for the Lamont-Doherty Earth Observatory, Palisades, New York, and the National Marine Fisheries Service, Silver Spring, Maryland. 102p.

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.

Makowski, C., J. A. Seminoff, and M. Salmon. 2006. Home range and habitat use of juvenile Atlantic green turtles (Chelonia mydas L.) on shallow reef habitats in Palm Beach, Florida, USA. Marine Biology 148:1167-1179.

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.

Mangel, J. C., and coauthors. 2010. Use of satellite telemetry to assess loggerhead turtle movements and fisheries interactions off Peru K. Dean, and M. C. L. Castro, editors. 28th Annual Symposium on Sea Turtle Biology and Conservation. National Marine Fisheries Service.

Mansfield, K. L., V. S. Saba, J. A. Keinath, and J. A. Musick. 2009. Satellite tracking reveals a dichotomy in migration strategies among juvenile loggerhead turtles in the Northwest Atlantic. Marine Biology 156(12):2555-2570.

Marcovaldi, M. A., and M. Chaloupka. 2007. Conservation status of the loggerhead sea turtle in Brazil: An encouraging outlook. Endangered Species Research 3:133-143.

Margaritoulis, D., and coauthors. 2003. Loggerhead turtles in the Mediterranean Sea: Present knowledge and conservation perspectives. Pages 175-198 *in* A. B. Bolten, and B. E. Witherington, editors. Loggerhead sea turtles. Smithsonian Books, Washington D.C.

Margaritoulis, D., and A. Demetropoulos. 2003. Proceedings of the First Mediterranean Conference on Marine Turtles. Barcelona Convention-Bern Convention- Bonn Convention (CMS), Nicosia, Cyprus.

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.

Márquez, M. R., M. A. Carrasco, M. C. Jimenez, C. P.-. S., and R. Bravo-G. 2005. Kemp's, and olive ridley sea turtles populations status. Pages 273-239 *in* M. S. Coyne, and R. D. Clark, editors. Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. .

Márquez, M. R., C. Peñaflores, and J. Vasconcelos. 1996. Olive ridley turtles (Lepidochelys olivacea) show signs of recovery at La Escobilla, Oaxaca. Marine Turtle Newsletter 73:5-7.

Marshall, C. D., A. L. Moss, and A. Guzman. 2009. Loggerhead Sea Turtle (Caretta caretta) Feeding on Mackerel-Baited Longline Hooks. Integrative and Comparative Biology 49:E266-E266.

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. 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.

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

Mate, B. R., B. A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. Marine Mammal Science 15(4):1246-1257.

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.

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.

May-Collado, L. J. 2006. Los mamíferos marinos de Costa Rica. Reporte para el Gobierno de Costa Rica y Conservación Internacional. LJMCR01. Available online at: http://delphinids.com/Publications_files/Mamiferos%20marinosLJMCR01.pdf Accessed 9/25/2007.

May-Collado, L. J., T. Gerrodette, J. Calambokidis, K. Rasmussen, and I. Sereg. 2005. Patterns of cetacean sighting distribution in the Pacific Exclusive Economic Zone of Costa Rica based on data collected from 1979-2001. Rev. Biol. Trop. (International Journal of Tropical Biology) 53(1-2):249-263.

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.

Mazaris, A. D., A. S. Kallimanis, J. Tzanopoulos, S. P. Sgardelis, and J. D. Pantis. 2009a. Sea surface temperature variations in core foraging grounds drive nesting trends and phenology of loggerhead turtles in the Mediterranean Sea. Journal of Experimental Marine Biology and Ecology.

Mazaris, A. D., G. Matsinos, and J. D. Pantis. 2009b. Evaluating the impacts of coastal squeeze on sea turtle nesting. Ocean & Coastal Management 52(2):139-145.

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.

McClellan, C. M., J. Braun-McNeill, L. Avens, B. P. Wallace, and A. J. Read. 2010. Stable isotopes confirm a foraging dichotomy in juvenile loggerhead sea turtles. Journal of Experimental Marine Biology and Ecology 387:44-51.

McDonald Dutton, D., and P. H. Dutton. 1998. Accelerated growth in San Diego Bay green turtles? Pages 175-176 *in* S. P. Epperly, and J. Braun, editors. Seventeenth Annual Sea Turtle Symposium.

McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic

calls of blue whales off California with gender data. Journal of the Acoustic Society of America 109:1728-1735.

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

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., 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., C. J. A. Bradshaw, and G. C. Hays. 2007. Satellite tracking reveals unusual diving characteristics for a marine reptile, the olive ridley turtle *Lepidochelys olivacea*. Marine Ecology Progress Series 329:239-252.

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.

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.

Meylan, A. B., B. W. Bowen, and J. C. Avise. 1990. A genetic test of the natal homing versus social facilitation models for green turtle migration. Science 248:724-727.

Miao, X., G. H. Balazsb, S. K. K. Murakawa, and Q. X. Li. 2001. Congener-specific profile, and

toxicity assessment of PCBs in green turtles (Chelonia mydas)from the Hawaiian Islands. The Science of the Total Environment 281:247-253.

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

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 Monitoring/Approaches and Technologies. Battelle Press, Columbus, Ohio.

Miller, J. D., K. A. Dobbs, C. J. Limpus, N. Mattocks, and A. M. Landry. 1998. Long-distance migrations by the hawksbill turtle, Eretmochelys imbricata, from north-eastern Australian. Wildlife Research 25:89-95.

Miller, P. J. O., and coauthors. 2009a. 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 I 56(7):1168-1181.

Miller, P. J. O., and coauthors. 2009b. 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.

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

Mitchell, E., and 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. Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Hawaii.

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.

Monagas, P., J. Oros, J. Anana, and O. M. Gonzalez-Diaz. 2008. Organochlorine pesticide levels in loggerhead turtles (Caretta caretta) stranded in the Canary Islands, Spain. Marine Pollution Bulletin 56:1949-1952.

Monzon-Arguello, C., and coauthors. 2009. Variation in spatial distribution of juvenile loggerhead turtles in the eastern Atlantic and western Mediterranean Sea. Journal of Experimental Marine Biology and Ecology 373(2):79-86.

Monzon-Arguello, C., C. Rico, A. Marco, P. Lopez, and L. F. Lopez-Jurado. 2010. Genetic characterization of eastern Atlantic hawksbill turtles at a foraging group indicates major undiscovered nesting populations in the region. Journal of Experimental Marine Biology and Ecology in press(in press):in press.

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.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkahehto. 2002. Cetacean distribution and relative abundance on the central eastern and southeastern Bering Sea shelf with reference to oceanographic domains. Progressive Oceanography 55(1-2):249-62.

Moreira, L., and K. A. Bjorndal. 2006. Estimates of green turtle (*Chelonia mydas*) nests on Trindade Island, Brazil, South Atlantic. Pages 174 *in* N. Pilcher, editor Twenty-third Annual Symposium on Sea Turtle Biology and Conservation.

Mori, K., F. Sato, and A. Mochizuki. 1998. Recent observation records onf the northern right whale in the waters of Ogasaw Ara (Bonin Islands), Japan. Pages 93-94 *in* The World Marine Mammal Science Conference, Monaco.

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.

Mortimer, J. A. 1982. Factors influencing beach selection by nesting sea turtles. Pages 45-51 *in*

K. Bjorndal, editor. The biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

Mortimer, J. A., and coauthors. 2003. Growth rates of immature hawksbills (*Eretmochelys imbricata*) at Aldabra Atoll, Seychelles (Western Indian Ocean). Pages 247-248 *in* J. A. Seminoff, editor Twenty-second Annual Symposium on Sea Turtle Biology and Conservation.

Mortimer, J. A., and M. Donnelly. in review. 2007 IUCN red list status assessment: hawksbill turtle (*Eretmochelys imbricata*).

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.

Muller-Karger, F. E., and C. Fuentes-Yaco. 2000. Characteristics of wind-generated rings in the eastern tropical Pacific Ocean. Journal of Geophysical Research – Oceans 105:1271-1284.

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.

Murakawa, S. K. K., G. H. Balazs, D. M. Ellis, S. Hau, and S. M. Eames. 2000. Trends in fibropapillomatosis among green turtles stranded in the Hawaiian Islands, 1982-98. K. H. J., and T. Wibbels, editors. Nineteenth Annual Symposium on Sea Turtle Biology and Conservation.

Murphy, T. M., and S. R. Hopkins. 1984. Aerial and ground surveys of marine turtle nesting beaches in the southeast region. Final Report to NOAA/NMFS/SEFC, U.S. Department of Commerce, 73p.

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.

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.

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

Nichols, W. J. 2005. Following redwood logs, rubber ducks, and drift bottles: Transoceanic developmental migrations of loggerhead turtles in the North Pacific Ocean. Pages 66 *in* M. S. Coyne, and R. D. Clark, editors. Proceedings of the Twenty-First Annual Symposium on Sea Turtle Biology and Conservation.

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.

Nishimura, W. 1994. Internesting interval and nest frequency for loggerhead turtles on Inakahama Beach, Yakushima Island, Japan. Marine Turtle Newsletter 67:21-22.

Nishiwaki, M. 1966a. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. Pages 171-191 *in* K. S. Norris, editor. Whales, dolphins, and porpoises. University of California Press, Berkeley, California.

Nishiwaki, M. 1966b. Distribution and migration of the larger cetaceans in the North Pacific shown by Japanese whaling results. Pages 171-191 *in* K. S. Norris, editor. Whales, dolphins, and porpoises. University of California Press, Berkeley, CA.

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

NMFS. 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. 2004a. Biological Opinion on the Proposed Marine Seismic Survey in the Southeast Caribbean Sea and adjacent Atlantic Ocean, and the Proposed Issuance of an MMPA authorization to Lamont-Doherty Earth Observatory [F/FPR/2003/01492]. National

Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 69p.

NMFS. 2004b. Endangered Species Act section 7 consultation on the proposed regulatory amendments to the FMP for the pelagic fisheries of the western Pacific region. Biological Opinion, February 23, 2004.

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

NMFS. 2005b. Biological Opinion on the Issuance of Scientific Research Permits (batched) in the North Pacific Ocean for Research on Large Whales and Pinnipeds (Permit Nos. 545-1761, 587-1767, 1071-1770, 731-1774, 393-1772, 945-1776, 1000-1617, 774-1719-02, 774-1714). NMFS Office of Protected Resources, Silver Spring, Maryland. 61p.

NMFS. 2006a. 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. 2006b. Biological Opinion on Sinking Exercises (SINKEX) in the Western North Atlantic Ocean. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 119p.

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

NMFS. 2006d. 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. 2006e. 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. 2006f. 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. 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. 2006f. National Marine Fisheries Service, Office of Protected Resources website: http://www.nmfs.noaa.gov/pr/.

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 populations of the olive ridley turtle (*Lepidochelys olivacea*). National Marine Fisheries Service, Silver Spring, Maryland.

NMFS, and USFWS. 2007a. Olive ridley sea turtle (*Lepidochelys olivacea*) 5-year review: Summary and evaluation. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources

U.S. Department of the Interior, U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Silver Spring, Maryland

Jacksonville, Florida.

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

NMFS and USFWS. 1998c. Recovery plan for U.S. Pacific populations of the green turtle (Chelonia mydas). National Marine Fisheries Service, Silver Spring, Maryland.

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

NMFS and USFWS. 1998e. Recovery plan for U.S. Pacific populations of the loggerhead turtle (Caretta caretta). NMFS and USFWS, Silver Spring, Maryland

Portland, Oregon.

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

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

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

NMFS and USFWS. 2007c. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: Summary and evaluation U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources

U.S. Department of the Interior, U.S. Fish and Wildlife Service, Southeast Region, Jacksonville

Ecological Services Field Office, Silver Spring, Maryland

Jacksonville, Florida.

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 and USFWS. 2007e. Loggerhead Sea Turtle (*Caretta caretta*) 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. 67p.

NMFS and USFWS. 2007f. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 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. 67p.

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.

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

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.

Northrop, J. W., C. Cummings, and M. F. Morrison. 1971. Underwater 20-Hz signals recorded near Midway Island. Journal of the Acoustical Society of America 49:1909-1910.

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

NRC. 1990. Decline of the Sea Turtles: Causes and Prevention.National Academy of Sciences, National Academy Press, Washington, D.C.

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.

Ocean Resource Foundation. 1998. Construction on Playa La Flor National Wildlife Refuge-Nicaragua. Available at: http://www.orf.org/currents001b.htm. Accessed 9/25/2007.

Offshore. 2009. Brazil's presalt tops Latin American E&P plays: Peru.

Offshore. 2010. Global E&P.

Ohsumi, S., and Y. Masaki. 1975. Japanese whale marking in the North Pacific, 1963-1972. Bulletin of the Far Seas Fisheries Research Laboratory 12:171-219.

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.

Okemwa, G. M., and A. Wamukota. 2006. An overview of the status of green turtles (Chelonia mydas) in Kenya. Pages 311 *in* M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Okuyama, J., and coauthors. 2009. Ontogeny of the dispersal migration of green turtle (Chelonia mydas) hatchlings. Journal of Experimental Marine Biology and Ecology.

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.

Palacios, D. M. 1999. Blue whale (*Balaenoptera musculus*) occurrence off the Galápagos Islands (1978-1995). Journal of Cetacean Research and Management 1(1):41-51.

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.

Palacios, D. M., K. M. Stafford, and F. B. Schwing. 2005. Temporal variations in blue whale acoustic detections in relation to environmental conditions in the northeastern tropical Pacific, 1996-2002. 16th Biennial Conference in the Biology of Marine Mammals, San Diego, California.

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

Pandav, B., and B. C. Choudhury. 1999. An update on the mortality of the olive ridley sea turtles

in Orissa, India. Marine Turtle Newsletter 83:10-12.

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

Papastavrou, V., S. C. Smith, and H. Whitehead. 1989b. 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).

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.

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

Parker, D. M., P. H. Dutton, K. Kopitsky, and R. L. Pitman. 2003. Movement and dive behavior determined by satellite telemetry for male and female olive ridley turtles in the Eastern Tropical Pacific. Pages 48-49 *in* J. A. Seminoff, editor Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. . NOAA.

Parks, S. E., M. Johnson, D. Nowacek, and P. L. Tyack. 2010a. Individual right whales call louder in increased environmental noise. Biology Letters.

Parks, S. E., M. Johnson, and P. Tyack. 2010b. Changes in vocal behavior of individual North Atlantic right whales in increased noise. Journal of the Acoustical Society of America 127(3 Pt 2):1726.

Payne, J. F., J. Coady, and D. White. 2009. Potential effects of seismic airgun discharges on monkfish eggs (Lophius americanus) and larvae., St. John's, Newfoundland.

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. 1990. 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., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Annals of the New York Academy of Sciences 188:110-141.

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.

Peckham, S. H., and coauthors. 2008. High mortality of loggerhead turtles due to bycatch, human consumption and strandings at Baja California Sur, Mexico, 2003 to 2007.

Endangered Species Research 5:171-183.

Pelletier, D., D. Roos, and S. Ciccione. 2003. Oceanic survival and movements of wild and captive-reared immature green turtles (Chelonia mydas) in the Indian Ocean. Aquatic Living Resources 16:35-41.

Pennington, J. T., and coauthors. 2006. Primary production in the eastern tropical Pacific: A review. Progress in Oceanography 69:285–317.

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.

Perrin, W. F., J. M. Coe, and J. R. Zweifel. 1976. Growth and reproduction of the spotted porpoise, Stenella attenuata, in the offshore eastern tropical Pacific. Fishery Bulletin 74:229-269.

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.

Perugini, M., and coauthors. 2006. Polychlorinated biphenyls and organochlorine pesticide levels in tissues of Caretta caretta from the Adriatic Sea. Diseases of Aquatic Organisms 71(2):155-161.

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.

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. A. 2009. Do Green Turtles Modify Their Nesting Seasons in Response to Environmental Temperatures? Chelonian Conservation and Biology 8(1):43-47.

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.

Pike, G. C., and I. B. MacAskie. 1969. Marine mammals of British Columbia. Bulletin of the Fisheries Research Board of Canada 171:1-54.

Pilcher, N. J. 2000. The green turtle, Chelonia mydas, in the Saudi Arabian Gulf. Chelonian Conservation and Biology 3(4):730-734.

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. 1990. Pelagic distribution and biology of sea turtles in the eastern tropical Pacific. Pp.143-148 *In:* T.H. Richardson, J.I. Richardson, and M. Donnelly (compilers), Proceedings of the 10th Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-278.

Pitman, R. L. 1991. Sea turtle associations with flotsam in the eastern tropical Pacific Ocean. Pages 94 *in* M. Salmon, and J. Wyneken, editors. Proceedings of the Eleventh Annual

Workshop on Sea Turtle Biology and Conservation. .

Pitman, R. L. 1993. Seabird associations with marine turtles in the eastern Pacific Ocean. Colonial Waterbirds 16(2):194-201.

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., R. Byles, and D. Owens. 1993. Migratory and reproductive behaviour of Lepidochelys in the eastern Pacific Ocean. B. A. Schroeder, and B. E. Witherington, editors. 13th Annual Sea Turtle Symposium on Sea Turtle Biology and Conservation. NOAA.

Plotkin, P. T. 1994. Migratory and reproductive behavior of the olive ridley turtle, Lepidochelys olivacea (Eschscholtz, 1829), in the eastern Pacific Ocean. Texas A&M University, College Station, Texas.

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.

Plotkin, P. T., R. A. Byles, and D. W. Owens. 1994a. Migratory and reproductive behavior of *Lepidochelys olivacea* in the eastern Pacific Ocean. Pages 138 *in* Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation, Jekyll Island, Georgia.

Plotkin, P. T., R. A. Byles, and D. W. Owens. 1994b. Post-breeding movements of male olive ridley sea turtles *Lepidochelys olivacea* from a nearshore breeding area. Department of Commerce.

Plotkin, P. T., R. A. Byles, D. C. Rostal, and D. W. Owens. 1991. Arribadas: Social events or simply aggregations? Preliminary results from satellite telemetry. Pages 95 *in* Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. .

Plotkin, P. T., R. A. Byles, D. C. Rostal, and D. W. Owens. 1995. Independent versus socially facilitated oceanic migrations of the olive ridley, Lepidochelys olivacea. Marine Biology 122:137-143.

Plotkin, P. T., D. W. Owens, R. A. Byles, and R. Patterson. 1996. Departure of male olive ridley turtles (Lepidochelys olivacea) from a nearshore breeding ground. Herpetologica 52(1):1-7.

Plotkin, P. T., D. C. Rostal, R. A. Byles, and D. W. Owens. 1997. Reproductive and developmental synchrony in female Lepidochelys olivacea. Journal of Herpetology 31(1):17-22.

Podreka, S., A. Georges, B. Maher, and C. J. Limpus. 1998. The environmental contaminant DDE fails to influence the outcome of sexual differentiation in the marine turtle Chelonia

mydas. Environmental Health Perspectives 106(4):185-188.

Polacheck, T. 1987. Relative abundance, distribution and inter-specific relationship of cetacean schools in the eastern tropical Pacific. Marine Mammal Science 3(1):54-77.

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., and coauthors. 2006. The Kuroshio Extension Bifurcation Region: a pelagic hotspot for juvenile loggerhead sea turtles. Deep-Sea Research II 53:362-339.

Polovina, J. J., and coauthors. 2004. Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific Ocean. Fisheries Oceanography 13(1):36-51.

Polovina, J. J., E. Howell, D. M. Parker, and G. H. Balazs. 2003. Dive-depth distribution of loggerhead (*Carretta carretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin 101(1):189-193.

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.

Prieto, A., and coauthors. 2001. Biological and ecological aspects of the hawksbill turtle population in Cuban waters. Report from the Republic of Cuba. First CITES wider Caribbean hawksbill turtle dialogue meeting, Mexico City.

Pritchard, P. C. H. 1969. Studies of the systematics and reproductive cycles of the genus Lepidochelys. University of Florida.

Pritchard, P. C. H. 1971. The leatherback or leathery turtle, Dermochelys coriacea. IUCN Monograph 1:1-39.

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. 1997. Evolution, phylogeny, and current status. Pages 1-28 *in* P. L. Lutz, and J. A. Musick, editors. The biology of sea turtles. CRC Press, Boca Raton, Florida.

Pugh, R. S., and P. R. Becker. 2001. Sea turtle contaminants: A review with annotated bibliography. U.S. Department of Commerce, National Institute of Standards and Technology, Chemical Science and Technology Laboratory, Charleston, South Carolina.

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.

Rankin-Baransky, K. 1997. Origin of loggerhead turtles (*Caretta caretta*) in the western North Atlantic Ocean as determined by mtDNA analysis.Masters Thesis submitted to Drexel University, June 1997. 49p.

Rasmussen, K., J. Calambokidis, and G. H. Steiger. 2004. Humpback whales and other marine mammals off Costa Rica and surrounding waters, 1996-2003. Report of the Oceanic Society 2003 field season in cooperation with elderhostel volunteers. Cascadia Research, Olympia, Washignton.

Rasmussen, K., and coauthors. 2007a. Southern Hemisphere humpback whales wintering off Central America: Insights from water temperature into the longest mammalian migration. Biology Letters 3(3):302-305.

Rasmussen, K., and coauthors. 2007b. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. Biology Letters 3:302-305.

Rees, A. F., and D. Margaritoulis. 2004. Beach temperatures, incubation durations, and estimated hatchling sex ratio for loggerhead sea turtle nests in southern Kyparissia Bay, Greece. British Chelonia Group Testudo 6(1):23-36.

Rees, A. F., A. Saad, and M. Jony. 2005. Marine turtle nesting survey, Syria 2004: discovery of a "major" green turtle nesting area. Page 38 in Book of Abstracts of the Second Mediterranean Conference on Marine Turtles. Antalya, Turkey, 4-7 May 2005.

Reeves, R. R., P. J. Clapham, R. L. B. Jr., and G. K. Silber. 1998. Recovery plan for the blue whale (Balaenoptera musculus). Office of Protected Resources, Silver Spring, MD.

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. 1999. Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP). SPREP, Apia, Samoa.

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

Reeves, R. R., T. D. Smith, E. A. Josephson, P. J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: Clues to migratory routes and possibly additional feeding grounds. Marine Mammal Science 20(4):774-786.

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.

Reich, K. J., and coauthors. 2010. Polymodal foraging in adult female loggerheads (Caretta caretta). Marine Biology 157:113-121.

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.

Reid, K. A., D. Margaritoulis, and J. R. Speakman. 2009. Incubation temperature and energy expenditure during development in loggerhead sea turtle embryos. Journal of Experimental Marine Biology and Ecology 378:62-68.

Reilly, S. B., and P. C. Fiedler. 1994. Interannual variability of dolphin habitats in the eastern tropical Pacific. I: Research vessel surveys, 1986-1990. Fishery Bulletin 92:434-450.

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

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.

Reiner, F., J. M. Gonçalves, and R. S. Santos. 1993. Two new records of Ziphiidae (Cetacea) for the Azores with an updated checklist of cetacean species. Arquipélago (Life and Marine Sciences) 11A:113-118.

Renaud, M. L., and J. A. Carpenter. 1994. Movements and submergence patterns of loggerhead turtles (Caretta caretta) in the Gulf of Mexico determined through satellite telemetry. Bulletin of Marine Science 55:1-15.

Resendiz, A., B. Resendiz, W. J. Nichols, J. A. Seminoff, and N. Kamezaki. 1998. First confirmed eastwest transpacific movement of a loggerhead sea turtle, Caretta caretta, released in Baja California, Mexico. Pacific Science 52(2):151-153.

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. 1978. 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. 1989a. 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. 1989b. 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. 1998. Marine Mammals of the World. Systematics and Distribution.Special Publication Number 4. The Society for Marine Mammalogy, Lawrence, Kansas.

Rice, M. R., and G. H. Balazs. 2010. Hawaiian green turtles dive to record depths during oceanic migrations. Pages 61 *in* K. Dean, and M. C. L. Castro, editors. 28th Annual Symposium on Sea Turtle Biology and Conservation.

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

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

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

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.

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.

Rivers, J. A. 1997. Blue whale, Balaenoptera musculus, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.

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.

Roark, A. M., K. A. Bjorndal, and A. B. Bolten. 2009. Compensatory responses to food restriction in juvenile green turtles (Chelonia mydas). Ecology 90(9):2524-2534.

Robinson, R. A., and coauthors. 2008. Travelling through a warming world: climate change and migratory species. Endangered Species Research.

Rodrigue, J.-P., C. Comtois, and B. Slack. 2009. The Strategic space of international transportation, 2nd edition edition.

Rodríguez-Fonseca, J. 2001. Diversidad y distribución de los cetáceos de Costa Rica. Revista de Biología Tropical 49(Suppl. 2):135-143.

Rodríguez-Fonseca, J., and P. Cubero-Pardo. 2001. Cetacean strandings in Costa Rica (1966-1999). Revista de Biología Tropical 49(2):667-672.

Rodríguez-Herrera, B., F. A. Chinchilla, and L. J. May-Collado. 2002. Lista de especies, endemismo y conservación de los de mamiferos de Costa Rica. Rev. Mex. Mastozoologia 6:19-41.

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.

Ross, J. P. 1979. Sea turtles in the Sultanate of Oman.

Ross, J. P. 1998. Estimations of the nesting population size of loggerhead sea turtles, Caretta caretta, Masirah Island, Sultanate of Oman. Pages 84-87 *in* S. P. Epperly, and J. Braun, editors. Proceedings of the Seventeenth Annual Sea Turtle Symposium. .

Ross, J. P., and M. A. Barwani. 1982. Review of sea turtles in the Arabian area. Pages 373-383 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

Ruiz, G. A. 1994. Sea turtle nesting population at Playa La Flor, Nicaragua: An olive ridley "arribada" beach. Pages 129-130 *in* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar, editors. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. .

Ruud, J. T. 1956. The blue whale. Scientific American 195:46-50.

Rybitski, M. J., R. C. Hale, and J. A. Musick. 1995. Distribution of organochlorine pollutants in Atlantic sea turtles. Copeia 1995 (2):379-390.

Saad, M. A. 1999. Title Hadramaut coast importance in conservation of endangered green turtle. Marine Sciences Resources Research Center, Aden. Unpublished report. 8.

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.

Saeki, K., H. Sakakibara, H. Sakai, T. Kunito, and S. Tanabe. 2000. Arsenic accumulation in three species of sea turtles. Biometals 13(3):241-250.

Sahoo, G., R. K. Sahoo, and P. Mohanty-Hejmadi. 1996. Distribution of heavy metals in the eggs and hatchlings of olive ridley sea turtle, Lepidochelys olivacea, from Gahirmatha, Orissa. Indian Journal of Marine Sciences 25(4):371-372.

Sakamoto, W., K. Sato, H. Tanaka, and Y. Naito. 1993. Diving patterns and swimming environment of two loggerhead turtles during internesting. Nippon Suisan Gakkaishi 59:1129-1137.

Sakamoto, W., I. Uchida, and K. Kureba. 1990. Deep diving behavior of the loggerhead turtle near the frontal zone. Nippon Suisan Gakkaishi 56:1435-1443.

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.

Salm, R. V. 1991. Turtles in Oman: Status, threats, and management options.

Salm, R. V., R. A. C. Jensen, and V. A. Papastavrou. 1993. Marine fauna of Oman: Cetaceans, turtles, seabirds, and shallow water corals. IUCN, Gland, Switzerland.

Samaran, F., C. Guinet, O. Adam, J.-F. o. Motsch, and Y. Cansi. 2010. Source level estimation of two blue whale subspecies in southwestern Indian Ocean. The Journal of the Acoustical Society of America 127(6):3800.

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.

Sato, K., and coauthors. 1998. Internesting intervals for loggerhead turtles, Caretta caretta, and green turtles, Chelonia mydas, are affected by temperature. Canadian Journal of Zoology 76:1651-1662.

Schmidt, J. 1916. Marking experiments with turtles in the Danish West Indies. Meddelelser Fra Kommissionen For Havundersogelser. Serie: Fiskeri. Bind V. Nr. 1. Kobenhavn.

Schmitt, T. L., D. J. St. Aubin, A. M. Schaefer, and J. L. Dunn. 2010. Baseline, diurnal variations, and stress-induced changes of stress hormones in three captive beluga, Delphinapterus leucas. Marine Mammal Science 26(3):637-647.

Schoenherr, J. R. 1991. Blue whales feeding on high concentrations of euphausiids in around Monterey Submarine Canyon. Canadian Journal of Zoology 69: 583-594.

Schofield, G., and coauthors. 2009. Microhabitat selection by sea turtles in a dynamic thermal marine environment. Journal of Animal Ecology 78(1):14-21.

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.

Schulz, J. P. 1984. Turtle conservation strategy in Indonesia. IUCN/WWF Report.

Schulz, J. P. 1987. Status of and trade in Chelonia mydas and Eretmochelys imbricata in Indonesia. Consultancy report prepared for IUCN Conservation Monitoring Centre.

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.

Sea Turtle Association of Japan. 2010. Sea turtles of Japan.

Sea Turtle Restoration Project. 2008. The Critical Nesting Beaches of Central America. Available at: http://www.seaturtles.org/progBackground.cfm?campaignBackgroundID=28. Accessed: 01/10/2008.

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

Sears, C. J., and coauthors. 1995. Demographic composition of the feeding population of juvenile loggerhead sea turtles (Caretta caretta) off Charleston, South Carolina: evidence from mitochondrial DNA markers. Marine Biology 123:869-874.

Sears, R., and coauthors. 1987. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Report of the International Whaling Commission (Special Issue 12):335-342.

Sears, R., and coauthors. 1990. Photographic identification of the blue whale (Balaenoptera musculus) in the Gulf of St. Lawrence, Canada. Reports of the International Whaling Commission Special Issue 12:335-342.

Seaturtle.org. 2010. Satellite tracking iniciativa carey del Pacifico oriental -ICAPO - eastern Pacific hawksbill initiative.

Segura, A., and R. M. Arauz. 1995. By-catch capture of sea turtles by two kinds of experimental longline gears in Pacific Costa Rica waters. Pp.125-127 *In:* J.I. Richardson and T.H. Richardson (compilers), Proceedings of the 12th Annual Symposium on Sea Turtle Biology and Conservation. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-361.

Seminoff, J. A. 2004. 2004 global status assessment: Green turtle (Chelonia mydas). IUCN Marine Turtle Specialist Group Review.

Seminoff, J. A., and T. T. Jones. 2006. Diel movements and activity ranges of green turtles (*Chelonia mydas*) at a temperate foraging area in the Gulf of California, Mexico. Herpetological Conservation and Biology 1(2):81-86.

Seminoff, J. A., T. T. Jones, A. Resendiz, W. J. Nichols, and M. Y. Chaloupka. 2003a. Monitoring green turtles (Chelonia mydas) at a coastal foraging area in Baja California, Mexico: Multiple indices to describe population status. Journal of the Marine Biological Association of the United Kingdom 83:1355-1362.

Seminoff, J. A., W. J. Nichols, A. Resendiz, and L. Brooks. 2003b. Occurrence of hawksbill turtles, Eretmochelys imbricata (Reptilia: Cheloniidae), near the Baja California Peninsula, Mexico. Pacific Science 57(1):9-16.

Seminoff, J. A., A. Resendiz, and W. J. Nichols. 2002a. Diet of East Pacific green turtles (Chelonia mydas) in the central Gulf of California, Mexico. Journal of Herpetology 36(3):447-453.

Seminoff, J. A., A. Resendiz, W. J. Nichols, and T. T. Jones. 2002b. Growth rates of wild green turtles (Chelonia mydas) at a temperate foraging area in the Gulf of California, México. Copeia 2002(3):610-617.

Senko, J., M. C. Lopez-Castro, V. Koch, and W. J. Nichols. 2010. Immature East Pacific green turtles (Chelonia mydas) use multiple foraging areas off the Pacific Coast of Baja California Sur, Mexico: First evidence from mark-recapture data. Pacific Science 64(1):125-130.

Shallenberger, E. W. 1981. The status of Hawaiian cetaceans. Final report to U.S. Marine Mammal Commission. MMC-77/23.

Shanker, K., and B. Mohanty. 1999. Operation Kachhapa: In search of a solution for the olive ridley of Orissa. Marine Turtle Newsletter 86:1-3.

Shanker, K., B. Pandav, and B. C. Choudhury. 2003. An assessment of the olive ridley turtle (Lepidochelys olivacea) nesting population in Orissa, India. Biological Conservation 115(1):149-160.

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.

Shirihai, H. 2002. A complete guide to Antarctic wildlife. Alula Press, Degerby, Finland.

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.

Sigler, M. F., C. R. Lunsford, J. M. Straley, and J. B. Liddle. 2008. Sperm whale depredation of sablefish longline gear in the northeast Pacific Ocean. Marine Mammal Science 24(1):16-27.

Sigurjónsson, J. 1995. On the life history and autoecology of North Atlantic rorquals. Whales, Seals, Fish, and Man:Blix, A.S., L. Walloe, and O. Ulltang (Eds.), Proceedings of the International Symposium on the Biology of Marine Mammals in the North East Atlantic. Tromso, Norway, 29 November - 1 December 1994. Elsevier. pp.425-441.

Sigurjónsson, J., and T. Gunnlaugsson. 1990. Recent trends in abundance of blue (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*) off West and Southwest Iceland, with a note on occurrence of other cetacean species. Report of the International Whaling Commission 40:537-551.

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.

Sirovic, A., J. A. Hildebrand, S. M. Wiggins, and D. Thiele. 2009. Blue and fin whale acoustic presence around Antarctica during 2003 and 2004. Marine Mammal Science 25(1):125-136.

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.

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

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, S. C., and H. Whitehead. 2000. The diet of Galápagos sperm whales *Physeter macrocephalus* as indicated by fecal sample analysis. Marine Mammal Science 16(2):315-325.

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 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.

Smultea, M., and M. Holst. 2003a. 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., and M. Holst. 2003b. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic study in the Hess Deep area of the Eastern Equatorial Tropical Pacific, July 2003. LGL, Ltd., King City, Ontario.

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.

Solow, A. R., K. A. Bjorndal, and A. B. Bolten. 2002. Annual variation in nesting numbers of marine turtles: The effect of sea surface temperature on re-migration intervals. Ecology Letters 5:742-746.

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.

SPREP. 2007. Pacific Islands regional marine species programme 2008–2012. Pacific ISlands Regional Marine Species Programme, Apia, Samoa.

Spring, C. S. 1982. Status of marine turtle populations in Papua New Guinea. Pages 281-289 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D. C.

Stafford, K. M. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. Marine Mammal Science 19(4):682-693.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 1999a. Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. Journal of the Acoustical Society of America 106:3687.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 1999b. Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. Journal of the Acoustical Society of America 106:3687.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 2001. Geographic and seasonal variation of Blue

whale calls in the North Pacific. Journal of Cetacean Research and Management 3(1):65-76.

STAJ. 2002. Population trends and mortality of Japanese loggerhead turtles, Caretta caretta in Japan. Western Pacific Sea Turtle Cooperative Research and Management Workshop, Honolulu, Hawaii.

Stamper, M. A., C. W. Spicer, D. L. Neiffer, K. S. Mathews, and G. J. Fleming. 2009. MORBIDITY IN A JUVENILE GREEN SEA TURTLE (CHELONIA MYDAS) DUE TO OCEAN-BORNE PLASTIC. Journal of Zoo and Wildlife Medicine 40(1):196-198.

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.

Starbird, C. H., Z. Hillis-Starr, J. T. Harvey, and S. A. Eckert. 1999. Internesting movements and behavior of hawksbill turtles (Eretmochelys imbricata) around Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Chelonian Conservation and Biology 3(2):237-243.

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.

Sternberg, J. 1981. The worldwide distribution of sea turtle nesting beaches. Sea Turtle Rescue Fund, Center for Environmental Education, Washignton, D. C.

Stevick, P., and coauthors. 2006. Estimated abundance of humpback whales off the west coast of Central and South America (group G). IWC Workshop on Comprehensive Assessment of Southern Hemisphere Humpback Whales, Hobart, Tasmania

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.

Stewart, B. S., S. A. Karl, P. K. Yochem, S. Leatherwood, and J. L. Laake. 1987. Aerial surveys for cetaceans in the former Akutan, Alaska, whaling grounds. Arctic 40(1):33-42.

Stimpert, A. K., W. W. L. Au, D. N. Wiley, and J. Straley. 2009. Humpback whale (Megaptera novaeangliae) click production and potential for echo-ranging. Pages 56 *in* 5th Animal

Sonar Symposium, Kyoto, Japan.

Stinson, M. L. 1984a. Biology of sea turtles in San Diego Bay, California, and in northeastern Pacific Ocean. San Diego State University, San Diego, California.

Stinson, M. L. 1984b. Biology of sea turtles in San Diego Bay, California, and in northeastern Pacific Ocean. Master's thesis. San Diego State University, San Diego, California.

Stokes, L. W., and S. P. Epperly. 2006. Lepidochelys olivacea (olive ridley sea turtle). Western North Atlantic Ocean. Herpetological Review 37(1):105.

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.

Storelli, M., M. G. Barone, and G. O. Marcotrigiano. 2007. Polychlorinated biphenyls and other chlorinated organic contaminants in the tissues of Mediterranean loggerhead turtle Caretta caretta. Science of the Total Environment 273(2-3):456-463.

Storelli, M., M. G. Barone, A. Storelli, and G. O. Marcotrigiano. 2008. Total and subcellular distribution of trace elements (Cd, Cu and Zn) in the liver and kidney of green turtles (Chelonia mydas) from the Mediterranean Sea. Chemosphere 70(5):908-913.

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.

Subsea World. 2008. SCAN Geophysical get contract for 2D seismic survey offshore Ecuador.

Sunderraj, S. F., W. J. Joshua, and V. V. Kumar. 2006. Sea turtles and their nesting habitats in Gujarat. Pages 156-169 in Shanker, K. and B.C. Choudhury (editors). Marine Turtles of the Indian Subcontinent. Universities Press, India.

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.

Swimmer, Y., and coauthors. 2005. Food color and marine turtle feeding behavior: Can blue bait reduce turtle bycatch in commercial fisheries? Marine Ecology Progress Series 295:273-278.

Talavera-Saenz, A., S. C. Gardner, R. R. Rodriquez, and B. A. Vargas. 2007. Metal profiles used as environmental markers of green turtle (Chelonia mydas) foraging resources. Science of the Total Environment 373(1):94-102.

Tanaka, E. 2009. Estimation of temporal changes in the growth of green turtles Chelonia mydas in waters around the Ogasawara Islands. Fisheries Science 75(3):629-639.

Taquet, C., and coauthors. 2006. Foraging of the green sea turtle Chelonia mydas on seagrass beds at Mayotte Island (Indian Ocean), determined by acoustic transmitters. Marine Ecology Progress Series 306:295-302.

Tarpy, C. 1979. Killer Whale Attack! National Geographic 155(4):542-545.

TEWG. 1998a. An assessment of the Kemp's ridley (Lepidochelys kempii) and loggerhead (Caretta caretta) sea turtle populations in the Western North Atlantic. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation.

TEWG. 1998b. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the western North Atlantic. A report of the Turtle Expert Working Group (TEWG); NOAA Technical Memorandum NMFS-SEFSC-409. 96p.

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.

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

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

Thomsen, B. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen, Aberdeen, Scotland.

Thorbjarnarson, J. B., S. G. Platt, and S. T. Khaing. 2000. Sea turtles in Myanmar: Past, and present. Marine Turtle Newsletter 88:10-11.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (Dermochelys coriacea) from Labrador. Canadian Field Naturalist 92(3):287.

Tiwari, M., K. A. Bjorndal, A. B. Bolten, and B. M. Bolker. 2005. Intraspecific application of the mid-domain effect model: Spatial, and temporal nest distributions of green turtles, Chelonia mydas, at Tortuguero, Costa Rica. Ecology Letters 8:918-924.

Tiwari, M., K. A. Bjorndal, A. B. Bolten, and B. M. Bolker. 2006. Evaluation of density-dependent processes, and green turtle Chelonia mydas hatchling production at Tortuguero, Costa Rica. Marine Ecology Progress Series 326:283-293.

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.

Tolstoy, M., J. Diebold, S. Webb, D. Bohnenstiehl, and E. Chapp. 2004. Acoustic calibration measurements. LGL Ltd., Ontario, Canada.

Tomas, J., J. Castroviejo, and J. A. Raga. 1999. Sea turtles in the south of Bioko Island (Equatorial Guinea). Marine Turtle Newsletter 84:4-6.

Tomás, J., P. Gozalbes, J. A. Raga, and B. J. Godley. 2008. Bycatch of loggerhead sea turtles:

insights from 14 years of stranding data. Endangered Species Research 5:161-169.

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).

Tourinho, P. S., J. A. I. d. Sul, and G. Fillmann. 2009. Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil? Marine Pollution Bulletin in press(in press):in press.

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

Trinidad, H., and J. Wilson. 2000. The bio-economics of sea turtle conservation and use in Mexico: History of exploitation and conservation policies for the olive ridley (Lepidochelys olivacea). Proceedings of the International Institute of Fisheries Economics, and Trade Conference. , Corvallis, Oregon.

Troëng, S., and M. Chaloupka. 2007. Variation in adult annual survival probability and remigration intervals of sea turtles. Marine Biology 151:1721-1730.

Troëng, S., and E. Rankin. 2005. Long term conservation efforts contribute to positive green turtle Chelonia mydas nesting trend at Tortuguero, Costa Rica. Biological Conservation 121:111–116.

Tuato'o-Bartley, N., T. E. Morrell, and P. Craig. 1993. Status of sea turtles in American Samoa in 1991. Pacific Science 47(3):215-221.

Tucker, A. D. 2009. Nest site fidelity and clutch frequency of loggerhead turtles are better elucidated by satellite telemetry than by nocturnal tagging efforts: Implications for stock estimation. Journal of Experimental Marine Biology and Ecology in press(in press):in press.

Turkozan, O., and C. Yilmaz. 2008. Loggerhead turtles, Caretta caretta, at Dalyan Beach, Turkey: Nesting activity (2004–2005) and 19-year abundance trend (1987–2005). Chelonian Conservation and Biology 7(2):178-187.

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

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. 2009. Human-generated sound and marine mammals. Physics Today 62(11):39-44.

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

Uchida, I., and M. Nishiwaki. 1995. Sea turtles in the waters adjacent to Japan. Pages 317-319 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles, volume Revised Edition. Smithsonian Institution Press, Washington, D.C.

USCG. 2010. History of the Amver System. United States Coast Guard.

USFWS, N. a. 1995. Status reviews for sea turtles listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.

USFWS, N. a. 1998. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, Maryland.

Van Dam, R. P., and C. E. Diez. 1997. Diving behavior of immature hawksbill turtles (Eretmochelys imbricata) in a Caribbean reef habitat. Coral Reefs 16(133-138).

van de Merwe, J. P. V., and coauthors. 2009. Chemical Contamination of Green Turtle (Chelonia mydas) Eggs in Peninsular Malaysia: Implications for Conservation and Public Health. Environmental Health Perspectives 117(9):1397-1401.

Vander Zanden, H. B., K. A. Bjorndal, K. J. Reich, and A. B. Bolten. 2010. Individual specialists in a generalist population: results from a long-term stable isotope series. Biology Letters in press(in press):in press.

Vanderlaan, A. S., and C. T. Taggart. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine Mammal Science 23(1):144-156.

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.

Velez-Zuazo, X., and coauthors. 2008. Dispersal, recruitment and migratory behavior in a hawksbill sea turtle aggregation. Molecular Ecology 17:839-853.

Vera, V. 2007. Nesting of green turtles in Aves Island Wildlife Refuge. 2006 season. Pages 275 *in* M. Frick, 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.

Volkov, A. F., and I. F. Moroz. 1977. Oceanological conditions of the distribution of cetacea in the eastern tropical part of the Pacific Ocean. Report of the International Whaling

Commission 27:186-188.

Wade, L. S., and G. L. Friedrichsen. 1979. Recent sightings of the blue whale, *Balenoptera musculus*, in the northeastern tropical Pacific. Fishery Bulletin 76(4):915-920.

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

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

Wallace, B. P., L. Avens, J. Braun-McNeill, and C. M. McClellan. 2009. The diet composition of immature loggerheads: Insights on trophic niche, growth rates, and fisheries interactions. Journal of Experimental Marine Biology and Ecology 373(1):50-57.

Wallace, B. P., and coauthors. 2010. Global patterns of marine turtle bycatch. Convervation Letters in press(in press):in press.

Wang, C., and P. C. Fiedler. 2006. ENSO variability in the eastern tropical Pacific: a review. Progress in Oceanography 69(2-4):239-266.

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. 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., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2009. U.S. Department of Commerce, NOAA, NMFS.

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. 2001. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2001. NOAA Technical Memorandum NMFS-NE-168:Woods Hole, Massachusetts. 318p.

Waters, S., and H. Whitehead. 1990. Population and growth parameters of Galapagos sperm whales estimated from length distributions. (Physeter catodon). Report of the International Whaling Commission 40:225-235.

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., and coauthors. 2000. Whale call data for the North Pacific November 1995 through July 1999: Occurrence of calling whales and source locations from SOSUS and other acoustic systems.Technical Report WHOI_00_02 available from Woods Hole Oceanographic Institution. 160pp.

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.

Waycott, M. B., J. Longstaff, and J. Mellors. 2005. Seagrass population dynamics and water quality in the Great Barrier Reef region: A review and future research directions. Marine Pollution Bulletin 51:343-350.

Weijerman, M. L., H. G. v. Tienen, A. D. Schouten, and W. E. J. Hoekert. 1998. Sea turtles of Galibi, Suriname. Pages 142-144 *in* R. Byles, and Y. Fernandez, editors. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. .

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

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

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 macro-cephalus), 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.

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

Whitehead, H. 1989. Formations of foraging sperm whales, *Physeter macrocephalus*, off the Galápagos Islands. Canadian Journal of Zoology 67(9):2131-2139.

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. 2002a. 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. 2003a. Sperm whales: social evolution in the ocean. University of Chicago Press, Chicago, Illinois. 431p.

Whitehead, H. 2003b. Sperm whales: Social evolution in the ocean. University of Chicago Press, Chicago, Illinois.

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.

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

Wibbels, T. 2003. Critical approaches to sex determination in sea turtle biology and conservation. Pages 103-134 *in* P. Lutz, J. Musik, and J. Wynekan, editors. Biology of sea turtles, volume 2. CRC Press.

Wilkinson, C. 2000. Status of coral reefs of the world: 2000. Global Coral Reef Monitoring Network, Australian Institute of Marine Science.

Willett, C. S. 1996. A study of anticyclonic eddies in the eastern tropical Pacific Ocean with integrated satellite, in situ, and modelled data. University of Colorado, Boulder.

Willett, C. S., R. Leben, and M. F. Lavın. 2006. Eddies and mesoscale processes in the eastern tropical Pacific: a review. Progress in Oceanography 69(2-4):218-238.

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., S. Hirama, and A. Mosier. 2003. Effects of beach armoring structures on marine turtle nesting. Florida Fish and Wildlife Conservation Commission.

Witherington, B., S. Hirama, and A. Mosier. 2007. Change to armoring and other barriers to sea turtle nesting following severe hurricanes striking Florida beaches. Florida Fish and Wildlife Conservation Commission.

Witherington, B., P. Kubilis, B. Brost, and A. Meylan. 2009. Decreasing annual nest counts in a globally important loggerhead sea turtle population. Ecological Applications 19(1):30-54.

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.

Witherington, B. E., R. Herren, and M. Bresette. 2006. *Caretta caretta* – Loggerhead Sea Turtle. Chelonian Research Monographs 3:74-89.

Witherington, B. E., R. Herren, and M. Bresette. 2006b. *Caretta caretta* – Loggerhead Sea Turtle. Chelonian Research Monographs 3:74-89.

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. 1981. Predation on Juvenile Green Sea Turtles, Chelonia mydas , By a Grouper, Promicrops lanceolatus (Pisces: Serranidae) in the Kingdom of Tonga, South Pacific. Bulletin of Marine Science. Vol. 31:no. 4.

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.

Work, T. M., and coauthors. 2009. In vitro biology of fibropapilloma-associated turtle herpesvirus and host cells in Hawaiian green turtles (Chelonia mydas). Journal of General Virology 90:1943-1950.

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.

Wyrtki, K. 1964. Upwelling in the Costa Rica Dome. Fishery Bulletin 63(2):355-372.

Wyrtki, K. 1967. Circulation and water masses in the eastern equatorial Pacific Ocean. International Journal of Oceanology and Limnology 1(2):117-147.

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.

Yasunaga, G., and Y. Fujise. 2009. Accumulation features of total and methyl mercury and selenium in tissues of common minke, Bryde's and sperm whales from the western North Pacific International Whalign Commission.

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.

Yochem, P. K., and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). In: Ridgway SH, Harrison R, editors. Handbook of Marine Mammals, vol. 3: The

Sirenians and Baleen Whales.:London: Academic Press. p 193-240.

Zárate, P. M., S. S. Cahoon, M. C. D. Contato, P. H. Dutton, and J. A. Seminoff. 2006. Nesting beach monitoring of green turtles in the Galapagos Islands: a 4-year evaluation. Pages 337 *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.

Zárate, P. M., M. A. Parra, M. Robles, P. H. Dutton, and J. A. Seminoff. 2010a. 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.

Zárate, P. M., M. A. Parra, M. Robles, and J. A. Seminoff. 2010b. Nesting site fidelity of green turtle in the Galapagos Islands. Pages 64 *in* K. Dean, and M. C. L. Castro, editors. 28th Annual Symposiumon Sea Turtle Biology and Conservation. National Marine Fisheries Service.

Zemsky, V. A., and E. G. Sazhinov. 1982. Distribution and current abundance of pygmy blue whales. V. A. Arsen'ev, editor. Marine Mammals. All-Union Research Institute of Marine Fisheries and Oceanography, Moscow.

Zerbini, A. N., P. J. Clapham, and P. R. Wade. 2010. Assessing plausible rates of population growth in humpback whales from life-history data. Marine Biology 157(6):1225-1236.

Zug, G. R., G. H. Balazs, J. A. Wetherall, D. M. Parker, and S. K. K. Murakawa. 2002. Age and growth of Hawaiian green sea turtles (Chelonia mydas): An analysis based on skeletochronology. Fishery Bulletin 100:117-127.

Zug, G. R., and R. E. Glor. 1998. Estimates of age and growth in a population of green sea turtles (Chelonia mydas) from the Indian River Lagoon system, Florida: A skeletochronological analysis. Canadian Journal of Zoology 76:1497-1506.