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

Biological Opinion

Agencies: The National Science Foundation

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

Activities Considered: Juan de Fuca Plate Evolution and Hydration Marine Geophysical Study in the Northeast Pacific Ocean

Issuance of an Incidental Harassment Authorization Pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) for the "Taking" of Marine Mammals Incidental to the Conduct of a Marine Geophysical Study in the Northeast Pacific Ocean

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

Approved by: ______________________

Date: JUN 13 2012

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1531 et seq.) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat that has been designated for such species, that agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected.

This ESA section 7 consultation considers two separate but related actions. The National Science Foundation (NSF) proposes to fund a marine geophysical survey which will be conducted by the Lamont-Doherty Earth Observatory (L-DEO). As the conduct of the survey would result in takes of marine mammals incidental to the survey, L-DEO must also apply for an Incidental Harassment Authorization (IHA) under the Marine Mammal Protection Act (MMPA), 16 U.S.C. §1371 (a)(5)(D); therefore, NMFS' Office of Protected Resources Permits and Conservation Division (Permits Division) is proposing to issue an IHA for the survey. Subsequently, the action agencies for consultation are NSF, L-DEO and the Permits Division.

The consulting agency is the Office of Protected Resources, Endangered Species Act Interagency Cooperation Division (Interagency Cooperation Division).

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

Consultation History

On January 19, 2012, NSF requested initiation of formal consultation with the Interagency Cooperation Division on the proposed conduct of three marine seismic surveys. The request was accompanied by a draft environmental assessment (EA) regarding the potential impacts of the proposed surveys on the environment. On January 27, 2012, NSF submitted a revised draft EA to the Interagency Cooperation Division. The Interagency Cooperation Division initiated consultation with NSF on the proposed survey on January 27, 2012.

On May 22, 2012, the Permits Division requested initiation of formal consultation with the Interagency Cooperation Division regarding the proposed issuance of IHAs for harassment of marine mammals incidental to the three proposed surveys. On May 25, 2012, the Permits Division submitted a draft IHA to the Interagency Cooperation Division. The Permits Division's IHA for each of the separate surveys was grouped into a single document. The Interagency Cooperation Division initiated consultation with the Permits Division on the proposed issuance of the IHA on May 25, 2012. On May 29, 2012, the Permits Division submitted a revised draft IHA to the Interagency Cooperation Division.

On June 8, 2012, NMFS issued a biological opinion to NSF and the Permits Division. Upon receiving new information regarding southern resident killer whales that revealed effects of the action to an extent not previously considered, the consultation was immediately reinitiated. Subsequently, on June 12, 2012, NSF revised their proposed action and postponed the Cascadia Thrust Zone survey and the Cascadia Subduction Zone survey pending revisions to the survey design to minimize southern resident killer whale exposure to potential stressors from certain portions of the two surveys.

BIOLOGICAL OPINION

Description of the Proposed Action

NSF is funding a marine geophysical survey off the Canadian west coast and the states of Washington and Oregon between June 13, 2012 and July 4, 2012. The survey will be conducted by Principal Investigators Drs. S. Carbotte and H. Carton (L-DEO) and Dr. P Canales (Woods Hole Oceanographic Institution). The purpose of the survey is to provide data to characterize the evolution and state of hydration of the Juan de Fuca plate crust and shallow mantle, from formation at the Juan de Fuca ridge, through alteration and hydration within the plate interior, to subduction at the Cascadia trench.

L-DEO will operate the *Langseth* as well as direct the operation of all acoustic sources for the surveys. As the survey is expected to incidentally harass marine mammals L-DEO has requested an IHA and, therefore, the Permits Division proposes to issue an IHA pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act, 16 U.S.C. 1371 (a)(5)(D) to L-DEO. Although NSF proposed to fund the survey from June 13 to July 4, 2012 the Permits Division proposes that the IHA would be valid from June 13 through July 25, 2012, to account for delays from equipment failure and inclement weather. The proposed IHA would authorize the incidental harassment of blue, fin, sei, humpback and sperm whales and Steller sea lions as well as other non-ESA listed whales and pinnipeds. Sea turtles may also be harassed during the conduct of seismic activities.

Overview of the Survey
Acoustic sources (a 36 airgun array, a multibeam echosounder (MBES) and a subbottom profiler (SBP)) will be deployed from the *R/V Marcus G. Langseth*. The MBES and SBP would operate continuously and simultaneously with the airguns. The *R/V Langseth* would tow a hydrophone streamer to receive the returning acoustic signals. A support vessel, the *Oceanus*, will deploy and retrieve ocean bottom seismometers (OBSs). The *Oceanus* would also operate a MBES and a SBP while underway. In addition to the OBSs land seismometers will also be deployed to receive returning acoustic signals.

The *R/V Langseth* is expected to depart from Astoria, Oregon, on June 13, 2012, to conduct the Juan de Fuca Plate Evolution survey and return there on July 4, 2012. The *Oceanus* will depart and return to port at Newport, Oregon after OBS deployment/retrievals are completed.

The seismic survey will take place in waters in the U.S. and Canadian Exclusive Economic Zones and off the coasts of Washington and Oregon in water ~50–3000 m deep (see Fig. 1). Three long transect lines and three semi-circular arcs will be shot using OBSs as the receivers, and most of those long lines will be shot again in multichannel seismic (MCS) mode using a streamer as the receiver. Additional offshore lines will be shot in MCS mode using the streamer, if time permits. The total survey effort will consist of ~2878 km of transect lines in depths >1000 m, 102 km in depths 100–1000 m, and 71 km in water depths <100 m. The northern and southern onshore-offshore lines are 70–310 and 15–450 km from shore, respectively. Approximately 18 days of seismic activity is expected to occur out of the 22 days total duration of this survey.

Source Vessel
The *Langseth* has a length of 71.5 m, a beam of 17.0 m, and a maximum draft of 5.9 m. The *Langseth* was designed with a propulsion system designed to be as quiet as possible to avoid interference with the seismic signals. The ship is powered by two Bergen BRG-6 diesel engines, each producing 3550 hp, which drive the two propellers directly. Each propeller has four blades, and the shaft typically rotates at 750 revolutions per minute (rpm). Although the vessel is equipped with an 800 hp bowthruster, it will not be used during seismic acquisition. Typical cruising speed for the Langseth is 18.5 km/hour but during seismic acquisition operation speed will be approximately 7.4-9.3 km/hour (about 4-5 nm/hr). Since the towed hydrophone streamer

is 8 km long the turning rate and maneuverability of the vessel will be limited while towing the gear.

Support Vessel

The *Oceanus* has a length of 54 m, a beam of 10 m, and a maximum draft of 5.3 m. The ship is powered by a single 3000-hp EMD diesel engine driving a single, controllable-pitch screw through a clutch and reduction gear, and an electric, 350-hp trainable bow thruster. The *Oceanus* cruises at 20.4 km/h (11 knots) and has a maximum speed of 26 km/h (14 knots).

Acoustic Equipment

Airguns

The *Langseth* will tow a 36-airgun array about 100 m (328 ft) behind the *Langseth*. This array is comprised of a mixture of Bolt 1500LL and 1900LL (2,000 psi) airguns, each ranging in size from 40–360 in^3 as appropriate. Airguns would be arranged in a configuration of four identical linear strings with a total discharge volume of 6,600 in^3. Energy for the airgun array would be compressed air supplied by compressors on board the *Langseth*. Each string contains 10 airguns, with 9 of them to be fired simultaneously and 1 reserved as a spare. The first and last airguns in each string would be spaced 16 m (52 ft) apart, with the four strings distributed across an area of approximately 24 m x 16 m (79 ft x 52 ft).

Airguns would fire a brief (lasting about 0.1 second) pulse[1] and remain silent during intervening periods. For the Juan de Fuca survey, the tow depth of the array will be 9 m during MCS surveys and 12 m during OBS surveys. Airgun shots will be fired about every 37.5 m (~16 s) for the MCS survey and 500 m (~200 s) for the OBS surveys.

The airgun array is predominantly low-frequency[2] with a dominant frequency component of 0–188 Hz. Airguns have been shown to produce frequencies up to 150 kHz albeit with substantially lower energy output. Source output (downward) from the airgun array would be 259 dB re 1 µPa • m (0-pk) and 265 dB re 1 µPa • m (pk-pk). Not all of the energy from airguns propagates downward as energy also propagates horizontally though at a lower energy output.

Airgun Signal Receiving Systems

The receiving system will consist of a hydrophone streamer deployed from the *Langseth* and/or OBSs deployed by the *Oceanus*. As the airguns are towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the on-board processing system for immediate analysis.

WHOI “D2” OBSs (approximately 1 m in height and 50 cm in diameter) are deployed during the survey and are held in place with anchors. Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9–11 kHz, and a response is received at a frequency of 9–13 kHz, releasing the instrument from the anchor to float to the surface.

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[1] Pulse duration is defined as the time at which 5 percent to 95 percent of the pulse energy has arrived.

[2] Frequencies are categorized as low-frequency (< 1,000 Hz), mid-frequency (1-10 kHz), and high-frequency (> 10 kHz).

OBSs will be deployed along the northern line and the along-shoreline. Once those lines have been shot, the OBSs will be retrieved and a number of them will be deployed along the southern line then retrieved once the line is shot.

Multi-beam Bathymetric Echosounders (MBESs)

The *Langseth's* MBES would be operated continuously and simultaneously with the airgun array to map the ocean floor. The hull-mounted Kongsberg EM 122 would operate at 10.5-13 kHz (usually 12 kHz), and have a maximum source level of 242 dB re 1 μPa (rms).

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

Sub-Bottom Profilers (SBPs)

Both the *Langseth* and the *Oceanus* operate SBPs. The *Langseth's* Knudsen 3260 SBP operates simultaneously with the airgun array and the MBES while the *Oceanus* would only operate its SBP. The SBP has a maximum source level of 222 dB re 1 μPa• m and transmits a 27 degree conical beam with pulse duration up to 64 ms. SBP pulse intervals are 1 s, with a common mode of operation being five pulses at 1-s intervals followed by a 5-s pause.

The *Oceanus* may operate one or two SBPs (a Knudsen 3260 SBP similar to the *Langseth's* and/or a Knudsen 320B/R SBP). The Knudsen 320B/R SBP emits a ping at 3.5 and/or 12 kHz with maximum power output of the 320B/R is 10 kilowatts for the 3.5-kHz section and 2 kilowatts for the 12-kHz section. Pulse length for the 3.5-kHz section of the 320B/R is 0.8–24 ms, and will usually be 6, 12, or 24 ms at study site water depths and in transit from Astoria. Pulse interval is 0.8–1.5 sec. The source level for the 320B/R is calculated to be 211 dB re 1 μPa·m; however, the system is rarely operated above 80% power level.

Monitoring and Reporting

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

Four PSVOs will be based aboard the *Langseth*, however, only two observers will be routinely scheduled for watch on the *Langseth's* observation tower during daylight hours. During meal times only one observer may be on watch. Observers typically are on watch for no more than four hours. The crew of the *Langseth* would also be instructed to assist in detecting marine mammals and turtles as well as implementing mitigation measures as possible.

During daytime, the PSVOs would systematically scan the area around the vessel with reticle binoculars (e.g., 7×50 Fujinon), Big-eye binoculars (25×150), thermal imaging cameras and the naked eye. Laser rangefinding binoculars (Leica LRF 1200 laser rangefinder or equivalent) would be available to train observers in visual distance estimation, however, the reticle binoculars are primarily used to estimate distances to animals directly. When stationed on the observation platform on the *Langseth*, eye level is about 21.5 m (70.5 ft) above sea level and PSVOs would be able to see in around the entire vessel and to a distance of about 10 km with the naked eye, 5 km or further with the big eyes, and 2-3 km or further with the reticle binoculars in optimal conditions.

Passive Acoustic Monitoring

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

The PAM system that would be used consists of a low-noise, towed hydrophone array connected to the vessel by a 'hairy' faired cable. The array would be deployed from a winch on the back deck of the *Langseth*. The tow cable is 250 m (about 820 ft) long, and the hydrophones are fitted in the last 10 m (about 33 ft) of cable. The PAM hydrophone array is typically towed at depths of less than 20 m (66 ft) and can detect marine mammal vocalizations at frequencies up to 250 kHz.

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

LDEO will submit a report to NMFS within 90 days after the end of the cruise. The report will describe the operations conducted as well as provide full documentation of methods, results, and interpretations of monitoring efforts during the cruise. The 90-day report will summarize the dates and locations of seismic operations, and all marine mammal and turtle sightings (dates, times, locations, activities, associated seismic survey activities). Information acquired through PAM including whether the vocal detection was linked with a visual sighting, date, time when first and last heard, position and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information will be included in the report. The report will also include estimates of the amount and nature of any potential "take" by harassment or other forms of take of marine mammals and sea turtles during the surveys.

Mitigation During Operations
L-DEO has adopted mitigation measures to minimize or avoid exposing protected species to harmful sound levels. These measures include airgun power-down, shut-down and ramp-up procedures.

Proposed Exclusion Zones for Power Down and Shut Down Procedures
L-DEO modeled the propagation of sound from the airgun array and from a single 1900LL 40-in^3 airgun, which will be used during power downs during the proposed survey. Table 1 provides the estimated distances for propagation radii at 160, 180, and 190 dB re 1μPa (rms) in deep [greater than 1,000 m (3,281 ft)], intermediate [100 to 1,000 m (328 ft to 3,281 ft)] and shallow water [less than 100 m (328 ft)] as the survey will occur in depths ranging from about 50 to more than 3,000 m deep (164 ft to 9843 ft). The 180 dB re 1μPa (rms) distance represents the exclusion zone criterion and the thresholds for power-down or shut down for cetaceans and sea turtles during the proposed surveys (see *Mitigation and Monitoring* section below). Estimated propagation distances to the 180 dB isopleth range from 40 m (0.02 nm) to 2,140 m (1.2 nm) depending on airgun volume and tow depth (see Table 1 below). The 190 dB re 1μPa (rms) distance represents the exclusion zone criterion and the thresholds for power-down or shut down for pinnipeds during the proposed survey. Estimated propagation distances to the 190 dB isopleth range from 12 m (0.006 nm) to 680 m (0.37 nm) depending on seismic source and volume.

Empirical propagation measurements for the *Langseth's* airguns were taken during a calibration study in 2007-2008 in the Gulf of Mexico (Tolstoy et al 2009). For the study the 36-airgun array was towed at 6 m (19.6 ft) in deep water (~1,600 m; 5,249 ft) as well as shallow water (~50 m; 131 ft). L-DEO modeled received level radii and compared the model results with the *Langseth's* calibration results in shallow and deep water. As results for measurements in intermediate-depth water are still under analysis, values halfway between the deep and shallow-water measurement results were used. However, the depth of the array was different in the Gulf of Mexico calibration study (6 m) than in the proposed surveys (9, 12, and 15 m); thus, correction factors have been applied to the distances reported by Tolstoy et al. (2009). The correction factors used were the ratios of the 160-, 180-, and 190-dB distances from the modeled results for the 36 airgun array towed at 6 m during the calibration study vs. the 9, 12, and 15 m tow depths used for the proposed surveys, from LGL (2009): 1.285, 1.338, and 1.364, respectively for 9 m; 1.467, 1.577, and 1.545, respectively for 12 m; and 1.647, 1.718, and 1.727, respectively for 15 m.

Table 1: Distances to which sound levels ≥ 190, 180, 170, and 160 dB re 1 μPa(rms) could be received from the single airgun and the airgun array for the survey.

Source and Volume	Tow Depth (m)	Water Depth*	Estimated RMS Radii (m) 190 dB	180 dB	160 dB
Single Bolt airgun (40 in^3)	6-15	Deep	12	40	385
		Intermediate	18	60	578
		Shallow	150	296	1,050
4 strings 36 airguns (6600 in^3)	9	Deep	400	940	3,850
		Intermediate	550	1,540	12,200
		Shallow	680	2,140	20,550

Power Down and Shut Down Procedures

If a cetacean or sea turtle is detected outside the 180 dB (rms) EZ or the 190 dB (rms) EZ for pinnipeds, but is likely to enter it, L-DEO would power-down the airgun array before the animal is within the EZ. If a marine mammal or turtle is already within the EZ when first detected, the airguns would be powered-down immediately. A power-down may also occur when the vessel is moving from one track line to another (i.e., during a turn). Power-down procedures involve reducing the number of operating airguns, typically to a single airgun (e.g., 40 in^3), to minimize the EZ so that marine mammals or turtles are no longer in or about to enter the 180 dB or 190 dB radii. The continued operation of at least one airgun during a power-down is intended to alert marine mammals and turtles to the presence of the seismic vessel in that area. Airgun shut down procedures (i.e., all operating airguns are turned off) are implemented if, during operation of the single airgun (as in during power down), a marine mammal or turtle is detected near or within the applicable EZ for the single airgun.

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

- is visually observed to have left the EZ, *or*
- has not been seen within the zone for 30 minutes (in the case of mysticetes and large odontocetes, including sperm whales) or 15 minutes (in the case of pinnipeds), *or*
- the vessel has moved outside the EZ for sea turtles (8 min of travel: the time it would take the *Langseth* to move outside the 180-dB EZ and leave the turtle behind).

Ramp-up Procedures

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

If after eight minutes with no airgun operations, L-DEO will implement ramp-up procedures for the array. Ramp up from a state of no airgun operations would begin with the smallest airgun in the array (40 in^3). Airguns would be added in a sequence such that the increase in source level would not exceed 6 dB/5min over a total duration of about 35 minutes. If, however, a single airgun has operated continuously, L-DEO proposes to resume firing at full power, eliminating the ramp up procedures on the assumption that marine mammals and turtles would be alerted to the approaching seismic vessel by sounds from the single airgun and could move away. During ramp-up, the PSVOs would monitor the EZ for the full airgun array, and if marine mammals or turtles are sighted within or near the applicable EZ during the day or near the vessel at night then power-down or shut-down would be implemented.

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

Marine Mammal Protection Act Incidental Harassment Authorization

The Permits Division has also proposed to issue an IHA to L-DEO for the harassment (Level B behavioral disruptions only) of marine mammals incidental to the proposed survey. This IHA is valid from June 13, 2012 through July 25, 2012. The proposed IHA includes the requirements L-DEO must comply with as part of its authorization. Following are the sections of the IHA that are relevant to ESA-listed species:

Mitigation and Monitoring Requirements

1. L-DEO shall:

   (a) Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (PSVOs) (except during meal times and restroom breaks, when at least one PSVO shall be on watch) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew shall also assist in detecting marine mammals, when practicable. PSVOs shall have access to reticle binoculars (7 x 50 Fujinon), big-eye binoculars (25 x 150), laser range-finding binoculars, and thermal imaging cameras. PSVO shifts shall last no longer than 4 hours at a time. PSVOs shall also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

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

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

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

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

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

(d) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One NMFS-qualified Protected Species Observer (PSO) and/or expert bioacoustician [i.e., Protected Species Acoustic Observer (PSAO)] shall monitor the PAM at all times in shifts no longer than 6 hours. An expert bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

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

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

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

(f) Visually observe the entire extent of the exclusion zone (EZ) [180 dB re 1 μPa (rms) for cetaceans and 190 dB re 1 μPa (rms) for pinnipeds] using NMFS-qualified PSVOs, for at least 30 minutes prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the EZ, L-DEO must delay the seismic survey until the marine mammal(s) has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the PSVO shall wait 30 minutes. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the EZ.

If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), L-DEO may start the second airgun without observing the entire EZ for 30 minutes prior, provided no marine mammals are known to be near the EZ (in accordance with Condition 1[h] below).

(g) Establish a 180 dB re 1 μPa (rms) and 190 dB re 1 μPa (rms) EZ for marine mammals before the 4-string airgun array (6,600 in^3) is in operation; and a 180 dB re 1 μPa (rms) and 190 dB re 1 μPa (rms) EZ before a single airgun (40 in^3) is in operation, respectively.

(h) Ramp-up procedures at the start of seismic operations or after a shut-down - Implement a “ramp-up” procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shut-down 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 shall increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the PSVOs shall monitor the 180 dB EZ for cetaceans or the 190 dB EZ for pinnipeds, and if marine mammals are sighted within or about to enter the relevant EZ, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from a shut-down or at the beginning of seismic operations requires that the PSVOs be able to view the full EZ as described in Condition 1(f).

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

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

(k) Following a power-down, if the marine mammal approaches the smaller designated EZ, the airguns must then be completely shut-down. Airgun activity shall not resume until the PSVO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales). Following a shut-down, the *Langseth* may resume airgun operations following ramp-up procedures described in Condition 1(h).

(l) Procedures after an extended power-down – Monitor the full 180 dB EZ for cetaceans and the full 190 dB EZ for pinnipeds. The *Langseth* may resume full power operations anytime after the entire array has been powered-down for more than 8 minutes. Resuming operations at full power after an extended power-down of more than 8 minutes requires that the PSVOs be able to view the full EZ as described in Condition 1(f). If the PSVO sees a marine mammal within or about to enter the relevant EZs, then the *Langseth* will implement a course/speed alteration or power-down.

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

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

(o) If a North Pacific right whale (*Eubalaena japonica*) is visually sighted, the airgun array shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting.

(p) If killer whales (*Orcinus orca*) are visually sighted or detected acoustically, the airguns array shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting or acoustic detection.

(q) To the maximum extent practicable, communicate with NMFS Northwest Regional Office and/or Orca Network for near real-time reporting of the whereabouts of killer whales.

(r) To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours and OBS operations (i.e., deploy/retrieve) to nighttime hours.

(s) To the maximum extent practicable, plan to conduct seismic surveys (especially when near land) from the coast (inshore) and proceed towards the sea (offshore) in order to avoid trapping marine mammals in shallow water.

Reporting Requirements

2 L-DEO shall:

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

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

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

(iii) An estimate of the number (by species) of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) for cetaceans and 190 dB re 1 μPa (rms) for pinnipeds with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on reported and corrected empirical values for the 36 airgun array and modeling measurements for the single airgun) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) for cetaceans and 190 dB re 1 μPa (rms) for pinnipeds with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

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

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

(c) In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), L-DEO shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov and the Northwest Regional Stranding Coordinator at 206-526-6550 (Brent.Norberg@noaa.gov). The report must include the following information:

(i) Time, date, and location (latitude/longitude) of the incident; the name and type of vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24 hours preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

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

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), L-DEO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov). The report must include the same information identified in Condition 7(c)(i) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate.

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), L-DEO shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov) within 24 hours of the discovery. L-DEO shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

3. L-DEO is required to comply with the Terms and Conditions of the ITS corresponding to NMFS's Biological Opinion issued to both NSF and NMFS's Office of Protected Resources.

Approach to the Assessment

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

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

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

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

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

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to an Action's effects on the environment (which we identify in our *response analyses*) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

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

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

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

Risk Analysis for Designated Critical Habitat

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

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

If the primary constituent elements of designated critical habitat (or physical, chemical or biotic phenomena that give the designated area value for the conservation of listed species) are likely to respond given exposure to the direct or indirect consequences of the proposed action on the natural environment, we ask if those responses are likely to be sufficient to reduce the quantity, quality or availability of those constituent elements or physical, chemical or biotic phenomena.

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

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

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

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

Evidence Available for the Consultation

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

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

Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area for this consultation will encompass the transit area to and from port in Astoria, Oregon, and the survey area in waters off Washington and Oregon (see Fig. 1) and into the U.S. and Canadian Exclusive Economic Zones (bounded by approximately 43° to 48° N by approximately 124° to 130° West) to the extent that the acoustic signals produced by the proposed survey decrease to background noise levels in the eastern Pacific Ocean:

The survey site occurs in waters approximately 1,000 to 3,000 m deep. L-DEO will survey up to about 3,050 km of track line and ensonify up to about 23,089 km^2 of ocean to 160 dB re 1 μPa (rms) during this survey.

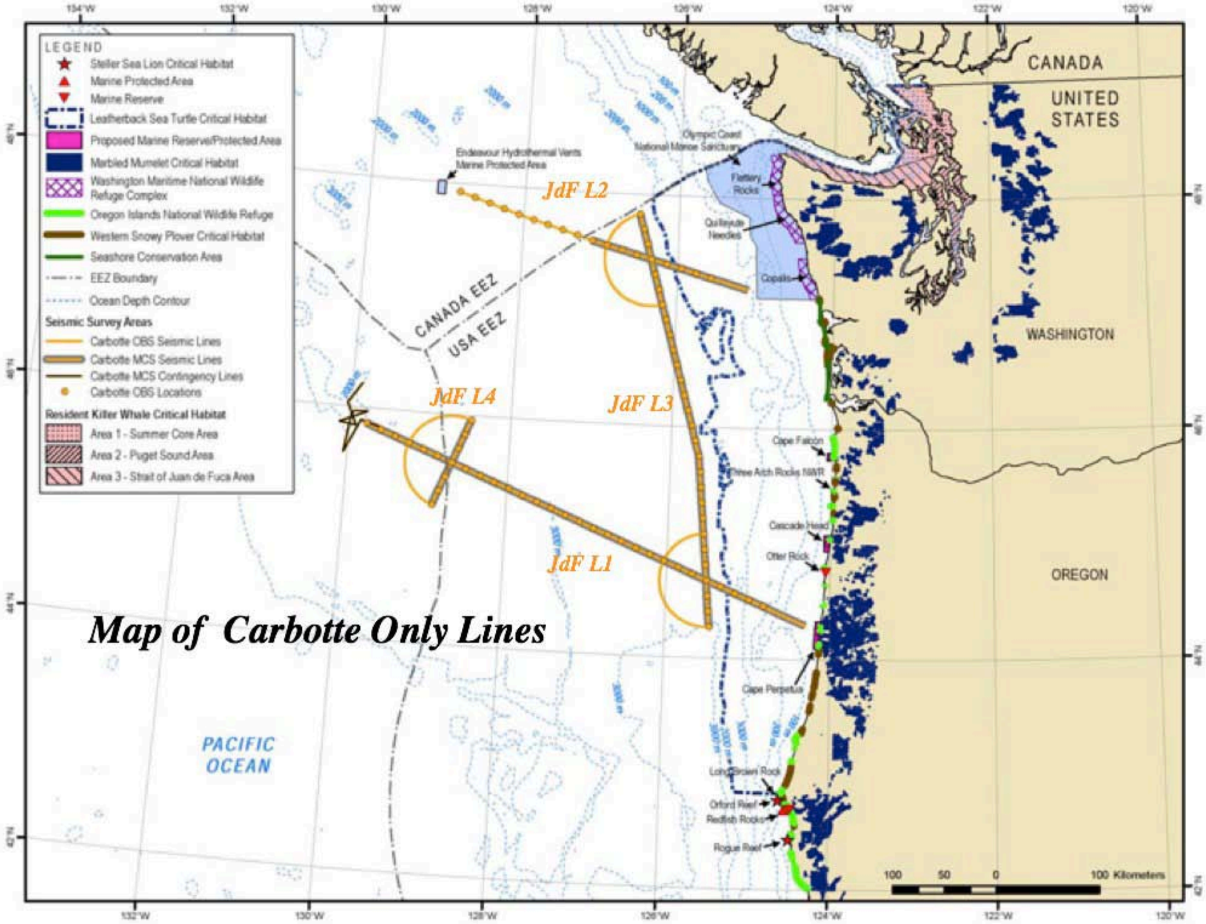

Figure 1: Survey area for the eastern Pacific Ocean survey showing seismic tracklines.

Status of Listed Resources

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

Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
North Pacific Right Whale	*Eubalaena japonica*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Southern Resident Killer Whale	*Orcinus orca*	Endangered
Steller Sea Lion (Eastern Distinct Population Segment)	*Eumetopias jubatus*	Threatened
Green sea turtle	*Chelonia mydas*	Endangered/ Threatened[3]
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Olive ridley	*Olivacea kempii*	Endangered /Threatened[4]
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead (North Pacific Distinct Population Segment)	*Caretta caretta*	Endangered
Green sturgeon (Southern Distinct Population Segment)	*Acipenser medirostris*	Threatened
Pacific Eulachon/smelt (Southern Distinct Population Segment)	*Thaleichthys pacificus*	Threatened
Chinook Salmon	*Oncorhynchus tshawytscha*	
Puget Sound		Threatened
Lower Columbia River		Threatened
Upper Columbia River Spring-run		Endangered
Snake River spring/summer run		Threatened
Upper Willamette River		Threatened
Coho Salmon	Oncorhynchus kisutch	
Lower Columbia River		Threatened
Oregon coast		Threatened
Southern Oregon/Northern California coast		Threatened
Sockeye	*Oncorhynchus nerka*	
Ozette Lake		Threatened
Snake River		Endangered
Steelhead	*Oncorhynchus mykiss*	
Lower Columbia River		Threatened

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[3] Green turtles are listed as threatened under the ESA, except for breeding colonies found in Florida and the Pacific coast of Mexico, which are listed as endangered.

[4] Olive ridley sea turtles are listed as threatened, except for the Mexico Pacific coast breeding colonies, which are listed as endangered.

Middle Columbia River	Threatened
Upper Columbia River	Threatened
Snake River	Threatened
Upper Willamette River	Threatened

Designated Critical Habitat

Leatherback Sea Turtle Critical Habitat

Critical habitat was designated on January 26, 2012, and includes two separate marine areas located in California and in Washington/Oregon out to the 2,000 m isobath.

Southern Green Sturgeon Critical Habitat

Critical habitat was designated on October 9, 2009, and includes U.S. coastal marine waters as well as certain estuarine and freshwater areas from Monterey Bay, California north to the U.S./Canada boundary.

Species and Critical Habitat Not Considered Further in this Opinion

As described in the Approach to the Assessment, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the various proposed activities. The first criterion was exposure or some reasonable expectation of a co-occurrence between one or more potential stressors associated with the proposed survey activities and a particular listed species or designated critical habitat: if we conclude that a listed species or designated critical habitat is not likely to be exposed to the activities, we must also conclude that the listed species or critical habitat is not likely to be adversely affected by those activities. The second criterion is the probability of a response given exposure, which considers susceptibility: species that may be exposed to sound propagating from airguns or sonars, for example, but are likely to be unaffected by those sound sources (at sound pressure levels they are likely to be exposed to) are also not likely to be adversely affected by those sources. We applied these criteria to the listed species and critical habitat that may occur within the Action Area for these proposed activities and a summary of our results follows.

North Pacific Right Whale

Historically, the endangered North Pacific right whale occurred in waters off the coast of British Columbia and the States of Washington, Oregon, and California (Clapham et al. 2004; Scarff 1986). However, the extremely low population numbers of this species in the North Pacific Ocean over the past five decades and the rarity of reports from these waters suggests that the probability of these whales being exposed to the activities associated with the proposed surveys is sufficiently small as to be discountable. As a result, this species will not be considered further in this Opinion.

Green, Hawksbill, Olive Ridley and Loggerhead Sea Turtles

Green, hawksbill, Olive ridley and loggerhead sea turtles occur along the coasts of British Columbia and the States of Washington and Oregon (Bowlby et al. 1994), but those occurrences are usually associated with mild or strong El Nino currents that push warmer water masses northward. When those water masses dissipate, as has happened at least twice over the past two years, green, hawksbill, Olive ridley, and loggerhead sea turtles become hypothermic in the colder, ambient temperatures. Because the Action Area occurs at the thermal limits of these sea turtles (primarily because of low sea surface temperatures), the probability of these sea turtles occurring in the Action Area is sufficiently small for us to conclude that they are not likely to be exposed to the activities considered in these consultation. As a result, these species will not be considered further in this Opinion.

Southern Resident Killer Whales

Three kinds of killer whales occur along the Pacific Coast of the United States: Eastern North Pacific (ENP) southern resident killer whales, ENP offshore killer whales, and ENP transient killer whales. Of these only the southern resident killer whales are listed as endangered or threatened under the ESA. Southern resident killer whales are observed primarily in the inland waters of Washington State and southern Vancouver Island during the summer months, although pods from this population have been observed as far north as southern Southeast Alaska and as far south as Monterey Bay, as well as near the Farallon Islands, and off Point Reyes (NMFS 2005a).

Southern Resident killer whales spend a significant portion of the year in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound, particularly during the spring, summer, and fall, when all three pods regularly occur in the Georgia Strait, San Juan Islands, and Strait of Juan de Fuca (Felleman et al. 1991; Heimlich-Boran 1988; Olson 1998; Osborne 1999). The K and L pods typically arrive in May or June and remain in this core area until October or November, although both pods make frequent trips lasting a few days to the outer coasts of Washington and southern Vancouver Island (Ford et al. 2000). During the July through September, all of the pods concentrate their activities in Haro Strait, Boundary Passage, the southern Gulf Islands, the eastern end of the Strait of Juan de Fuca, and several localities in the southern Georgia Strait (Felleman et al. 1991; Ford et al. 2000; Heimlich-Boran 1988; Olson 1998). The local movement of southern resident killer whales usually follows the distribution of prey (Heimlich-Boran 1988; Heimlich-Boran 1986; Nichol and Shackleton 1996).

Killer whale whistles are tonal signals that have longer duration (0.06–18 seconds) and frequencies ranging from 0.5–10.2 kHz (Thomsen et al. 2001). Killer whales are reported to whistle most often while they have been engaged in social interactions rather than during foraging and traveling (Thomsen et al. 2002). Northern resident killer whale whistles have source levels ranging from 133 to 147 dB re 1 µPa at 1 m (Miller 2006).

Killer whale pulsed calls are the most commonly observed type of signal associated with killer whales (Ford 1989). With both northern and southern resident killer whales, these signals are relatively long (600–2,000 ms) and range in frequency between 1 and 10 kHz; but may contain harmonics up to 30 kHz (Ford 1989). The variable calls of killer whales have source levels ranging from 133 to 165 dB while stereotyped calls have source levels ranging from 135 to 168 dB re 1 µPa at 1 m (Miller 2006). Killer whales use these calls when foraging and traveling (Ford 1989).

Killer whale hearing is the most sensitive of any odontocete tested thus far. Hearing ability extends from 1 to at least 120 kHz, but is most sensitive in the range of 18-42 kHz (Szymanski et al. 1999). The most sensitive frequency is 20 kHz, which corresponds with the approximate peak energy of the species' echolocation clicks (Szymanski et al. 1999). This frequency is lower than in many other toothed whales. Hearing sensitivity declines below 4 kHz and above 60 kHz.

Within the June to July time period for this survey, sightings as well as passive acoustic recorder data indicate that southern resident killer whales may either occur within the inland waters of Puget Sound, Strait of Juan de Fuca, and southern Georgia Strait or along the continental shelf area off Washington state at least as far south as Grays Harbor (Hanson pers. comm. 2012). The only trackline within the vicinity of Grays Harbor is the northern east-west trackline. The southern end of this trackline occurs slightly north of Grays Harbor and approximately 150 km from the shoreline (20 km from the continental shelf) at approximately the 1,000 m bathymetry contour. Seismic shooting of this trackline will start at the southern end and proceed west.

The airgun array is predominantly low-frequency[5] with a dominant frequency component of 0–188 Hz. Airguns have been shown to produce frequencies up to 150 kHz albeit with substantially lower energy output. Not all of the energy from airguns propagates downward as energy also propagates horizontally though at a lower energy output. Two to three sonars could be in use at anytime during the surveys. The sonars will operate in the 3.5 kHz to 13 kHz range (usually 12 kHz), and have a maximum source level of ranging between 211 dB and 242 dB re 1 µPa (rms) (for further information on the airgun array and sonars see *Acoustic Equipment* on pages 4-5 of this Opinion). We assume the dominant sound at distances from the airguns would be the low-frequencies given that transmission loss for higher-frequency sounds is relatively greater.

Southern Resident killer whales are expected to occur either within the inland waters of Puget Sound, Strait of Juan de Fuca, and southern Georgia Strait or on the continental shelf area as far south as Grays Harbor off Washington State during the timeframe of the proposed action. The southern end of the northern trackline occurs in deep water at approximately the 1,000 m bathymetry contour. The distances of the 180/160 dB dB re 1 µPa(rms) propagation isopleths (the distances to which acoustic harassment/harm onset may occur) for the airgun array are estimated at 1.54/12.2 km, respectively for 1,000 m depths (see page 8 for isopleth distances in various water depths) and these isopleths decrease in range as water depth increases.

Because of the geographical locations where southern resident killer whales are likely to occur and their hearing abilities (mid-to high-frequencies), the distance from the continental shelf of the closest trackline to shore and the expected distances of sonar and airgun sound propagation, we do not expect that southern resident killer whales will be adversely affected by the proposed survey activities. As a result, this species will not be considered further in this Opinion.

Pacific Salmon and Steelhead Trout

Salmon and steelhead trout may occur within the Action Area for the proposed survey. Although the data available on the hearing sensitivities of Pacific salmon and trout is limited, that information suggests that the species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which

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[5] Frequencies are categorized as low-frequency (< 1,000 Hz), mid-frequency (1-10 kHz), and high-frequency (> 10 kHz).

is a “hearing generalist” with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the salmon and trout species considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008). Based on this information we assume that salmon and steelhead trout would hear the airguns, but not hear the mid-and high-frequencies emitted by the sonars.

All fish have two sensory systems that are used to detect sound in the water including the inner ear, which functions very much like the inner ear found in other vertebrates, and the lateral line, which consists of a series of receptors along the body of the fish (Popper 2008). The inner ear generally detects higher frequency sounds while the lateral line detects water motion at low frequencies (below a few hundred Hz) (Hastings et al. 1996). A sound source produces both a pressure wave and motion of the medium particles (water molecules in this case), both of which may be important to fish. Fish detect particle motion with the inner ear. Pressure signals are initially detected by the gas-filled swim bladder or other air pockets in the body, which then re-radiate the signal to the inner ear (Popper 2008). Because particle motion attenuates relatively quickly, the pressure component of sound usually dominates as distance from the source increases.

The lateral line system of a fish allows for sensitivity to sound (Hastings and Popper 2005). This system is a series of receptors along the body of the fish that detects water motion relative to the fish that arise from sources within a few body lengths of the animal. The sensitivity of the lateral line system is generally from below 1 Hz to a few hundred Hz (Coombs and Montgomery 1999; Popper and Schilt 2009).

In studies in which fish species were found to have incurred TTS, hearing returned to normal within 24 hrs after the end of exposure (e.g., Smith et al. 2004a, 2006). Fish seem to be able to regenerate lost hair cells and recover from TTS quickly with no permanent damage (e.g., Smith et al. 2006). Behavioral changes such as those demonstrated by marine mammals upon exposure to approaching vessels (e.g., avoidance, altered swimming speed and direction) also occur in fish. Although data are limited, we assume that some salmon and trout may experience a stress response if exposed to seismic pulses at various levels of intensity during the proposed activities at close range for unusually long periods of time; however, this is not anticipated to occur during the proposed activities given their wide dispersal in the Pacific Ocean. We expect only temporary effects with a return to their pre-exposure behavior as the airguns move away from the fish. Given the wide dispersal into the Pacific Ocean and the expected responses of Pacific salmon and trout we conclude that the these species are not likely to be adversely affected by survey activities. As a result, these species will not be considered further in this Opinion.

Steller Sea Lion Critical Habitat

Critical Habitat for the Eastern DPS includes California and Oregon rookeries and associated areas located at Pyramid Rock on Rogue Reef (42 26.4N latitude, 124 28.1W longitude) and Long Brown Rock (42 47.3N latitude, 124 36.2W longitude) and Seal Rock (42 47.1N latitude 124 35.4W longitude) on Orford Reef in Oregon and Ano Nuevo Island (37 06.3N latitude, 122 20.3W longitude), southeast Farallon Island (37 41.3N latitude, 123 00.1W longitude), and Sugarloaf Island and Cape Mendocino (40 26.0N latitude, 124 24.0W longitude) in California.

Critical habitat for the eastern population of Steller sea lions has not been designated in the State of Washington. The aquatic zones extend 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery in California and Oregon.

The designation for this species includes sites necessary to support one or more Steller sea lion life stages and protects quality growth, reproduction, and feeding. Primary constituent elements necessary for the conservation of this species includes access to rookeries, haulouts and foraging habitats with prey of sufficient quantity, quality and availability. Available prey in Oregon and Washington includes rockfish, hake, flatfish, squid, octopus, and lamprey.

Orford Reef and Rogue Reef in Oregon are located ~175 and ~220 km south of the southern-most trackline. As the 160 dB re 1 μPa(rms) isopleth is estimated to extend about 20.6 km from the *Langseth* during the proposed surveys we expect that airgun received levels would be far below 160 dB re 1 μPa(rms) at which we may expect Steller sea lions and any prey resources that are likely available to Steller sea lions to experience behavioral harassment. Females nursing pups and pups less than 6 months are expected to remain close to the rookery and juveniles less than one year are depth limited to 20 m during foraging, therefore, we do not expect survey activities to exclude Steller sea lions from these rookeries or foraging habitat particularly given the distance from the proposed survey area.

All fish have two sensory systems that are used to detect sound in the water including the inner ear, which functions very much like the inner ear found in other vertebrates, and the lateral line, which consists of a series of receptors along the body of the fish (Popper 2008). The inner ear generally detects higher frequency sounds while the lateral line detects water motion at low frequencies (below a few hundred Hz) (Hastings et al. 1996). A sound source produces both a pressure wave and motion of the medium particles (water molecules in this case), both of which may be important to fish. Fish detect particle motion with the inner ear. Pressure signals are initially detected by the gas-filled swim bladder or other air pockets in the body, which then re-radiate the signal to the inner ear (Popper 2008). Because particle motion attenuates relatively quickly, the pressure component of sound usually dominates as distance from the source increases.

The lateral line system of a fish allows for sensitivity to sound (Hastings and Popper 2005). This system is a series of receptors along the body of the fish that detects water motion relative to the fish that arise from sources within a few body lengths of the animal. The sensitivity of the lateral line system is generally from below 1 Hz to a few hundred Hz (Coombs and Montgomery 1999; Popper and Schilt 2009).

Cephalopods such as octopus and squid appear to be sensitive to the low frequency particle motion component of a sound field and not pressure although they possess a statocyst organ (Mooney et al 2012). Based on behavioral conditioning experiments Packard et al (1990) confirmed that squid (Loligo vulgaris), octopus (Octopus vulgaris), and S. officinalis can detect acceleration stimuli from 1 to 100 Hz.

The distances of the proposed survey from the areas where eastern Steller sea lions are expected to occur within critical habitat are sufficient enough that we do not expect these sea lions to be excluded from rookeries, haulouts and foraging habitats with prey of sufficient quantity, quality and availability. Because of the particle motion associated with the seismic signals to which fish and cephalopods are sensitive to would attenuate relatively quickly and the sensitivity of the lateral line (limited sensitivity to within a few body lengths) to acoustic signals we would not expect potential prey (fish or cephalopods) at these distances from the survey activities to experience behavioral disruptions that would result in decreases in their quantity, quality, or availability. Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources are not likely to decline as a result of exposure to survey activities. As a result, this critical habitat will not be considered further in this Opinion.

Salmon and Steelhead Trout Critical Habitat

NMFS has designated critical habitat for the salmon and steelhead trout that may occur in the survey area. The specific geographic extent of these designations includes inland freshwater and nearshore marine waters of rivers and streams. The designation for these species includes sites necessary to support one or more salmon and steelhead life stages. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. Specific primary constituent elements include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat, and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Based on our analyses of the evidence available, the proposed surveys do not overlap with or occur in proximity to survey activities, and therefore, we do not expect the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation to be exposed to the stressors associated with the proposed survey activities. As a result, critical habitat for these species are not likely to be adversely affected by proposed survey activities and we will not consider these habitats in greater detail in the remainder of this Opinion.

Status of Species Considered in this Biological Opinion

The remainder of this section consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the proposed survey. Each narrative presents a summary of information on the distribution and population structure of each species to provide a foundation for the exposure analyses that appear later in this Opinion. A summary of information on the threats to the species and the species' status given those threats is provided as points of reference for the subsequent jeopardy determinations. That is, NMFS relies on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

More detailed background information on the status of these species and critical habitat can be found in a number of published documents including status reviews, recovery plans for the blue whale (NMFS 1998b), fin whale (NMFS 2010d), fin and sei whale (NMFS 1998a), humpback whale (NMFS 1991), sperm whale (NMFS 2010e), a status report on large whales prepared by

Perry et al. (1999a) and the status review and recovery plan for the leatherback sea turtle (NMFS and USFWS 1998; NMFS and USFWS 2007).

Blue Whale

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson et al. 2008). Generally, blue whales are seasonal migrants between high latitudes in summer, where they feed, and low latitudes in winter, where they mate and give birth (Lockyer and Brown 1981).

Distribution

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

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

In the North Pacific Ocean, blue whales have been recorded off the island of Oahu in the main Hawaiian Islands and off Midway Island in the western edge of the Hawaiian Archipelago (Barlow 2006; Northrop et al. 1971; Thompson and Friedl 1982), although blue whales are rarely sighted in Hawaiian waters and have not been reported to strand in the Hawaiian Islands.

In the eastern tropical Pacific Ocean, the Costa Rica Dome appears to be important for blue whales based on the high density of prey (euphausiids) available in the Dome and the number of blue whales that appear to reside there (Reilly and Thayer 1990). Blue whales have been sighted in the Dome area in every season of the year, although their numbers appear to be highest from June through November. Blue whales have also been reported year-round in the northern Indian Ocean, with sightings in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Mizroch et al. 1984). The migratory movements of these whales are unknown.

Blue whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea. Blue whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the

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

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

Population Structure

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

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

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

Natural Threats

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

Anthropogenic Threats

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

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 194, 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

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

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

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

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

Status and Trends

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

It is difficult to assess the current status of blue whales because (1) there is no general agreement on the size of the blue whale population prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population prior to whaling, although some authors have concluded that their population numbers about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser et al. 1981). These estimates, however, are more than 20 years old.

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

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

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

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

Diving and Social Behavior

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

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

Vocalization and Hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see McDonald et al. 1995). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. Reported source levels are 180-188 dB re 1µPa, but may reach 195 dB re 1µPa (Aburto et al. 1997; Clark and Gagnon 2004; Ketten 1998; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 μPa_{rms} -1 m in the 17-30 Hz range and pygmy blue whale calls at 175± 1 dB re 1 μPa_{rms} -1 m in the 17-50 Hz range. In addition to information about blue whale sound production, a recent study by Melcón et al (2012) demonstrated that blue whales responded to mid-frequency sonar (1-8 kHz).

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

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

Direct studies of blue whale hearing have not been conducted, but it has been assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). While we still expect blue whales to be most sensitive to low frequencies, studies suggest that blue whales can also hear and react to mid-frequency sounds.

Critical Habitat
NMFS has not designated critical habitat for blue whales.

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

Distribution
Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast seaward to the continental shelf (about the 1,000-fathom contour). In this region, they tend to occur north of Cape Hatteras where they accounted for about 46 percent of the large whales observed in surveys conducted between 1978 and 1982. During the summer months, fin whales in this region tend to congregate in feeding areas between 41°20'N and 51°00'N, from shore seaward to the 1,000-fathom contour. This species preys opportunistically on both invertebrates and fish (Watkins et al. 1984). They feed by filtering large volumes of water for the associated prey.

In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985a). The overall distribution may be based on prey availability. Fin whales are larger and faster than humpback and right whales and are less concentrated in nearshore environments.

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

Population Structure
Fin whales have two recognized subspecies: *Balaoptera physalus physalus* occurs in the North Atlantic Ocean while *B. p. quoyi* (Fischer 1829) occurs in the Southern Ocean. Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Within these major areas, different organizations use different population structure.

In the North Atlantic Ocean, the International Whaling Commission recognizes seven management units or “stocks” of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West

Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea, is believed to be genetically distinct from other fin whale populations.

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

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

Mizroch et al. (1984) identified five fin whale “feeding aggregations” in the Pacific Ocean: (1) an eastern group that move along the Aleutians, (2) a western group that move along the Aleutians (Berzin and Rovnin 1966; Nasu 1974); (3) an East China Sea group; (4) a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (Rice 1974); and (5) a group centered in the Sea of Cortez (Gulf of California). Hatch (2004) reported that fin whale vocalizations among five regions of the eastern North Pacific were heterogeneous: the Gulf of Alaska, the northeast North Pacific (Washington and British Columbia), the southeast North Pacific (California and northern Baja California), the Gulf of California, and the eastern tropical Pacific.

Sighting data show no evidence of migration between the Sea of Cortez and adjacent areas in the Pacific, but seasonal changes in abundance in the Sea of Cortez suggests that these fin whales might not be isolated (Tershy et al. 1993). Nevertheless, Bérubé et al. (2002) concluded that the Sea of Cortez fin whale population is genetically distinct from the oceanic population and have lower genetic diversity, which suggests that these fin whales might represent an isolated population.

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

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

Anthropogenic Threats
Fin whales have undergone significant exploitation, but are currently protected under the IWC. Fin whales are still hunted in subsistence fisheries off West Greenland. In 2004, five males and six females were killed, and two other fin whales were struck and lost. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005).

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

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

Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008).

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

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

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

Status and Trends

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

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

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

Regardless of which of these estimates, if any, have the closest correspondence to the actual size and trend of the fin whale population, all of these estimates suggest that the global population of fin whales consists of tens of thousands of individuals and that the North Atlantic population consists of at least 2,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

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

Diving and Social Behavior

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

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

Vocalization and Hearing

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

Although their function is still in doubt, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997; Payne and Webb.

1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999).

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

Critical Habitat

NMFS has not designated critical habitat for fin whales.

Humpback Whale

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

Distribution

In the Atlantic Ocean, humpback whales range from the mid-Atlantic bight, the Gulf of Maine, across the southern coast of Greenland and Iceland, and along coast of Norway in the Barents Sea. These humpback whales migrate to the western coast of Africa and the Caribbean Sea during the winter.

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Tomlin 1967, Nemoto 1957, Johnson and Wolman 1984 as cited in NMFS 1991). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during the winter.

In the Southern Ocean, humpback whales occur in waters off Antarctica. These whales migrate to the waters off Venezuela, Brazil, southern Africa, western and eastern Australia, New Zealand, and islands in the southwest Pacific during the austral winter. A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

Population Structure

Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they feed. During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different “reproductive areas” will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form "open" populations; that is, populations that are connected through the movement of individual animals.

Based on genetic and photo-identification studies, the NMFS currently recognizes four stocks, likely corresponding to populations, of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific (Hill and DeMaster 1998). However, gene flow between them may exist. Humpback whales summer in coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during winter. However, more northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in the waters around Hawai′i while the eastern North Pacific population (also called the California-Oregon-Washington-Mexico stock) winters along Central America and Mexico. However, Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure. Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai′i and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawai′i may have emigrated from Mexican wintering areas. A "population" of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in the Mariana Islands, at Guam, Rota, and Saipan from January-March (Darling and Cerchio 1993; Eldredge 1991; Eldredge 2003; Rice 1998). During summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2008; Calambokidis 1997; Calambokidis et al. 2001).

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

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

Historically, humpback whales occurred in Puget Sound. Since the 1970s, however, humpback whales have become rare within Puget Sound, although at least five humpback whales have been observed in Puget Sound since 1976 (Calambokidis et al. 1990; Calambokidis et al. 2004; Osborne et al. 1988). Although humpback whales no longer appear to occur in Puget Sound very rarely, they have consistently been more common than any other large cetacean observed off the coast of Washington State for more than a decade (Calambokidis et al. 2009; Calambokidis et al. 2004; Forney 2007). Humpback whales occur in those waters seasonally from May through November, becoming fairly common beginning in July, and reaching peak densities from August to September and declines substantially from September onward (Calambokidis 1997; Calambokidis and Chandler. 2000; Calambokidis et al. 2001; Calambokidis et al. 1997; Green et al. 1992). During that time interval, humpback whales have been reported in coastal waters, on the continental shelf, and the continental slope, with concentrations occurring in steep slope water near Grays, Astoria, and Nitinat canyons (Forney 2007; Green et al. 1992).

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

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

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

Anthropogenic Threats

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

Humpback whales are also killed or injured during interactions with commercial fishing gear. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. NMFS estimates that between 2002 and 2006, there were incidental serious injuries to 0.2 humpback annually in the Bering Sea/Aleutian Islands sablefish longline fishery. This estimation is not considered reliable. Observers have not been assigned to a number of fisheries known to interact with the Central and Western North Pacific stocks of humpback whale. In addition, the Canadian observation program is also limited and uncertain (Angliss and Allen 2009).

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

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

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

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

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

Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific (southeast Alaska), most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (Dolphin 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al. 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

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

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

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

Critical Habitat

NMFS has not designated critical habitat for humpback whales.

Sei Whale

The distribution of the sei whale is not well known, but this whale is found in all oceans. Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). Sei whales migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985a). During summer in the North Pacific, the sei whale can be found from the Bering Sea to the northern GOA and south to southern California, and in the western Pacific from Japan to Korea. Its winter distribution is concentrated at about 20°N, and sightings have been made between southern Baja California and the Islas Revilla Gigedo (Rice 1998). No breeding grounds have been identified for sei whales; however, calving is thought to occur from September to March.

Distribution

In the western Atlantic Ocean, sei whales occur from Nova Scotia and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985b). In the eastern Atlantic Ocean, sei whales occur in the Norwegian Sea (as far north as Finnmark in northeastern Norway), occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b).

In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20°-23°N (Gambell 1985b; Masaki 1977).
Sei whales occur throughout the Southern Ocean during the summer months, although they do not migrate as far south to feed as blue or fin whales. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of Southern Africa and Australia.

Population Structure

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

Some mark-recapture, catch distribution, and morphological research indicate more than one population may exist – one between 155°-175° W, and another east of 155° W (Masaki 1976; Masaki 1977) in the North Pacific. Sei whales have been reported primarily south of the Aleutian

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

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

In the early to mid-1900s, sei whales were hunted off the coast of British Columbia (Gregr et al. 2000; Pike and Macaskie 1969). Masaki (1977) presented sightings data on sei whales in the North Pacific from the mid-1960s to the early 1970s. Over that time interval sei whales did not appear to occur in waters of Washington State and southern British Columbia in May or June, their densities increased in those waters in July and August (1.9 - 2.4 and 0.7 - 0.9 whales per 100 miles of distance for July and August, respectively), then declined again in September. More recently, sei whales have become known for an irruptive migratory habit in which they appear in an area then disappear for time periods that can extend to decades. Based on a sei whale that stranded near Port Angeles and the sei whales observed by Forney and her co-workers (Forney 2007), we know that these whales still occur in waters off Washington, Oregon, and northern California.

Natural Threats

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

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

Anthropogenic Threats

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

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

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast between 1975 and 1996, two showed evidence of collisions (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada’s Maritime Provinces (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in death. One sei whale was killed in a collision with a vessel off the coast of Washington in 2003 (Waring et al. 2009). New rules for seasonal (June through December) slowing of vessel traffic in the Bay of Fundy to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to reduce sei whale ship strike mortality by 17 percent.

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

Status and Trends

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

Ohsumi and Fukuda (1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973. From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Harwood and Hembree. 1987; Perry et al. 1999a). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911-1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). There have been no direct estimates of sei whale populations for the eastern Pacific Ocean (or the entire Pacific). Between 1991 and 2001, during aerial surveys, there were two confirmed sightings of sei whales along the U.S. Pacific coast.

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

Diving and Social Behavior

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 min (Gambell 1985b). The depths of sei whale dives have not been studied; however the composition of their diet suggests that they do not perform dives in excess of 300 meters. Sei whales are usually found in small groups of up to 6 individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985b).

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

Vocalization and Hearing

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

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

Critical Habitat

NMFS has not designated critical habitat for sei whales.

Sperm Whale

Distribution

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

Population Structure

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

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

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

Natural Threats

Sperm whales are known to be occasionally predated upon by killer whales (Jefferson et al. 1991; Pitman et al. 2001) by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic Threats

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

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

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

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

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

Status and Trends

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

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

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

Diving and Social Behavior

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

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Clarke 1986; Whitehead 2002b). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

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

Vocalization and Hearing

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

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

Critical Habitat

NMFS has not designated critical habitat for sperm whales.

Eastern Population of Steller Sea Lion

Steller sea lions "forage" nearshore and in pelagic waters. They are capable of traveling long distances in a season and can dive to approximately 1300 ft (400 m) in depth.

Distribution

Steller sea lions are distributed mainly around the coasts to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaiddo, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California. The population is divided into the Western and the Eastern distinct population segments (DPSs) at 144° West longitude (Cape Suckling, Alaska). The Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia). The Eastern DPS includes sea lions living in southeast Alaska, British Columbia, California, and Oregon.

Population Structure

Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple 2002). At sea, groups usually consist of females and subadult males; adult males are usually solitary while at sea (Loughlin 2002). An area of high occurrence extends from the shore to the 273-fathom (500-m) depth. For the Gulf of Alaska, foraging habitat is primarily shallow, nearshore, and continental shelf waters 4.3 to 13 nm (8 to 24 km) offshore with a secondary occurrence inshore of the 3,280 ft (1,000 m) isobath, and a rare occurrence seaward of the 3,280 ft (1,000 m) isobath. Steller sea lions have been sighted foraging in the middle of the Gulf of Alaska (Navy 2006).

Eastern Steller sea lions are distributed from California to Alaska and the population includes all rookeries east of Cape Suckling, Alaska south to Año Nuevo Island, which is the southernmost extant rookery. Most adult Steller sea lions occupy rookeries during the pupping and breeding season, which extends from late May to early July (Pitcher and Calkins 1981). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts.

Rookeries of the eastern population of Steller sea lions occur in British Columbia, Oregon, and northern California; but there are no rookeries in Washington (Angliss and Outlaw 2008). Steller sea lions occur regularly throughout the year in the Pacific Northwest and several haul outs for these sea lions occur along the coast from the Columbia River to Cape Flattery and on the southern coast of Vancouver Island near the Strait of Juan de Fuca (Jeffries et al. 2000).

When they are not resting on haul outs, Steller sea lions primarily occur from the shore to the 500 meter (1,640 foot) isobath; they occur in waters deeper than this isobath, but their occurrence becomes increasingly rare. Steller sea lions also occur in the Strait of Juan de Fuca, around San Juan and Whidbey islands, and through the Strait of Georgia with some observations in the southern portion of Puget Sound. They are rare in Hood Canal.

Natural Threats

Reproductive failure and neonate, juvenile, and adult mortality resulting from disease probably occur in both DPSs of Steller sea lions. Antibodies to two types of bacteria (Leptospira and Chlamydiia), one marine calicivirus (San lilipel Sea Lion Virus), and seal herpes virus (SeHV), which could produce such effects, were present in blood taken from Steller sea lions in Alaska (Barlough et al. 1987; Calkins and Goodwin 1988; Vedder et al. 1987).

Causes of pup mortality include drowning, starvation caused by separation from the mother, crushing by larger animals, disease, predation, and biting by females other than the mother (Edie 1977; Orr and Poulter 1967). Pup mortality on rookeries has not been thoroughly studied. Steller sea lions are probably eaten by killer whales and sharks, but the possible impact of these predators is unknown. The occurrence of shark predation on other North Pacific pinnipeds has been documented, but not well quantified (Ainley et al. 1985).

Parasites of Steller sea lions include intestinal cestodes; trematodes in the intestine and bile duct of the liver; nematodes in the stomach, intestine, and lungs; acainthocephalans in the intestine; acarian mites in the nasopharynx and lungs; and an anopluran skin louse(Dailey and Brownell 1972; Dailey and Hill 1970).

Anthropogenic Threats

Historically, the Eastern DPS of Steller sea lions was subjected to substantial mortality by humans, primarily due to commercial exploitation and both sanctioned and unsanctioned predator control (NMFS 2008b). Commercial exploitation occurred primarily in the 1800s and early 1900s while unsanctioned predator control probably persisted into the 1970s in some locations. State sanctioned commercial harvest of Steller sea lions ended in 1972 with the advent of the MMPA.

Although not well documented, there is little doubt that numbers of Steller sea lions were greatly reduced in many locations by these activities (NMFS 2008b). Commercial hunting and predator control activities have been discontinued and no longer affect this DPS. In contrast to the Western DPS, which is experiencing potential human-related threats from competition with fisheries (potentially high), incidental “take” by fisheries (low), and toxic substances (medium) no threats to continued recovery were identified for the Eastern DPS. Although several factors affecting the Western DPS also affect the Eastern DPS (e.g., environmental variability, killer whale predation, toxic substances, disturbance, shooting), these threats do not appear to be at a level sufficient to keep the Eastern DPS from continuing to recover, given the long term sustained growth of the population as a whole (NMFS 2008b).

Steller sea lions are also harassed during research targeting sea lions and incidental to research on other marine mammals. NMFS’ Permits Division has issued nine permits from 2006-2011 that authorized the incidental disturbance of 33,050 individuals from the eastern population of Steller sea lions during research on killer whales and other cetaceans in Alaska, California, Washington and Oregon.

Status and Trend
The Steller sea lion was initially listed as a threatened species under the ESA on April 5, 1990 (55 FR 12645). The minimum abundance estimate for the Eastern DPS is estimated at 45,095 to 55,832 (Angliss and Allen 2009). The Eastern DPS has increased at an annual rate of approximately 3 percent since at least the late 1970s (Pitcher et al. 2007) and may be a candidate for removal from the list of threatened and endangered species (NMFS 2008b).

On December 13, 2010 NMFS published a 90-day finding on petitions to delist the Eastern DPS of the Steller sea lion. The finding stated that substantial scientific or commercial information is available such that a status review is warranted. On April 18, 2012, NMFS published a rule to delist the Eastern Steller sea lion DPS. A final rule announcing whether this DPS will actually be delisted is expected in 2013.

Diving and Social Behavior
Steller sea lions use terrestrial habitat as haul-out sites for periods of rest, molting, and as rookeries for mating and pupping during the breeding season. At sea, they are seen alone or in small groups, but may gather in large "rafts" at the surface near rookeries and haul outs. Steller sea lions tend to make shallow dives of less than 820 ft (250 m) but are capable of deeper dives (NMFS 2008b). Adult females stay with their pups for a few days after birth before beginning a regular routine of alternating foraging trips at sea with nursing their pups on land. Female Steller sea lions use smell and distinct vocalizations to recognize and create strong social bonds with their newborn pups. Females usually mate again with males within 2 weeks after giving birth.

Vocalization and Hearing
On land, territorial male Steller sea lions usually produce low frequency roars (Loughlin et al. 1987; Schusterman et al. 1970). The calls of females range from 30 Hz to 3 kHz, with peak frequencies from 150 Hz to 1 kHz; typical duration is 1.0 to 1.5 sec (Campbell et al. 2002). Pups produce bleating sounds.

Underwater sounds are similar to those produced on land (Loughlin et al. 1987). When the underwater hearing sensitivity of two Steller sea lions was tested, the hearing threshold of the male was significantly different from that of the female. The range of best hearing for the male was from 1 to 16 kHz, with maximum sensitivity (77 dB re 1 µPa - 1 m) at 1 kHz. The range of best hearing for the female was from 16 kHz to above 25 kHz, with maximum sensitivity (73 dB re 1 µPa - 1 m) at 25 kHz. Because of the scarcity of information relating to hearing in steller sea lions and other pinnipeds, Southall et al (2007) estimated the functional underwater hearing range of all pinnipeds as between 75 Hz and 75 kHz.

Leatherback Sea Turtle
Distribution
Leatherback turtles are widely distributed throughout the oceans of the world. The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the

Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there.

Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale et al. 1994, Eckert 1998, Eckert 1999a). In the North Atlantic Ocean, leatherback turtles regularly occur in deep waters (>328 ft), and an aerial survey study in the north Atlantic sighted leatherback turtles in water depths ranging from 3 to 13,618 ft, with a median sighting depth of 131.6 ft (CeTAP 1982). This same study found leatherbacks in waters ranging from 7 to 27.2°C.

In the Pacific Ocean, leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific between 71°N and 47°S latitude and in all other major pelagic ocean habitats (NMFS and USFWS 1998). Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been hypothesized that leatherback sea turtles probably mate outside of tropical waters, before females swim to their nesting beaches (Eckert and Eckert 1988).

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

Population Structure

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

Natural Threats

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

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

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

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

In the Pacific Ocean, between 1,000 and 1,300 leatherback sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set longline fisheries based out of Hawaii are estimated to have captured and killed several hundred leatherback sea turtles before they were closed in 2001. When they were re-opened in 2004, with substantial modifications to protect sea turtles, these fisheries were estimated to have captured and killed about 1 or 2 leatherback sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawaii are estimated to have captured about 19 leatherback sea turtles, killing about 5 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future (NMFS 2008). Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawaii and American Samoa.

Shrimp trawls in the Gulf of Mexico capture the largest number of leatherback sea turtles: each year, they have been estimated to capture about 3,000 leatherback sea turtles with 80 of those sea turtles dying as a result. Along the Atlantic coast of the U.S., NMFS estimated that about 800 leatherback sea turtles are captured in pelagic longline fisheries, bottom longline and drift gillnet fisheries for sharks as well as lobster, deep-sea red crab, Jonah crab, dolphin fish and wahoo, and Pamlico Sound gillnet fisheries. Although most of these turtles are released alive, these fisheries combine to kill about 300 leatherback sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Castroviejo et al. 1994; Graff 1995). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux et al. 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio, 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95% (Eckert and Lien, 1999). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS 2001). There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

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

Status

The leatherback turtle is listed as endangered under the ESA throughout its global range. Increases in the number of nesting females have been noted at some sites in the Atlantic Ocean, but these are far outweighed by local extinctions, especially of island populations, and the demise of populations throughout the Pacific, such as in Malaysia and Mexico. Spotila et al. (1996) estimated the global population of female leatherback turtles to be only 34,500 (confidence limits: 26,200 to 42,900) nesting females; however, the eastern Pacific population has continued to decline since that estimate, leading some researchers to conclude that the leatherback is now on the verge of extinction in the Pacific Ocean (e.g. Spotila et al. 1996, Spotila, et al. 2000).

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

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

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

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

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

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

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

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

Diving and Social Behavior

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

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

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

Hearing

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

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

Green Sturgeon

Green sturgeon are found along the shorelines of the west coast from Ensenada, Mexico, along California/Oregon/Washington, north through the Bering Sea and Canada and Asian shorelines of the northern Pacific Ocean (Moyle 2002). Green sturgeon are the most marine-oriented of the sturgeon species.

Distribution

Green sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. Early life-history stages reside in fresh water, with adults returning to freshwater to spawn. Adults typically migrate into fresh water beginning in late February; spawning occurs from March-July, with peak activity from April-June (Moyle et al. 1995). Juvenile green sturgeon spend 1-4 years in fresh and estuarine waters before dispersing widely into the Pacific Ocean (Beamesderfer and Webb 2002, Moyle et al 1992).

Population Structure

The species is divided into two genetically distinct but physically indistinguishable clades: a Northern DPS whose populations are relatively healthy, and a Southern DPS that has undergone significant decline (Adams et al. 2007). Only the Southern DPS of green sturgeon is listed under the ESA. Southern green sturgeon currently consist of a single population that occurs in San Francisco Bay and the river systems associated with the bay (Adams et al. 2007). Southern green sturgeon are known to spawn in the Sacramento River and have been reported to spawn in the Feather River (Adams et al. 2007).

Natural Threats
Green sturgeon eggs and larvae are likely preyed upon by a variety of larger fish and animals, while sub-adult and adult sturgeon may occasionally be preyed upon by shark sea lions, or other large body predators. Physical barriers, changes in water flow and temperatures may also affect freshwater survival.

Anthropogenic Threats
Southern green sturgeon are primarily threatened by reductions in the area of spawning habitat associated with the construction of dams in the Sacramento River system (e.g., Oroville, Shasta and Keswick dams). Southern green sturgeon are also threatened by elevated temperatures in freshwater river systems, harvests, entrainment by water projects, exposure to toxic chemicals, and invasive species (Adams et al. 2007; Erickson and Webb 2007).

Climate change has the potential to affect sturgeon in similar, if not more significant ways it affects salmonids. Elevated air temperatures could lead to precipitation falling as rain instead of snow. Additionally, snow would likely melt sooner and more rapidly, potentially leading to greater flooding during melting and lower water levels at other times, as well as warmer river temperatures. Although sturgeon can spawn over varied benthic habitat, they prefer localized depressions in riverbeds (Moyle et al. 1992; Moyle et al. 1995). Increased extremes in river flow (i.e., periods of flooding and low flow) can alternatively disrupt and fill in spawning habitat that sturgeon rely upon (ISAB 2007). If water flow is low during migration events, it is likely that new obstacles can impede or block sturgeon movement. As with other anadromous fishes, sturgeon are uniquely evolved to the environments that they live in. Because of this specificity, broad scale changes in environment can be difficult to adapt to, including changes in water temperature (Cech Jr. et al. 2000). Sturgeon are also sensitive to elevated water temperatures. Temperature triggers spawning behavior. Warmer water temperatures can initial spawning earlier in a season for salmon and the same can be true for sturgeon (ISAB 2007). If river and lake temperatures become anomalously warm, juvenile sturgeon may experience elevated mortality due to lack of cooler water refuges in freshwater habitats. Apart from direct changes to sturgeon survival, altered water temperatures may disrupt habitat, including the availability of prey (ISAB 2007). Warmer temperatures may also have the effect of increasing water use in agriculture, both for existing fields and the establishment of new ones in once unprofitable areas (ISAB 2007). This means that streams, rivers, and lakes will experience additional withdrawal of water for irrigation and increasing contaminant loads from returning effluent. Overall, it is likely that global warming will increase pressures on sturgeon survival and recovery.

Green sturgeon are targeted by a subsistence tribal fishery in the Klamath River as well as a small commercial fishery and some sport fisheries along the Pacific Coast. The majority of harvests since 1985 have taken place in the lower Columbia River; although this fishery has declined because of increasingly restrictive fishing regulations (Adams et al. 2002). Mixed stock fisheries along the Pacific coast annually harvested an average of approximately 1,350 green sturgeon during 1994–2001 (Adams et al. 2002). We do not know whether or to what degree these fisheries harvested southern green sturgeon, but the distribution of southern green sturgeon would expose them to these fisheries.

Sturgeon species generally accumulate contaminants in their tissues. White sturgeon from the Kootenai River have been found to contain aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, zinc, DDE, DDT, PCBs, and other organochlorines (Kruse and Scarnecchia 2002). Mercury has also been identified from white sturgeon of the lower Columbia River (Webb et al. 2006). Numerous organochlorines, including DDT, DDD, DDE, chlordane, and dieldrin have also been identified in these fish (Foster et al. 2001). Observed concentrations are likely sufficient to influence reproductive physiology.

Status and Trend

The southern population of green sturgeon was listed as threatened on April 7, 2006 (71 FR 17757). Critical habitat for this species was designated on October 9, 2009 (74 FR 52300).

Data on the demographic status and trend of southern green sturgeon are very limited. Available information comes from two predominant sources, fisheries and tagging. Only three data sets were considered useful for the population time series analyses by NMFS' biological review team: the Klamath Yurok Tribal fishery catch, a San Pablo sport fishery tag returns, and Columbia River commercial landings (BRT 2005). Using San Pablo sport fishery tag recovery data, the California Department of Fish and Game produced a population time series estimate for the southern DPS. This data suggest that green sturgeon abundance may be increasing, but the data showed no significant trend. The data set is not particularly convincing, however, as it suffers from inconsistent effort and since it is unclear whether summer concentrations of green sturgeon provide a strong indicator of population performance (BRT 2005). Although there is not sufficient information available to estimate the current population size of southern green sturgeon, catch of juveniles during state and federal salvage operations in the Sacramento delta are low in comparison to catch levels before the mid-1980s.

Hearing

We do not have specific information on hearing in green sturgeon. However, Meyer and Popper (Meyer and Popper 2002) recorded auditory evoked potentials to pure tone stimuli of varying frequency and intensity in lake sturgeon and reported that lake sturgeon detect pure tones from 100 to 2000 Hz, with best sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (Astronotus ocellatus) and goldfish (Carassius auratus) and reported that the auditory brainstem responses for the lake sturgeon are more similar to the goldfish (which is can hear up to 5000 Hz) than to the oscar (which can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered in the same auditory group as the goldfish.

Lovell et al. (Lovell et al. 2005) also studied sound reception in and the hearing abilities of paddlefish (Polyodon spathula) and lake sturgeon (Acipenser fulvescens). They concluded that both species were responsive to sounds ranging in frequency from 100 to 500 Hz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of southern green sturgeon.

Critical Habitat

Critical habitat was designated for this species on October 9, 2009 (74 FR 52300). Designated habitat includes Coastal U.S. marine waters within 60 fathoms (110 m) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor).

The principle biological or physical constituent elements essential for the conservation of southern green sturgeon in freshwater include: food resources; substrate of sufficient type and size to support viable egg and larval development; water flow, water quality such that the chemical characteristics support normal behavior, growth and viability; migratory corridors; water depth; and sediment quality. Primary constituent elements of estuarine habitat include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality. The specific primary constituent elements of marine habitat include food resources, water quality, and migratory corridors.

Critical habitat of southern green sturgeon is threatened by several anthropogenic factors. Four dams and several other structures currently are impassible for green sturgeon to pass on the Sacramento, Feather, and San Joaquin rivers, preventing movement into spawning habitat. Threats to these riverine habitats also include increasing temperature, insufficient flow that may impair recruitment, the introduction of striped bass that may eat young sturgeon and compete for prey, and the presence of heavy metals and contaminants in the river.

Southern Population of Pacific Eulachon

Eulachon is an anadromous species that spawns in the lower portions of certain rivers draining into the northeastern Pacific Ocean ranging from Northern California to the southeastern Bering Sea in Bristol Bay, Alaska (NMFS 2010a; Schultz and DeLacy 1935).

Distribution

Eulachon have been described as common in Grays Harbor and Willapa Bay on the Washington coast, “abundant” in the Columbia River, common in Oregon’s Umpqua River, and abundant in the Klamath River in northern California. They have been described as rare in Puget Sound and Skagit Bay in Washington; Siuslaw River, Coos Bay, and Rogue River in Oregon; and Humboldt Bay in California (Emmett et al. 1991). However, Hay and McCarter (2000) and Hay (2002) identified 33 eulachon spawning rivers in British Columbia and 14 of these were classified as supporting regular yearly spawning runs.

Population Structure

The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to, and including, the Mad River in California (75 FR 13012). The southern population of Pacific eulachon consists of several core populations that include populations in the Columbia and Fraser Rivers with smaller populations in several other river systems in Canada, including the Nass and Skeena Rivers. Within the Columbia River Basin, the major and most consistent spawning runs return to the mainstem of the Columbia River (from just upstream of the estuary, river mile 25, to immediately downstream of Bonneville Dam, river mile 146) and in the Cowlitz River. Periodic spawning also occurs in the Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers (tributaries to the Columbia River). Historically, there may have been a population in the Klamath River (75 FR 13012).

Natural Threats

Eulachon have numerous avian predators including harlequin ducks, pigeon guillemots, common murres, mergansers, cormorants, gulls, and eagles. Marine mammals such as humpback whales, orcas, dolphins, Steller sea lions, California sea lions, northern fur seals, harbor seals, and beluga whales are known to feed on eulachon. During spawning runs, bears and wolves have been observed consuming eulachon. Fishes that prey on eulachon include white sturgeon, spiny dogfish, sablefish, salmon sharks, arrowtooth flounder, salmon, Dolly Varden char, Pacific halibut, and Pacific cod. In particular, eulachon and their eggs seem to provide a significant food source for white sturgeon in the Columbia and Fraser Rivers (75 FR 13012).

Anthropogenic Threats

Southern eulachon are primarily threatened by increasing temperatures in the marine, coastal, estuarine, and freshwater environments of the Pacific Northwest that are at least causally related to climate change; dams and water diversions, water quality degradation, dredging operations in the Columbia and Fraser Rivers; commercial, recreational, and subsistence fisheries in Oregon and Washington that target eulachon; and bycatch in commercial fisheries.

Eulachon are particularly vulnerable to capture in shrimp fisheries in the United States and Canada as the marine areas occupied by shrimp and eulachon often overlap. In Oregon, the bycatch of various species of smelt (including eulachon) has been as high as 28 percent of the total catch of shrimp by weight (Hannah and Jones 2007). There are directed fisheries in Alaska state waters for eulachon in Upper Cook Inlet, the Copper River area, and in southeast Alaska. There has been little commercial activity in recent years, due to either lack of interest or closures resulting from concerns over diminished spawning runs, but there is potential for substantial amounts of harvest (Ormseth and Vollenweider 2007).

Status

The southern population of eulachon was listed as threatened on 18 March 2010 (75 FR 13012).

Hearing

We do not have specific information on hearing in eulachon, but we assume that they are hearing generalists whose hearing sensitivities would be similar to salmon. Species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available on this group resulted from studies of the hearing capability of Atlantic salmon (Salmo salar), which has relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the eulachon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008).

Critical Habitat
Critical habitat was designated for this species on October 20, 2011 (76 FR 65324). Designated critical habitat encompasses 16 specific areas within the states of California, Oregon, and Washington. The designated areas are a combination of freshwater creeks and rivers and their associated estuaries, comprising approximately 539 km (335 mi) of habitat.

Critical habitat is designated to include the following areas in California, Oregon, and Washington:

(1) Portions of the Mad River, Red wood Creek and Klamath Rivers in California; (2) Portions of the Umpqua River, Tenmile Creek, Sandy River, Columbia River, and Grays River in Oregon; and (3) Portions of Skamokawa Creek, Elochoman River, Cowlitz River, Toutle River, Kalama River, Lewis River, East Fork of the Lewis River, Quinault River Quinault River and Elwha River in Washington. All of these rivers/creeks except for the Mad River, Red wood Creek, Klamath River, Umpqua River, Tenmile Creek, Quinault River and Elwha River are tributaries within the Columbia River.

These areas contain physical or biological features essential to the conservation of the DPS, including (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Critical habitat of southern eulachon is threatened by several anthropogenic factors. Dams and several other structures such as on the Columbia and Elwha Rivers currently are impassible for eulachon to pass upstream, preventing movement into spawning habitat. Threats to these riverine habitats also include increasing temperature, insufficient flow that may impair recruitment and the presence of heavy metals and contaminants in the river.

Environmental Baseline

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

Some of those activities, most notably commercial whaling, occurred extensively in the past, ended, and no longer appear to affect the whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect listed species. The following discussion summarizes the principal phenomena that are known to affect the likelihood that these endangered and threatened species will survive and recover in the wild.

Natural Mortality

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

Neonate, juvenile, and adult Steller sea lion mortality result from disease caused by bacteria (Leptospira and Chlamydiia, etc. and viruses (seal herpes virus). Causes of pup mortality include drowning, starvation caused by separation from the mother, crushing by larger animals, disease, predation, and biting by females other than the mother (Edie 1977; Orr and Poulter 1967). Pup mortality on rookeries has not been thoroughly studied. Predation by killer whales and sharks also occur but the possible impact of these predators is unknown. Parasites of Steller sea lions include intestinal cestodes; trematodes in the intestine and bile duct of the liver; nematodes in the stomach, intestine, and lungs; acainthocephalans in the intestine; acarian mites in the nasopharynx and lungs; and an anopluran skin louse(Dailey and Brownell 1972; Dailey and Hill 1970).

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

Listed fish are also affected by predation. Eulachon have numerous avian predators including harlequin ducks, pigeon guillemots, common murres, mergansers, cormorants, gulls, and eagles. Marine mammals such as humpback whales, orcas, dolphins, Steller sea lions, California sea lions, northern fur seals, harbor seals, and beluga whales are known to feed on eulachon. Green sturgeon eggs and larvae are likely preyed upon by a variety of larger fish and animals, while sub-adult and adult sturgeon may occasionally be preyed upon by sharks, or other large body predators.

Human-Induced Mortality

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

Species Act of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were captured and killed in the Pacific Ocean with an unknown number of additional animals captured and killed before 1900 (Perry et al. 1999a). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada. 1972); 46,000 fin whales between 1947-1987 (Rice 1984); and 25,800 sperm whales (Barlow et al. 1997). North Pacific right whales once numbered 11,000 animals but commercial whaling has now reduced their population to 29-100 animals (Wada 1973).

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale species, Steller sea lions and sea turtles. For example, in 1978, Nishimura and Nakahigashi (1990) estimated that 21,200 turtles, including greens, leatherback turtles, loggerheads, olive ridleys and hawksbills, were captured annually by Japanese tuna longliners in the Western Pacific and South China Sea, with a reported mortality of approximately 12,300 turtles per year. Using commercial tuna longline logbooks, research vessel data and questionnaires, Nishimura and Nakahigashi (1990) estimated that for every 10,000 hooks in the Western Pacific and South China Sea, one turtle is captured, with a mortality rate of 42 percent. NMFS has observed 3,251 sets, representing approximately 3,874,635 hooks (data from February 1994 through December 31, 1999). The observed entanglement rate for sperm whales would equal about 0.31 whales per 1,000 sets or 0.0002 per 1,000 hooks. At those rates, we would expect about 200 sperm whales entanglements per 1,000 sets. However, only one sperm whale has been entangled in this gear; as a result, NMFS believes that the estimated entanglement rate substantially overestimates a sperm whale’s actual probability of becoming entangled in this gear and the potential hazards longline gear poses to sperm whales.

Mixed stock fisheries along the Pacific coast annually harvested an average of approximately 1,350 green sturgeon during 1994–2001 (Adams et al. 2002). We do not know whether or to what degree these fisheries harvested southern green sturgeon, but the distribution of southern green sturgeon would expose them to these fisheries. Eulachon are particularly vulnerable to capture in shrimp fisheries in the United States and Canada as the marine areas occupied by shrimp and eulachon often overlap. In Oregon, the bycatch of various species of smelt (including eulachon) has been as high as 28 percent of the total catch of shrimp by weight (Hannah and Jones 2007).

Habitat Degradation and Loss

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

The impacts from these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (*e.g.*, DDT, PCBs, and polyaromatic hydrocarbons) and immunosuppression (De Swart et al. 1996; Harder et al. 1992; Ross et al. 1995). Organochlorines are chemicals that tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing, some of these contaminants can be passed from the mother to developing offspring. Contaminants like organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (O'Hara and Rice 1996; O'Hara et al. 1999; O'Shea and Brownell Jr. 1994). Adverse health effects have also been linked to contaminants in fish. Sturgeon species generally accumulate contaminants in their tissues. White sturgeon from the Kootenai River have been found to contain aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, zinc, DDE, DDT, PCBs, and other organochlorines (Kruse and Scarnecchia 2002). Mercury has also been identified from white sturgeon of the lower Columbia River (Webb et al. 2006).

The Sacramento River contains the only known green sturgeon spawning population for the southern DPS due to a substantial loss of spawning habitat behind Keswick and Shasta dams (USFWS 1995b, historical habitat data summarized in Lindley et al. 2004). It is unlikely that green sturgeon reproduced in their current spawning area under the historical temperature regime that occurred before the construction of Shasta and Keswick dams, however, at present, water temperatures in the current spawning area are lower due to releases from Shasta Dam making spawning possible. Other potential adult migration barriers to green sturgeon include the Red Bluff Diversion Dam (RBDD), Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and the Delta Cross Channel Gates on the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River.

Climate Change

The effects of climate change on marine species in the action area remain largely unknown. Gaps in information on species movements and distribution, the difficulty involved with studying highly mobile animals such as marine mammals and turtles, as well as insufficient historical information and long-term data sets on habitat and distribution all complicate any potential conclusions on the effects of climate change for these species (Kintisch 2006; Simmonds and Isaac 2007). However, possible effects of climatic variability include the following: alteration of ecological community composition and structure, possibly resulting in species relocating from areas they currently use in response to changes in oceanic conditions; use of an altered range as temperature-dependent distribution limits change; changes to migration patterns or community structure; changes to species abundance; increased susceptibility to disease and contaminants; alterations to prey composition and availability; and altered timing of breeding (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006; McMahon and Hays 2006). Such changes could affect reproductive success and survival, and therefore have consequences for the recovery of marine mammals, sea turtles and fish (Robinson et al. 2005; Learmonth et al. 2006; Cotté and Guinet 2007).

Natural and Anthropogenic Sounds
The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson et al. 1995).

Ambient Noise
Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994a; NRC 2000; NRC 2003; NRC 2005; Richardson et al. 1995). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta et al.(2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (1976) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century.

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

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick 1983). At any given time and place, the ambient noise level is a mixture of these noise types. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sound levels tend to be higher than when the bottom is absorptive.

McDonald et al. (2006) reported that wind-driven wave noise was an important contributor to ocean ambient noise in the 200–500 Hz band. Ross (1976) and Wenz (Wenz 1962) compared wind data for five northeast Pacific sites and concluded wind was the primary cause for differences in average ambient noise levels above 200 Hz. Assuming the observed increases in ambient noise these authors reported are representative of the larger coast, McDonald et al. (2006) concluded that the breakpoint between shipping and wind dominated noise has probably now moved well above 200 Hz.

Measurements taken at San Nicholas Island, which were considered representative of patterns that would occur across the Pacific Coast of Washington, identified seasonal differences in ocean ambient levels due to seasonal changes in wind driven waves, biological sound production, and shipping route changes (McDonald et al. 2006). The strongest seasonal signal at the San Nicolas South site was attributed to blue whale singing (Burtenshaw et al. 2004) which had a broad peak near 20 Hz in the spectral data (because fin whales occur in the area throughout the year, the seasonal difference was attributed to blue whales, which only occur in the areas seasonally). When the band of fin whale calls were excluded, the average February 2004 ambient pressure spectrum level was 10–14 dB higher than the February 1965 and 1966 levels over the 10–50 Hz band. Above 100 Hz, there was a 1–2 dB difference between the two sets of February noise data (McDonald et al. 2006).

Ship Strikes

Collisions with commercial ships are an increasing threat to many large whale species, particularly because shipping lanes cross important large whale breeding and feeding habitats or migratory routes. Based on the data available from Douglas et al. (2008), Jensen and Silber (2004), and Laist et al. (2001), there have been at least 25 incidents in which marine mammals are known to have been struck by ships in the Puget Sound region and southwestern British Columbia. The marine mammals that were involved in almost half of these incidents died as a result of the strike and they suffered serious injuries in four of those strikes.

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

Anthropogenic Noise

The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson et al. 1995).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994b; NRC 2000; NRC 2003; NRC 2005; Richardson et al. 1995). As discussed in the preceding section, much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984) 1984), but the long-term effects, if any, are unclear or not detectable. Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Commercial Shipping

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (NRC 2003; Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (Ross 1976) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. Within the action area identified in this Opinion, the vessel sound inside the western half of the Strait of Juan de Fuca and off the Washington coast comes from cargo ships (86 percent), tankers (6 percent), and tugs (5 percent) (NMFS 2008a citing Mintz and Filadelfo 2004a, 2004b)).

Galli et al. (2003) measured ambient noise levels and source levels of whale-watch boats in Haro Strait. They measured ambient noise levels of 91 dB (at frequencies between 50-20,000 Hz) on extremely calm days (corresponding to sea states of zero) and 116 dB on the roughest day on which they took measures (corresponding to a sea state of ~5). Mean sound spectra from acoustic moorings set off Cape Flattery, Washington, showed that close ships dominated the sound field below 10 kHz while rain and drizzle were the dominant sound sources above 20 kHz. At these sites, shipping noise dominated the sound field about 10 to 30 percent of the time but the amount of shipping noise declined as weather conditions deteriorated. The large ships they measured produced source levels that averaged 184 dB at 1 m +- 4 dB, which was similar to the 187 dB at 1 m reported by Greene (1995).

Commercial and Private Marine Mammal Watching

In addition to the federal vessel operations, private and commercial shipping vessels, vessels (both commercial and private) engaged in marine mammal watching also have the potential to impact whales in the proposed action area. A study of whale watch activities worldwide has found that the business of viewing whales and dolphins in their natural habitat has grown rapidly over the past decade into a billion dollar ($US) industry involving over 80 countries and territories and over 9 million participants (Hoyt 2001). In 1988, the Center for Marine Conservation and the NMFS sponsored a workshop to review and evaluate whale watching programs and management needs (CMC and NMFS 1988). That workshop produced several recommendations for addressing potential harassment of marine mammals during wildlife viewing activities that include developing regulations to restrict operating thrill craft near cetaceans, swimming and diving with the animals, and feeding cetaceans in the wild.

Since then, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines which in part state that viewers should: (1) remain at least 50 yards from dolphins, porpoise, seals, sea lions and sea turtles and 100 yards from large whales; (2) limit observation time to 30 minutes; (3) never encircle, chase or entrap animals with boats; (4) place boat engine in neutral if approached by a wild marine mammal; (5) leave the water if approached while swimming; and (6) never feed wild marine mammals. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states that: "*NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals or sea lions in the wild. This includes attempting to swim with, pet, touch or elicit a reaction from the animals.*"

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic. Another concern is that preferred habitats may be abandoned if disturbance levels are too high.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. The whales' responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions.

The Impact of the Baseline on Listed Resources

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

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

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

Few of the anthropogenic phenomena that represent potential risks to whales in the Action Area seem likely to kill whales. Instead, most of these phenomena — close approaches by whale-watching and research vessels, anthropogenic sound sources, pollution, and many fishery interactions — would affect the behavioral, physiological, or social ecology of whales in the region. Reports suggest that the response of whales to many of the anthropogenic activities in the Action Area are probably short-lived, which suggests that the responses would not be expected to affect the fitness of individual whales. Most of these reports relate to humpback whales during their winter, breeding season; there are very few reports of the behavioral responses of other whale species to human activity in the action area.

Gauthier and Sears (1999), Weinrich et al. (1992), Clapham and Mattila (1993), Clapham et al. (1993) concluded that close approaches for biopsy samples or tagging did cause humpback whales to respond or caused them to exhibit “minimal” responses when approaches were “slow and careful.” This caveat is important and is based on studies conducted by Clapham and Mattila (1993) of the reactions of humpback whales to biopsy sampling in breeding areas in the Caribbean Sea. These investigators concluded that the way a vessel approaches a group of whales had a major influence on the whale’s response to the approach; particularly cow and calf pairs. Based on their experiments with different approach strategies, they concluded that experienced, trained personnel approaching humpback whales slowly would result in fewer whales exhibiting even a minimal response.

At the same time, several lines of evidence suggest that these human activities might have greater consequences for individual whales (if not for whale populations). Several investigators reported behavioral responses to close approaches that suggest that individual whales might experience stress responses. Baker et al. (1983) described two responses of whales to vessels, including: (1) “horizontal avoidance” of vessels 2,000 to 4,000 meters away characterized by faster swimming and fewer long dives; and (2) “vertical avoidance” of vessels from 0 to 2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins (1981c) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions.

Bauer (1986) and Bauer and Herman (1986) studied the potential consequences of vessel disturbance on humpback whales wintering off Hawai′i. They noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels.

Baker et al. (1983) and Baker and Herman (1986) summarized the response of humpback whales to vessels in their summering areas and reached conclusions similar to those reached by Bauer and Herman (1986): these stimuli are probably stressful to the humpback whales in the action area, but the consequences of this stress on the individual whales remains unknown. Studies of other baleen whales, specifically bowhead and gray whales document similar patterns of short-term, behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel’s engine was turned on even at distance of approximately 3,000 ft (900 m). Weinrich et al. (1992) associated “moderate” and “strong” behavioral responses with alarm reactions and stress responses, respectively.

Beale and Monaghan (2004a) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity. None of the existing studies examined the potential effects of numerous close approaches on whales or gathered information on levels of stress-related hormones in blood samples that are more definitive indicators of stress (or its absence) in animals.

There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004a; Frid 2003; Frid and Dill 2002; Gill and Sutherland 2001; Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combination of these responses (Frid and Dill 2002; Romero 2004; Sapolsky 2000; Walker et al. 2005). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996; Müllner et al. 2004), and the death of individual animals (Daan et al. 1996).

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

Effects of the Proposed Actions

Pursuant to Section 7(a)(2) of the ESA, federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed survey and issuance of the IHA by NMFS for "takes" of marine mammals during the seismic studies would expose listed species to seismic airgun pulses, as well as sound emitted from a multi-beam bathymetric echosounder and sub-bottom profilers. 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, and lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment is to determine if it is reasonable to expect the proposed activities to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned about behavioral disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences. The proposed IHA would authorize non-lethal "takes" by harassment of listed species during survey activities. The ESA does not define harassment nor has NMFS defined the term pursuant to the ESA through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, "...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's regulatory definition of "harass"[6] pursuant to the ESA. For this Opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of disturbance or injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

Evidence Available for the Assessment

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

Assumptions

In conducting the effects analysis for the proposed actions, several assumptions must be made due to gaps in available information. Definitive statements on the effects of sound from the proposed activities are complicated because detection of sounds by these animals depends on the acoustic properties of the source (spectral characteristics and intensity), transmission characteristics of the water, and sensitivity of hearing in each species. Furthermore, responses to sounds can be highly variable between individuals and may depend on an animal's activity at time of exposure, motivation for that activity, age, and any habituation or sensitization to sounds.

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

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[6] 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)

Based on the assumptions for what the different taxa can hear, we expect that blue, fin, and sei whales would be sensitive to low frequency sounds and that humpback whales and Steller sea lions would be sensitive to low- to mid-frequency sounds. Sperm whales would be sensitive to mid- to high-frequency sounds. Sea turtles would be sensitive to lower frequency sounds such as those produced by seismic airguns. Green sturgeon and the eulachon would be sensitive to low frequency sounds.

Published studies of these and other species' responses or lack of response to anthropogenic sounds are available; we assume that responses noted in these studies mean that individuals of similar species, for which no studies are available, would respond similarly. To examine the potential for sounds to mask the detection of natural sounds at similar frequencies, or to induce temporary or permanent reductions in an individual's hearing threshold, the analysis examined results from controlled exposure studies. Given fundamental similarities in ear anatomy among marine mammals, sperm whales were expected to experience similar types of physiological changes when exposed to similar sounds. There is no information regarding leatherback sea turtle hearing sensitivities. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtles (their best hearing sensitivity will be in the low frequency range from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies), and therefore, we will assume information related to other sea turtle species applies to leatherback sea turtles as well. The is also no information specific to green sturgeon hearing sensitivities but existing information for other species of sturgeon are available and we assume that green sturgeon hearing will be similar to those of other species of sturgeon. For eulachon, we assumed that their hearing sensitivities are similar to salmonids for which information is available, albeit limited.

Potential Stressors

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

- disturbance from acoustic energy associated with airguns and sonars (multi-beam echosounder, sub-bottom profiler),
- disturbance from sounds generated by vessel engines; and
- ship strikes.

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

Disturbance from Acoustic Sources

Airgun Array

Sounds produced by the airguns are short pulses occurring for less than one second. For the proposed activity, the pulse duration is 0.1s and would occur every 12 s or every 37.5 m as the *Langseth* travels 11 km/h. Most of the energy in the sound pulses emitted by airguns occurs at low frequencies (0-188 Hz), with considerably lower levels for frequencies above 1,000 Hz, and smaller amounts of energy emitted up to ~150 kHz (LGL Ltd. 2012).

As described in LGL, Ltd (2012), airguns function by venting high-pressure, compressed air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure oscillations. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle, and coalesce pressure levels into one pulse. The resulting downward-directed pulse has a fraction of a second duration, with only one strong positive and one strong negative peak pressure (Caldwell and Dragoset 2000). Although the pulse produced by an airgun is directed downward, sound also propagates horizontally but at lower sound levels than in the vertical direction.

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

As mentioned in the *Description of the Proposed Actions* section, the airgun array source output (downward) from the airgun array would be 259 dB re 1 μPa • m (0-pk) and 265 dB re 1 μPa • m (pk-pk). The source levels for airgun arrays are nominal source levels for sound directed downward, which represent the theoretical source level close to a single point source emitting the same sound as that emitted by the arrays. The actual source for airgun arrays is a distributed sound source (i.e., multiple guns) rather than a single point source. In order to communicate the levels of sound from the array, back calculations must be made from far field measurements to acquire a theoretical value of the source level. This theoretical source level is never actually realized for airgun arrays because airguns are distributed over several meters; the highest sound levels actually measurable in the water close to the airgun array (such as one meter) will never be as high as the nominal source level. For the *Langseth* array, the highest sound level actually measurable at any location in the water from the airguns is estimated at approximately 265 dB (pk-pk). Given the directional nature (downward) of the sound propagating from these airgun arrays, the effective source level for sound propagating in near-horizontal directions will be substantially lower than the nominal source level, although this horizontal propagation is known to occur over many kilometers from the source. The theoretical point source estimates for airgun arrays are useful, however, for accurately reflecting received levels in the far-field (at more than 75 to 100 m; Caldwell and Dragoset 2000).

Pathways for received seismic sound include direct paths from the source, indirect paths that include reflection from the sea surface and bottom, and often indirect paths including segments propagating through bottom sediments. Sound propagating via indirect paths travels longer distances and often arrives later than sounds received via a direct path. However, sound may also travel faster through sediments than in water, and thus may arrive earlier than the direct arrival despite traveling a greater distance. Variations in travel time lengthen the duration of a received pulse; seismic pulses of about 10 to 20 ms in duration at the source can be longer when received at long horizontal distances. For example, for an airgun array operating in the Beaufort Sea, pulse duration was about 300 ms at a distance of 8 km, 500 ms at 20 km, and 850 ms at 73 km (Greene and Richardson 1988). Seasonally and spatially variable environmental characteristics also play a role in determining the frequencies and sound levels that a marine mammal may experience when exposed to propagating airgun sounds (DeRuiter and Doukara 2012).

Multi-beam Bathymetric Echosounder (MBES)

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

For deep-water operation, each "ping" consists of eight (in water depths greater than 1000 m) or four (in water depths less than 1000 m) successive fan-shaped transmissions which ensonifies a sector that extends 1° fore-aft. The successive transmissions span an overall cross-track angular extent of about 150°, with 2-ms gaps between pings for successive sectors. Continuous wave signals (waves of constant energy and frequency) increase from 2 to 15 ms long in water depths up to 2600 m and frequency-modulated (FM) chirp signals up to 100 ms long are used in water depths greater than 2,600 m.

Sub-Bottom Profilers (SBP)

The *Langseth* is equipped with a Knudsen Chirp 3260 sub-bottom profiler to provide information about the sea floor. The SBP would operate simultaneously with the airgun array and the MBES. Energy from the SBP is directed downward by a hull-mounted 3.5 kHz transducer and varies with water depth. The SBP has a maximum source level of 204 dB re 1 μPa but varies with water depth. The beam is transmitted as a 27 degree cone, with pulse duration of up to 64 ms. The interval between SBP pulses is 1 s, with a common mode of operation being five pulses at 1-s intervals followed by a 5-s pause.

The *Oceanus* is also equipped with a SBP that will be in use while underway and during OBS deployment and retrieval. The Knudsen 320B/R SBP is hull-mounted and operates at 3.5 and/or 12 kHz. The energy from the SBP is directed downward via a hull-mounted 3.5-kHz transducer array. The maximum power output of the 320B/R is 10 kilowatts for the 3.5-kHz section and 2 kilowatts for the 12-kHz section. The pulse length for the 3.5-kHz section of the 320B/R is 0.8–24 ms, and will usually be 6, 12, or 24 ms at the water depths at the study sites and in transit from Astoria. The pulse interval is 0.8–1.5 sec. The source level for the 320B/R is calculated to be 211 dB re 1 μPa·m; however, the system is rarely operated above 80% power level.

While deploying and retrieving OBSs the *Oceanus* would operate a Knudsen 3260 SBP and/or a Knudsen 320B/R SBP. The Knudsen 320B/R SBP is a dual-frequency transceiver designed to operate at 3.5 and/or 12 kHz. The energy from the SBP is directed downward via a hull-mounted 3.5-kHz transducer array. The maximum power output of the 320B/R is 10 kilowatts for the 3.5-kHz section and 2 kilowatts for the 12-kHz section. The pulse length for the 3.5-kHz section of the 320B/R is 0.8–24 ms, and will usually be 6, 12, or 24 ms at the water depths at the study sites and in transit from Astoria. The pulse interval is 0.8–1.5 sec. Using the Sonar Equations and assuming 100% efficiency in the system (impractical in real world applications), the source level for the 320B/R is calculated to be 211 dB re 1 μPa·m; however, the system is rarely operated above 80% power level.

Disturbance from Vessel Noise and Risk of Ship Strike

The use of airguns requires a vessel to tow the array through the water column. The *Langseth* will tow the airgun array at speeds of 4-5 km/hr. A moving vessel poses some risk of disturbance and ship strike to large whales, pinnipeds and sea turtles. Sounds emitted by large vessels can be characterized as low-frequency, continuous, and tonal, and sound pressure levels at a source will vary according to speed, burden, capacity and length (Richardson *et al.* 1995). Although the *Langseth* contains quieting technologies that reduce their acoustic signature (relative to the acoustic signature of similarly-sized vessels) marine animals would still detect the *Langseth* and its acoustic equipment. Ona et al (2007) suggests that research vessels equipped with quieting technologies can result in increased behavioral reactions.

For vessels, the set of variables that help determine whether marine mammals are likely to be disturbed include: (1) the number of vessels in the area and the animal's assessment of the risks associated with those vessels; (2) the distance between vessels and marine mammals; (3) the vessel's speed and path; (4) the predictability of the vessel's path; (5) noise associated with the vessel and the rate at which the engine noise increases; and (6) the type of vessel.

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

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

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

Behavioral changes such as those demonstrated by marine mammals upon exposure to approaching vessels (e.g., avoidance, altered swimming speed and direction) also occur in fish (Sarà et al 2007, Sand et al 2008). As with marine mammals it is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two. Is has been suggested, however, that ships produce high levels of infrasonic and low-frequency noise in the range of fish hearing capabilities and that those frequencies may be responsible for observed reactions (Sand et al 2008). Since green sturgeon and eulachon are most sensitive to low-frequency sounds, we would expect these species to hear vessels in the Action Area.

Because the *Langseth* would travel at speeds of about 4-5km/hr the vessel would have a rather predictable path surveying the tracklines with occasional turns and occasional starting and stopping of acoustic activity. Deploying and retrieving OBSs would also result in occasional starting and stopping but still a predictable path. This steady speed and routine pattern would create a steady increase or decrease in noise level making the two vessels' whereabouts predictable. Because of the slow speeds during the survey and we would not expect vessel collisions to occur. We expect listed fish species to change swimming direction either vertically or horizontally and avoid the vessels. We expect large whales and Steller sea lions to be able to detect the *Langseth* and *Oceanus*. Large whales, leatherback sea turtles and Steller sea lions should also be detected by the PSVOs. Further, vocalizing marine mammals should be detected by PAM, further minimizing the risk of strikes.

Exposure Analysis

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

NMFS applies certain acoustic thresholds to help determine at what point during exposure to seismic airguns (and other acoustic sources) marine mammals are considered "harassed", pursuant to the MMPA (65 FR 16374; March 28, 2000). These thresholds are used to develop safety radii around a source and the necessary shut-down criteria, and are applied to sea turtles as well as marine mammals for the proposed activities. Seismic airgun noise can propagate substantial distances (e.g., Nieukirk *et al.* 2004), although at lower sound levels than the designated acoustic thresholds. L-DEO estimated the safety radii around the proposed *Langseth* operations for the survey using an acoustic propagation model, adjusted with empirical data gathered in the Gulf of Mexico in 2009. The modeled distances from the airgun array and the mitigation airgun from which sound levels (rms) might be received in water depths encountered during the survey are listed in the Table 2 below.

The exposure analysis for this consultation is concerned with the numbers of blue, fin, sei, humpback and sperm whales, Steller sea lions, leatherback sea turtles, southern green sturgeon and southern eulachon likely to be exposed to received levels that disrupt one or more behavioral patterns that are essential to the animal's life history or its contribution to its population. We are also concerned with the likely exposure to received levels greater than 180 dB re 1 µPa (rms), which constitutes the shut-down criterion for cetaceans and pinnipeds that is also applied here to sea turtles and received levels greater than 190 dB re 1 µPa (rms) for Steller sea lions. Currently, there are no estimated received levels to indicate at what point during exposure to seismic airguns (and other acoustic sources) green sturgeon or eulachon are considered "harassed".

Table 2: Distances to Estimated Radii for the Survey

			Estimated RMS Radii (km)		
Source and Volume	**Tow Depth (m)**	**Water Depth***	190 dB	180 dB	160 dB
Single Bolt airgun (40 in^3)	6-15	Deep	0.01	0.04	0.39
		Intermediate	0.02	0.06	0.58
		Shallow	0.15	0.29	1.05
4 strings 36 airguns (6600 in^3)	9	Deep	0.40	0.94	3.85
		Intermediate	0.55	1.54	12.20
		Shallow	0.68	2.14	20.55

This maximum distance falls within the visibility range from the *Langseth.* When stationed on the observation platform on the *Langseth*, eye level is about 21.5 m (70.5 ft) above sea level and PSVOs would be able to see around the entire vessel and to a distance of about 10 km with the naked eye, 5 km or further with the Big Eyes and 2-3 km or further with the reticle binoculars in optimal weather conditions. The 180 and 190 dB radii will not always reach these distances, as shorter radii will occur during the use of smaller numbers of airguns (e.g., the use of a single airgun during turns or power-down procedures). However, based on these maximum propagation distances, our concern is the probability of ESA-listed whales and leatherback sea turtles and Steller sea lions, occurring within the 180 and 190- dB ranges, respectively from the *R/V Langseth* during seismic operations.

Marine Mammals

The IHA application contained the estimated number of ESA-listed whales and Steller sea lions that might be exposed to received levels equal to or greater than 160 dB re 1 µPa (rms) in the Action Area (LGL Ltd. 2012). LGL, Ltd (2012) states that if an individual marine mammal stayed in the survey area during the entire survey it would be exposed an average of two times. These estimates assume that no animals would move away from the survey vessel.

The marine mammals (blue, fin, sei, humpback and sperm whale and Steller sea lions) exposure estimates are based on the best available density information and a planned ensonified area of ~23,089 km^2 for this survey. All estimated trackline distances include the maximum distances surveyed--the planned track lines plus the contingency track line, that would be within the 160-dB isopleth on one or more occasions during the survey. The resulting take estimates are listed in Table 3 below and are probably over estimates as they assume that no animals would move away from the sounds.

Table 3: Take Estimates for the Survey

Survey	Species	Take Estimate	Percent of Regional Population
Juan de Fuca	Blue	4	0.17
	Fin	30	0.18
	Sei	4	0.03
	Humpback	19	0.09
	Sperm	24	0.10
	Steller sea lions	303	0.46

Description of Listed Species and Designated Critical Habitat Exposed to Survey Activities

Blue Whales

Information available regarding blue whales indicates that whales in the Action Area during the June through July survey period are part of the eastern North Pacific population. The eastern North Pacific population feeds in California waters from June to November (Calambokidis et al. 1990; Mate et al. 1999). Although sightings are rare off Oregon, calls from blue whales have been heard (McDonald et al. 1995; Stafford et al. 1998; Von Saunder and Barlow 1999). Four blue whale sightings were reported during the Oregon/Washington portions of abundance surveys in 2008: one sighting occurred near (~45°N, 128°W) the southern Carbotte survey area (Barlow 2010). From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual whales that might be exposed to survey activities. We expect, however, that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Fin Whales

Information available regarding fin whales indicates that whales in the Action Area during the June through July survey period are part of the California/Oregon/Washington population.

Aggregations of fin whales are found year-round off southern and central California (Dohl et al. 1980, 1983; Forney et al. 1995; Barlow 1997) and in the summer off Oregon (Green et al. 1992). Vocalizations from fin whales have been detected year-round off northern California, Oregon, and Washington (Moore et al. 1998). At least 20 fin whale sightings were reported during the Oregon/Washington portions of the survey in 2008; several sightings occurred near the proposed survey areas (Barlow 2010). We expect that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Sei Whales

Information available regarding sei whales indicates that whales in the Action Area during the June through July survey period are part of the eastern north Pacific population. Only nine confirmed sightings of sei whales were made in California, Oregon, and Washington waters during extensive ship and aerial surveys between 1991- 2008 (Hill and Barlow 1992; Carretta and Forney 1993; Mangels and Gerrodette 1994; VonSaunder and Barlow 1999; Barlow 2003; Forney 2007; Barlow 2010). Green et al. (1992) did not report any sightings of sei whales in aerial surveys of Oregon and Washington. From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual whales that might be exposed to survey activities. We expect, however, that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Humpback Whales

Information available regarding humpback whales indicates that whales in the Action Area during the June through July survey period are part of the California/Oregon/Washington population that forages off those states during the survey period.

The humpback whale is the most common species of large cetacean reported off the coasts of Oregon and Washington from May to November, with highest numbers reported from May to September. No humpbacks have been observed there in the winter (Green et al. 1992; Calambokidis et al. 2000, 2004). Off Oregon and Washington, humpbacks occur primarily over the continental shelf and slope during the summer and fall, with few reported in offshore pelagic waters (Green et al. 1992, Calambokidis et al. 2004a). Humpbacks tend to concentrate off areas associated with upwelling, in particular along the southern edge of Heceta Bank (~44°N, 125°W), in the Blanco upwelling zone (~43°N), in Oregon. During aerial surveys conducted up to ~550 km off the Oregon/Washington coast, only one humpback whale was reported in offshore waters >200 m deep ~70 km west of Cape Blanco during the spring (Green et al. 1992). Encounter rates off Oregon/Washington during the summer were highest over the slope followed by shelf waters, with no sightings in offshore waters (Green et al. 1992). At least 12 humpback whale sightings were reported during the Oregon/Washington portions of the survey in summer/fall 2008; four sightings occurred in or near the Holbrook survey area (Barlow 2010).

From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual whales that might be exposed to survey activities. We expect, however, that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Sperm whales

Information available regarding sperm whales indicates that whales in the Action Area during the June through July survey period are part of the California/Oregon/Washington population. Green et al. (1992) reports that sperm whales are seen off Oregon in every season except winter while in California sperm whales are found year-round (Dohl et al. 1983; Barlow 1995; Forney et al. 1995 *in* LGL, Ltd 2012), especially between April to mid-June and between August to mid-November (Rice 1974). Based on abundance surveys conducted in 1991–2008, the estimated abundance of sperm whales off the coasts of Oregon and Washington is 329 (Barlow 2010). Three sperm whale sightings were reported in water depths >2000 m during the Oregon/ Washington portions of the survey in 2008 (Barlow 2010). Sperm whales are most likely to be encountered in the deep waters of the northern and southern Carbotte survey areas. From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual whales that might be exposed to survey activities. We expect, however, that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Steller sea lions

Information available regarding Steller sea lions indicates that the Stellers in the Action Area during the survey period are members of the eastern DPS of Steller sea lions.

Breeding adults occupy rookeries from late May to early July (NMFS 2008b). The eastern stock of Steller sea lion rookeries are located in southeast Alaska, British Columbia, Oregon, and California (Allen and Angliss 2011). Males arrive at rookeries in May to establish their territory and are soon followed by females. Breeding adults occupy rookeries from late May to early July (NMFS 2008b). Non-breeding males use haulouts or occupy sites at the periphery of rookeries during the breeding season (NRC 2003). Pupping occurs from mid May to mid July (Pitcher and Calkins 1981) and peaks in June (Pitcher et al. 2002). In Oregon, breeding occurs during the months of June and July (USFWS 2011).

Territorial males fast and remain on land during the breeding season (NMFS 2008b). Andrews et al. (2001) estimated that females foraged for generally brief trips (7.1–25.6 h) around rookeries, spending 49–76% of their time at the rookeries. Females with pups feed principally at night during the breeding season, and generally stay within 30 km of the rookeries in shallow (30–120 m) water (NMFS 2008b). Steller sea lion pups enter the water 2–4 weeks after birth (Sandegren 1970 in Raum-Suryan et al. 2002), but do not tend to move from their natal rookeries to haulouts with their mothers until they are 2–3 months old (Merrick et al. 1988 in Raum-Suryan et al. 2002). During the non-breeding season, sea lions may disperse great distances from the rookeries.

During surveys off the coasts of Oregon and Washington, Bonnell et al. (1992) noted that 89% of sea lions occurred over the shelf at a mean distance of 21 km from the coast, with the farthest sighting ~40 km from shore; all sightings occurred near or in waters <200 m deep.

Three rookeries and seven haul-out sites are located in Oregon; several haul-out sites are also located in Washington (NMFS 2008b). Jeffries et al. (2000) identified four haul-out sites in the Split Rock area (47.4°N); animals at these haulout locations are assumed to be immatures and non-breeding adults associated with rookeries in Oregon and British Columbia (Pitcher et al. 2007).

We expect that individuals within the Action Area would be foraging individuals representing non-breeding adults and juveniles of both sexes through early July as breeding males would be on the rookeries. Starting in early July through the remainder of the survey period individuals within the Action Area are foragers representing all ages, life stages and both sexes.

Mitigation measures and monitoring activities during the proposed survey include visual and passive acoustic monitoring, an exclusion zone within the 180 dB isopleth for cetaceans and leatherback sea turtles and the 190-dB isopleth for Steller sea lions, power-down and shut-down procedures and ramp-up procedures for airguns. These measures are expected to reduce the risk that ESA-listed whales and leatherback sea turtles would occur within the 180 dB radius and

Steller sea lions would occur within the 190 dB radius; therefore, any exposures that might occur are more likely to involve blue, fin, sei, humpback and sperm whales at received levels less than 180 dB re 1 μPa and Steller sea lions at received levels less than 190 dB re 1 μPa.

Leatherback Sea Turtles

Leatherbacks occur north of central California during the summer and fall, when sea surface temperatures are highest (Dohl et al. 1983; Brueggeman 1991). Some aerial surveys of California, Oregon, and Washington waters suggest that most leatherbacks occur in continental slope waters and fewer occur over the continental shelf.

Based on a recent study tracking mature females from both the eastern and western Pacific nesting populations of leatherback sea turtles, we assume that any leatherback sea turtles that would be exposed to survey activities would be mature female members of the eastern Pacific population (nesting along the west coast of Mexico and Central America) (Bailey et al 2012). Since the study did not track males or juvenile females, we assume that males of any age and immature females from both eastern and western Pacific populations could also be exposed to survey activities. These turtles could be migrating or foraging.

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

Southern Green Sturgeon DPS

Within the Action Area the Southern green sturgeon occupy coastal estuaries and coastal marine waters from southern Oregon to Washington, including Humboldt Bay, the lower Columbia river estuary, Willapa Bay and Grays Harbor. Limited spawning information suggests that adult green sturgeon migrate every 2-4 years from oceanic to fresh water from March to July, with peak activity from mid-April to mid-June. Green sturgeon spend a large portion of their lives in coastal marine waters as subadults and adults. Prior to reaching sexual maturity and between spawning years, subadults and adults occupy coastal estuaries adjacent to their natal rivers, as well as throughout the West coast, and coastal marine waters within 110 m depth. Green sturgeon inhabit certain estuaries on the northern California, Oregon, and Washington coasts during the summer. Particularly large aggregations of green sturgeon occur in the Columbia River estuary and Washington estuaries and include green sturgeon from all known spawning populations.

From the information available, we expect that Southern green sturgeon may be exposed to activities conducted during the June through July survey period. Individuals within the Action Area would be either foraging or ascending their natal rivers to spawn (March to July) during the survey time period. Exposed individuals represent juveniles, subadults and adults of both sexes.

Southern Pacific Eulachon DPS

Eulachon is an anadromous species that spawns in the lower portions of certain rivers along the California, Oregon and Washington coastlines. They are frequently found in Grays Harbor and

Willapa Bay on the Washington coast, the Columbia and Umpqua Rivers in Oregon and the Klamath River in northern California. They have been described as rare in Skagit Bay in Washington and the Siuslaw and Rogue Rivers and Coos Bay in Oregon.

Spawning generally occurs in January, February, and March in the Columbia River, the Klamath River, and the coastal rivers of Washington and Oregon. After about 20-40 days eggs hatch and are carried downstream by the currents to estuarine waters where they remain for several weeks or longer before entering the ocean. Juveniles move from shallow nearshore areas onto the continental shelf where they disperse widely to waters as deep as 182 m (597 ft). Little is known about eulachon movements in nearshore areas and the ocean.

From the information available, we expect that Southern Pacific eulachon may be exposed to activities conducted during the three surveys. Individuals within the Action Area would be foraging during the time period for the survey and represent juveniles, subadults and adults of both sexes.

Leatherback Critical Habitat

Designated critical habitat within the Action Area includes approximately 43,798 square km stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 64,760 square km stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The designated areas comprise approximately 108,558 square km of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet (80 m).

The primary constituent element essential for conservation of leatherback turtles is the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia, Phacellophora,* and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

Portions of the northern and southern survey tracklines occur within leatherback critical habitat while a third trackline occurs outside but parallel to leatherback critical habitat. We expect that prey resources within the Washington/Oregon portions of critical habitat will be exposed to survey activities. Critical habitat designated off California is not expected to be exposed to survey activities.

Green Sturgeon Critical Habitat

Critical habitat was designated for this species on October 9, 2009 (76 FR 65324). Designated habitat includes Coastal U.S. marine waters within 60 fathoms (110 m) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor).

The principle biological or physical constituent elements essential for the conservation of southern green sturgeon in freshwater include: food resources; substrate of sufficient type and size to support viable egg and larval development; water flow, water quality such that the chemical characteristics support normal behavior, growth and viability; migratory corridors; water depth; and sediment quality. Primary constituent elements of estuarine habitat include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality. The specific primary constituent elements of marine habitat include food resources, water quality, and migratory corridors.

The southern end of the southern trackline enters green sturgeon critical habitat. The southern end of the northern trackline approaches to within 50 km of designated critical habitat. We expect that prey resources within the Washington/Oregon portions of critical habitat will be exposed to survey activities. We do not expect critical habitat designated off California to be exposed to airgun signals.

we do not expect altered or reduced occurrence of prey species because of the increased weakening of the sound energy associated with airgun signals at increasing distances from the source. Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources are not likely to decline as a result of being exposed to survey activities nor likely to exclude green sturgeon from designated critical habitat or alter the primary constituent elements of the critical habitat in California. As a result, we will not consider the California portions of critical habitat in greater detail in the remainder of this Opinion.

Exposure to MBES and SBPs

The vessel-based MBES and SBPs used during the proposed activities are downward-directed with a narrow fore-aft beamwidth. Any exposures to sonar pings that might occur would be expected to be brief, given the short duration of pulses and the fact the vessel will be transiting and ensonifying a narrow swath. Any animal at depth near the trackline would be in the main beam for only one or two segments of the beam and is not likely to be exposed to repeated pings because of the narrow beamwidth; however, acoustic energy from the ping propagates outside of the main beam to form sidelobes. The sidelobes, are typically 20 dB to 30 dB below the main lobe level (Lurton and DeRuiter 2011).

Blue, humpback and sperm whales and Steller sea lions exhibit hearing at higher frequencies and sound pulses from the MBES (12 kHz) and SBP (3.5 kHz and possibly 12 kHz) would be audible to individuals within the extent of the ensonified beam and to some extent beyond. However, Kremser *et al.* (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal would have to pass at close range and be swimming at speeds similar to the vessel to be subjected to sound levels that could cause temporary threshold shifts. We assume the same would be true for Steller sea lions.

For sea turtles and listed fish, available information indicates detection of sounds in the low-frequency range below those produced by the MBES and SBP. Based on this information, these species exposed to received levels of MBES and SBPs (3.5 and 12 kHz) are not likely to detect these sounds, and therefore, will not respond to these sounds.

For critical habitat, information on prey species within that habitat indicates that species such as certain fish and invertebrates such as cephalopods detect sounds in the below those produced by the MBES and SBPs (3.5 and 12 kHz). Based on this information, these species are not likely to detect these sounds, and therefore, will not respond to these sounds.

RESPONSE ANALYSIS

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

Effects of exposure to airguns

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

Threshold Shifts

Few studies exist that examine hearing impairment in marine mammals or sea turtles resulting from exposure to a strong sound. An animal can experience temporary threshold shift (TTS) or permanent threshold shift (PTS). A threshold shift involves reduced sensitivity to sounds, requiring them to be stronger to be audible. Duration of TTS can be minutes, hours, or days, with eventual recovery to normal hearing thresholds. For sound exposures near the TTS onset threshold, hearing sensitivity recovers rapidly after exposure to the noise ends; however, few data on sound levels and durations necessary for mild TTS have been obtained for marine mammals, and none of the published data examine TTS elicited by exposure to multiple pulses of sound (LGL, Ltd 2012). PTS involves physical damage to the sound receptors in the ear, resulting in total or partial deafness, or impairment of hearing at specific frequency ranges. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal (Miller 2005).

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

For sperm whales, LGL, Ltd (2012) concluded from the available data that when exposed to single short pulses, the TTS threshold appears to be a function of the energy content of the pulse (Finneran et al. 2002, 2005). Given the available data, the received energy level of a single seismic pulse (with no frequency weighting) might need to be 186 dB SEL or ~196–201 dB re 1 μPa (rms) in order to produce brief, mild TTS. Exposure to several strong seismic pulses that each have received levels near 190 dB re 1 μPa (rms) might result in cumulative exposure of ~186 dB SEL and, thus, slight TTS, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. The distances from the *Langseth's* airguns at which the received energy level (per pulse, flat-weighted) would be expected to be greater than or equal to 190 dB re 1 μPa (rms) are estimated to range between 12 and 865 m depending on the survey (Table 1 page 9). For an odontocete closer to the surface, the maximum radius with greater than or equal to 190 dB re 1 μPa (rms) would be smaller. A higher level of sound is necessary to cause PTS. On an SEL basis, Southall et al. (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB for there to be risk of PTS. Thus, for cetaceans they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of ~198 dB re 1 μPa^2 s (15 dB higher than the TTS threshold for an impulse), where the SEL value is cumulated over the sequence of pulses. A cetacean would need to receive one or more pulses with peak pressure exceeding 230 (0-peak). A peak pressure of 230 dB re 1 μPa (3.2 bar m, 0-pk) would only be found within a few meters of the largest (360-in^3) airguns in the planned airgun array (Caldwell and Dragoset 2000) while 218 dB re 1 μPa could be received further away from the array.

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

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

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from more prolonged (non-pulse) exposures suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001). Southall et al. (2007) estimate that the PTS threshold could be a cumulative M-weighted SEL of ~186 dB re 1 μPa^2 s and ~218 dB peak pressure in the harbor seal exposed to impulse sound. This PTS threshold may or may not be correct for Steller sea lions. Mitigation measures mentioned above for whales would also apply to Steller sea lions and would help reduce the received level of any exposures that may occur and further minimize the risk of PTS or TTS.

Although leatherback sea turtles detect low frequency sound, the potential effects on sea turtle biology remain largely unknown (Samuel 2005). TTS in loggerhead sea turtles is reported to have been observed during studies by Moein *et al.* (1994). Turtle hearing was tested before, within 24 hours after, and two weeks after exposure to pulses of airgun sound. Moein *et al.* (1994) used an evoked potential method to test sea turtle hearing and concluded that the turtles exhibited some change in their hearing when tested within 24 hours after exposure (relative to pre-exposure hearing). The authors found that hearing had reverted to normal when tested two weeks after exposure. The size of the airgun used or the received sounds levels were not provided; therefore, the levels of airgun sounds that apparently elicited TTS are not known (NMFS 2006c). These findings indicate that TTS may occur in sea turtles exposed to seismic sources; however, turtles in the study were confined. Sea turtles at sea might exhibit avoidance behavior and, thus, reduced exposure to seismic pulses. For any sea turtles that exhibit little or no behavioural avoidance, or if turtles habituate to seismic noise such that avoidance reactions cease, these individuals could sustain hearing loss if exposed to high enough sound levels from seismic airguns (LGL Ltd. 2008). Mitigation measures mentioned above for whales would also apply to sea turtles and would help reduce the received level of any exposures that may occur and further minimize the risk of PTS or TTS.

For listed fish species TTS studies suggest that while TTS can occur it only occurs after long-term exposure at 170-180 dB re 1 μPa (rms) and only in species that have specialized hearing with relatively wide hearing ranges over 2 kHz and lower hearing thresholds (Popper and Hastings (2009b). Based on information gained from other species of sturgeon, we assume that green sturgeon have hearing sensitivities from 100 to 500 Hz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz (Lovell et al. 2005). Based on the information available, we assume that the eulachon have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008). In studies in which fish species were found to have incurred TTS, hearing returned to normal within 24 hrs after the end of exposure (e.g., Smith et al. 2004a, 2006). Fish seem to be able to regenerate lost hair cells and recover from TTS quickly with no permanent damage (e.g., Smith et al. 2006).

Auditory Interference (Masking)

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

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

Male Steller sea lions usually produce low frequency roars (Loughlin et al. 1987; Schusterman et al. 1970). The calls of females range from 30 Hz to 3 kHz, with peak frequencies from 150 Hz to 1 kHz; typical duration is 1.0 to 1.5 sec (Campbell et al. 2002). Although the findings by Madsen *et al.* (2006) suggest frequencies of seismic pulses can overlap the range of Steller sea lion communication, the strongest spectrum levels of airguns are below 200 Hz (0-188 Hz for the *Langseth* airguns). The proposed seismic survey could mask some Steller sea lion calls, however, any masking that might occur would likely be temporary because seismic sources are discontinuous and the seismic vessel would continue to transit.

For sea turtles, hearing capabilities are centered in the low frequency range, as are the dominant frequencies of seismic pulses. However, it is not clear whether sea turtles produce biologically significant sounds. If they do, and given the overlap of seismic frequencies and turtle hearing capabilities, it would not be unreasonable to anticipate some masking may result from the proposed seismic activities. Given the frequency overlap between seismic frequencies and hearing capabilities masking can occur, however, we do not have enough information to determine the extent of any masking should it occur.

Listed fish hearing capabilities are centered in the low frequency range, as are the dominant frequencies of seismic pulses. We do not have information regarding production of biologically significant sounds in green sturgeon and eulachon. Given the frequency overlap between seismic frequencies and hearing capabilities masking can occur, however, we do not have enough information to determine the extent of any masking, should it occur.

Behavioral Responses of Whales

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

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

McCauley *et al.* (1998; 2000b) studied the responses of humpback whales off western Australia to a full-scale seismic survey with a 16-gun 2,678-in^3 array, as well as to a single 20-in^3 airgun with a source level of 227 db re 1µPa·m (pk-pk). The authors found the overall distribution of humpback whales migrating through the study area was unaffected by the full-scale seismic program, but that localized avoidance of the array and, to a lesser extent, the single airgun did occur. Avoidance reactions began at 5–8 km from the array and 2 km from the single airgun. Mean avoidance distance from the airgun corresponded to a received sound level of 140 db re 1µPa (rms), the level at which humpbacks started to show avoidance reactions to an approaching airgun. However, some humpback whales, especially males, approached within distances 100 to 400 m where the maximum received level was 179 db re 1µPa (rms). Potter *et al.* (2007) also reported localized avoidance of seismic airguns off Nova Scotia, but that whales did not move outside the detection range. Humpback whales summering in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 100-in^3 airgun (Malme *et al.* 1985 *as cited in* NMFS 2006d). Some humpbacks appeared to exhibit a startle response at received levels of 150-169 db re 1µPa. Despite the possibility of subtle effects, the author concluded there was no clear evidence of avoidance at received levels up to 172 db re 1µPa. These studies indicate that humpback whales could begin avoiding the proposed seismic survey at received lower received levels, but that some individuals may not avoid the airgun operations at levels up to 180 db re 1µPa.

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

For sperm whales, available studies for a variety of anthropogenic sounds indicate these whales may or may not exhibit responses to such sounds, and that responses that do occur are variable. Based on available information, it appears sperm whales may react strongly to a novel acoustic stimulus but may habituate to the presence of some anthropogenic sounds (NMFS 2006b). Sperm whale responses to various anthropogenic sounds include disruptions of sperm whale clicking and behavior from sonars (Watkins and Schevill 1975; Watkins *et al.* 1985; Goold 1999), pingers (Watkins and Schevill 1975), the Heard Island Feasibility Test (Bowles *et al.* 1994), and the Acoustic Thermometry of Ocean Climate or ATOC (Calambokidis *et al.* 1998; Costa *et al.* 1998). Sperm whales have been observed to temporarily stop clicking in response to pinger sounds in the frequency range 6-13 kHz (Watkins and Schevill 1975); however, this response is thought to be one of listening, rather than of fear (NMFS 2006b). For example, sperm whales also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Goold (1999) reported distinct changes in vocalizations of six sperm whales off Scotland during a shepherding operation by vessels driving the whales through a narrow channel using ship noise and echosounder/fishfinder emissions. A recent preliminary analysis of acoustic data from the northern Gulf of Mexico also indicates that sperm whales are, in some cases, affected by the passing of vessels, with fewer clicks and fewer whales detected afterwards (Ioup *et al*. 2005 *as cited in* NMFS 2006b). It is not known if this reflects a change in sound-producing behavior, or the physical movement of whales away from the source. Similar changes were also observed when the data were analyzed for the effects of a passing tropical storm (Newcomb *et al*. 2004 *as cited in* NMFS 2006b).

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

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

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

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

Contrary to the observations mentioned above, results of other studies indicate there is considerable tolerance of seismic surveys by at least some sperm whales. Davis *et al.* (2000) noted that sighting frequency for sperm whales did not differ significantly between different acoustic levels used in the northern Gulf of Mexico. A study off northern Norway reported that sperm whales continued to call and remained in the area for at least 13 days when exposed to pulses from a distant seismic vessel, involving received levels up to 146 dB re 1 μPa pk-pk (i.e., 130 dB (rms) (Madsen *et al.* 2002). Similarly, a study conducted off Nova Scotia analyzing recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall Howard 1999 *as cited in* NMFS 2006h). Recent data from vessel-based monitoring programs in the United Kingdom (U.K.) also suggested that sperm whales showed no noticeable avoidance response. Compilation and analysis of data on responses of marine mammals to seismic surveys off the U.K. did not result in statistically significant evidence of avoidance by sperm whales

(Stone and Tasker 2006). One interpretation is that sperm whales have a high tolerance for certain types of noise (e.g., André *et al.* 1997).

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

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

Particular whales might not respond to the vessels, while in other circumstances, they may change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). For the ESA-listed whale species exposed to seismic airguns during the proposed activities, any alterations of normal behavior that result in avoidance of biologically important habitat or reductions in foraging opportunities could be biologically significant. The proposed activities would overlap with foraging and possibly migrating whales in the action area. If repeated displacement or disruption of animals occurred, the reproduction and recruitment rates could be reduced. As mentioned previously, the maximum repeat exposure of individuals expected during the proposed activities would be two times on average, assuming whales do not alter their location between subsequent seismic firing of that transect. Although the proposed activities could overlap with foraging whales, given the limited duration of the proposed seismic activities (25 days), the vastness of the survey site and the mitigation measures to minimize the risk of exposure at received levels of concern, we do not anticipate that behavioral responses to the proposed activities would significantly result in reduced foraging opportunities. Because of these reasons, we do not expect these responses to reduce the fitness of the blue, fin, sei, humpback and sperm whales that occur within the Action Area.

Behavioral Responses of Steller Sea lions

Visual monitoring from seismic vessels has shown slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. In the Beaufort Sea, some ringed seals avoided an area of 100 m to (at most) a few hundred meters around seismic vessels, but many seals remained within 100–200 m of the trackline as the operating airgun array passed by (e.g., Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). Ringed seal sightings averaged somewhat farther away from the seismic vessel when the airguns were operating than when they were not, but the difference was small (Moulton and Lawson 2002). Similarly, in Puget Sound, sighting distances for harbor seals and California sea lions tended to be larger when airguns were operating (Calambokidis and Osmek 1998). However, previous telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998).

As for listed whale species above, any alterations of Steller sea lion normal behavior that results in avoidance of biologically important habitat, essential life functions or reductions in foraging opportunities could be biologically significant. The proposed activities would overlap with foraging and breeding Steller sea lions in the action area. If repeated displacement or disruption of animals occurred, the reproduction and recruitment rates could be reduced. However, as mentioned previously, the maximum repeat exposure of individuals expected during the proposed activities would be once, assuming sea lions do not alter their location between subsequent seismic firing of that transect. Although the proposed activities are expected to overlap with breeding and foraging sea lions, given the limited duration of the proposed seismic activities and the mitigation measures to minimize the risk of exposure at received levels of concern, we do not anticipate that behavioral responses to the proposed activities would significantly result in reduced foraging or breeding opportunities. Even if sea lion responses upon exposure to acoustic sounds during the survey are as strong as those evident in the telemetry study mentioned above (Thompson et al. 1998), any behavioral responses or disruptions in Steller sea lion behavior are expected to be temporary, with sea lions expected to resume their behavior after the seismic vessel has moved out of their immediate area without permanent impairment of feeding, breeding or other behaviors.

Behavioral Responses of Sea Turtles

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

(Lenhardt 2002; McCauley 2001 *as cited in* NMFS 2006h), as well as swimming towards the surface at the onset of the sound (Lenhardt 1994).

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

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

A more recent study by DeRuiter and Doukara (2012) reported on the observed reactions of loggerhead sea turtles during a seismic survey in the Mediterranean Sea off Algeria. The seismic survey was conducted with a 13-airgun array (nominal source level of 252 dB re 1µPa at 1 m (peak)), towed at a depth of 11.5m at 5 kts. All but 3 (swimming underwater) of the 164 loggerheads observed (98 percent), were motionless at the surface when observed and ranged from 10s of meters to nearly 2 km from the vessel when sighted. Observed reactions include head raising (6), flipper agitation (7), air bubble production around head (2) or diving. Of the 86 turtles whose dive behavior could be visually tracked until their passage more than 100 m behind the array, 49 (57 percent) dove (dove before passing behind the airgun array) and 37 (43 percent) did not dive (were in view at the surface until they had passed more than 100 m behind the airgun array). At least 6 turtles dove immediately following an airgun shot indicating a startle response. The authors suggest that loggerhead turtles interrupted basking behavior and dove (an avoidance response) in response to airgun sounds at relatively close ranges (130 m median distance, 839 m maximum distance) and exposure levels estimated at about 191 dB re 1µPa at 1 m (peak) at 130 m and 175 dB re 1µPa at 1 m (peak) at 839 m.

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

Behavioral Responses of Listed Fish

There is limited information available regarding behavioral responses of fish species to intense sounds. Conclusions of behavioral studies on fish on a coral reef suggested no substantial or permanent changes to fish behavior (Wardle et al 2001); no changes in swimming direction or speed in response to sound exposure levels (single discharge) reaching175 dB re 1 $\mu Pa^2 \cdot s$ and peak levels of over 200 dB re 1 µPa on a variety of fish species (Jorgenson and Gyselman 2009); and low responses and possibly acclimation to pile driving noise for caged Atlantic Ocean species, although results could not be used for other studies (Mueller-Blenkle et al. 2010).

Non-Auditory Physical or Physiological Effects

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

Stress responses by animals involve the autonomic nervous system, producing changes in heart rate, blood pressure, and gastrointestinal activity that are typically of short duration. Such responses may or may not have significant long-term effects on an individual's welfare (NMFS 2006g). Stress responses may also involve the neuroendocrine system and hormones associated with the HPA-axis (hypothalamus-pituitary-adrenal system) in mammals or the hypothalamus-pituitary-interrenal axis in some reptiles. Functions affected by stress include immune competence, reproduction, metabolism, and behavior (NMFS 2006g). Stress is an adaptive response and does not normally place an animal at risk; however, *distress* (allostatic loading) involves a stress response resulting in a biological consequence to the individual and lasts until the animal replenishes its energy reserve sufficient to restore normal function. Minimal information is available on the physiological responses of marine mammals and sea turtles upon exposure to anthropogenic sounds. Given studies of other marine and terrestrial animals, it would be reasonable to assume that some marine mammals might experience physiological stress responses that would be classified as "distress" upon exposure to mid- and low-frequency sounds. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities could be stressful for some individuals. Therefore, exposure to levels sufficient to trigger onset of PTS or TTS might be accompanied by physiological stress responses, as terrestrial animals are known to exhibit such responses under similar conditions (NRC 2003; NMFS 2006g). Stress responses may also occur at levels lower than those required for onset of TTS (NMFS 2006g). Although the magnitude and biological significance of any stress responses that might occur remain unknown, exposure to seismic sources would be limited in duration and some whales may exhibit some avoidance of seismic sources. Mitigation measures and monitoring are expected to help reduce the likelihood of exposure at levels of concern, further minimizing risk to listed whales and Steller sea lions.

It is possible that some marine mammal species may be susceptible to injury or stranding after exposure to seismic pulses; however there is no definitive evidence that these effects occur, even in close proximity to large airgun arrays (see discussion below under *Strandings*) (LGL, Ltd 2011). Available information indicates that gas and fat embolisms may potentially occur if cetaceans ascend too quickly when exposed to aversive sounds or if sounds in the environment cause the destabilization of existing bubble nuclei (see Potter 2004; Arbelo *et al.* 2005; Fernández *et al.* 2005a). There is speculation that gas and fat embolisms can occur during exposure to mid-frequency sonar; however, no available evidence indicates these effects occur in response to airgun sounds (LGL, Ltd 2012).

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

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

Strandings

Available information indicates that marine mammals close to underwater detonations can be killed or severely injured, with auditory organs especially susceptible to injury (Ketten *et al.* 1993; Ketten 1995). However, seismic airgun pulses are less energetic and have slower rise times, and there is no evidence available conclusively linking airguns to serious injury, death, or stranding even in the case of large airgun arrays (Gordon *et al.* 2003; L-DEO 2006). Evidence implicating seismic airguns in the stranding of marine mammals does exist for two beaked whales in the Gulf of California (*Ziphius cavirostris* – not listed under the ESA nor currently considered a candidate for such listing), and possibly for four *Z. cavirostris* in the Galápagos Islands (Gentry 2002; Gordon *et al.* 2003). There appeared to be a temporal correlation between these events and seismic operations by the vessel *R/V Maurice Ewing* in the vicinity; however, a causal link could not be established for either event. Other strandings of beaked whales have also occurred, associated with military mid-frequency sonar transmissions – e.g., in the Bahamas, Canary Islands, and eastern Mediterranean Sea (Frantzis 1998). These other strandings were associated with military mid-frequency sonar (generally 2-10 kHz and relatively narrow bandwidth), which differs from the sound produced by seismic arrays (broadband and below 1 kHz). However, evidence that sonar pulses can lead to physical damage or mortality (even if indirectly) (U.S. Department of Commerce and U.S. Department of the Navy 2001; Jepson *et al.* 2003; Fernández *et al.* 2005) suggests that caution is still warranted when considering the effects on marine mammals from any high-intensity pulsed sound, such as from seismic airguns.

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

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

Effects on Prey

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

Several studies have shown that short, sharp sounds can cause overt or subtle changes in fish behavior and distribution. Chapman and Hawkins (1969) tested the reactions of whiting (hake) in the field to an airgun. When the airgun was fired, the fish showed a sudden downward movement, changing their distribution from being dispersed between 25 m (80 ft) and 55 m (180 ft) depth, to forming a compact layer below 55 m (180 ft). Toward the end of an hour-long exposure to the airgun pulses the fish had habituated to the sound and risen back upward in the water column, despite the continued presence of sound pulses. However, when the airgun resumed firing after a dormant period, the fish exhibited another downward response. Pearson *et al.* (1992) conducted a controlled experiment to determine the effects of strong sound pulses on several species of rockfish off California. Exposing rockfish to an airgun with a source level of 223 dB re 1 μPa, the authors reported startle and alarm responses in these fish. Popper *et al.* (2005) report the occurrence of threshold shifts in some fish after exposure to airguns, with recovery in 24 hours. In other airgun experiments, catch-per-unit-effort (CPUE) of demersal fish was reported to decline when airgun pulses were emitted (Skalski *et al.* 1992; Dalen and Knutsen 1986, Dalen and Raknes 1985, both *as cited in* NMFS 2006h). Reductions in the catch may have resulted from a change in the behavior of the fish. Fish schools descended to near the bottom when the airgun was firing, and the fish may have changed their swimming and schooling behavior. Fish behavior returned to normal minutes after the sounds ceased. In the Barents Sea, abundance of cod and haddock measured acoustically was reduced by 44 percent within 9.2 km (5 nm) of an area where airguns operated (Engås *et al.* 1993 *as cited in* NMFS 2006h). Actual catches declined by 50 percent throughout the trial area and 70 percent within the shooting area. This reduction in catch decreased with increasing distance until 30-33 km (16-18 nm), where catches were unchanged.

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

A range of invertebrates are reported to be sensitive to low-frequency (10–150 Hz) hydroacoustic disturbances induced by sound waves or other sources – e.g., jelly fish, crustaceans, arrow worms, octopus, and squid (Western Australian Department of Industry and Resources 2002). This sensitivity overlaps the dominant frequency range of seismic pulses, indicating that invertebrates could likely perceive seismic activity (Western Australian Department of Industry and Resources 2002). Available studies report responses to airgun shots as being limited to transient alarm responses such as tail-flicks (lobsters) or siphon closing (ascidians) (Western Australian Department of Industry and Resources 2002), although mortality of giant squid in the Bay of Biscay may possibly have been linked to seismic airgun activity in the area (Guerra *et al.* 2004). McCauley *et al*. (2000a; 2000b) examined the effect of marine seismic surveys on captive squid and cuttlefish and reported a strong startle response or directed movement away from airguns during sudden, nearby start-ups at received levels of 174 dB re 1 μPa mean squared pressure. Alarm responses in squid were detected during gradual ramp-up of airguns once levels exceeded 156-161 dB re 1 μPa mean squared pressure. Squid in these trials appeared to make use of the sound shadow measured near the water surface. These responses for captive squid suggest that behavioral changes and avoidance of operating airguns would likely occur. The authors concluded squid significantly alter their behavior at an estimated distance of 2–5 km (1.1–2.7 nm) from an approaching large seismic source. A more recent study by André et al (2011) exposed four species of squid and octopus in a tank to two hours of intense sounds. The authors reported tissue degeneration cause by the sounds. However, this study had substantial design and control problems and the results could have been attributed to those problems. Some whales and leatherback sea turtles feed on concentrations of zooplankton. A reaction by zooplankton to a seismic impulse would only be relevant to whales if it caused a concentration of zooplankton to scatter. Pressure changes of sufficient magnitude to cause that type of reaction would probably occur only very close to the source. Impacts on zooplankton behavior are predicted to be negligible, and that would translate into negligible impacts on those mysticetes that feed on zooplankton

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

Effects of exposure to MBES and SBPs

Sperm whales, humpback whales and Steller sea lions are presumed to be more sensitive to mid- and high-frequency sounds, and may be able to hear the mid-frequency sounds of the MBES and SBP sonars. Because no new ping is transmitted before the previous echo (and possibly 2 or 3 multiple echoes) has been received the duty cycle is in the range of 0.1% to 1%.

Lurton and DeRuiter (2011) conducted several case studies are compared with currently accepted threshold values for marine mammal sound exposure. Base on the case studies the authors concluded that while echosounders may transmit at high sound pressure levels, the very short duration of their pulses and their high spatial selectivity make them unlikely to cause damage to marine mammal auditory systems, at the present. The authors also suggested that there remains a possibility that echosounders may affect marine mammal behavior at ranges on the order of kilometers; however, the likelihood and biological effects of such behavioral responses to sound remain poorly understood at present (Lurton and DeRuiter 2011). The authors did not study echosounders operating simultaneously with airgun signals or with other echosounders, therefore any application of these case studies to simultaneous acoustic signal operations remains unknown.

However, we expect any exposures to these sources would be brief as the vessel passes by and individual pulses will be very short. Potential for exposure is further reduced by the fact that sounds from these sources would dissipate over an area smaller than that affected by seismic airguns, for which mitigation measures would minimize exposure within the 180dB re 1μPa isopleths for whales.

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

Recent stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals (see *Strandings* above). However, the sonars proposed for use by L-DEO differ from sonars used during Naval operations, which generally have a longer pulse duration and are often directed close to horizontal as opposed to the more downward-directed MBES and SBPs. The sound energy that would be received by any individuals exposed to the MBES and SBP sources during the proposed activities is lower relative to naval sonars (LGL Ltd. 2012), as is the duration of exposure. In addition, the area of possible influence for the MBES and SBPs is much smaller, consisting of a narrow zone close to and below the source vessel. Because of the unlikelihood of exposure and the brief duration for any individual that might be exposed, it is not likely MBES and SBP sonar pose a risk to sperm and humpback whales and Steller sea lions during the proposed activities. In addition, Boebel *et al.* (2006) assessed the relative risk posed by various scientific acoustic instruments and concluded that multi-beam systems and sub-bottom profilers similar to those to be used during the proposed activities presented a low risk for auditory or any other injuries, and that an individual would require exposure to 250–1,000 pulses from a sub-bottom profiler to be at risk for TTS. To be susceptible to TTS, a whale would have to pass at very close range and match the vessel's speed – the probability of this occurring in the proposed survey is expected to be very small.

Masking of sperm whale, humpback whale and Steller sea lion communications is not expected to occur appreciably due to MBES or SBP signals given their directionality and the brief period when an individual mammal is likely to be within its beam. Masking of blue, sei and fin whales communications are not expected because their vocalization are in the low frequency range below signals emitted by these sonars.

For leatherback sea turtles, green sturgeon and eulachon available information indicates detection of sounds in the low-frequency range; based on this information, any individuals of these species exposed to received levels of mid-frequency (1 kHz–10 kHz) sounds or higher are not likely to detect these sounds. Therefore, leatherback sea turtles, green sturgeon and eulachon are not likely to respond physiologically or behaviorally to received sounds from the MBES and SBP sonars to be used during the proposed survey.

Critical Habitat

There are three critical habitat designations that will be discussed here: leatherback sea turtle critical habitat, green sturgeon critical habitat and eulachon critical habitat.

Leatherback critical habitat includes approximately 43,798 square km stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 64,760 square km stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The designated areas comprise approximately 108,558 square km of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet (80 m). We expect that prey resources within the Washington/Oregon portions of critical habitat will be exposed to survey activities. Critical habitat designated off California is not expected to be exposed to survey activities.

The primary constituent element essential for conservation of leatherback sea turtles is the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia*, *Phacellophora,* and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

Designated habitat for green sturgeon includes coastal U.S. marine waters within 60 fathoms (110 m) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon

(Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor).

The principle biological or physical constituent elements essential for the conservation of southern green sturgeon in freshwater include: food resources; substrate of sufficient type and size to support viable egg and larval development; water flow, water quality such that the chemical characteristics support normal behavior, growth and viability; migratory corridors; water depth; and sediment quality. Primary constituent elements of estuarine habitat include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality. The specific primary constituent elements of marine habitat include food resources, water quality, and migratory corridors. We expect that prey resources within the Washington/Oregon portions of critical habitat will be exposed to survey activities.

Eulachon critical habitat encompasses 16 specific areas within the states of California, Oregon, and Washington. The designated areas are a combination of freshwater creeks and rivers and their associated estuaries, comprising approximately 539 km (335 mi) of habitat. Critical habitat is designated to include the following areas in Oregon and Washington:

> (1) Portions f the Umpqua River, Tenmile Creek, Sandy River, Columbia River, and Grays River in Oregon; and
> (2) Portions of Skamokawa Creek, Elochoman River, Cowlitz River, Toutle River, Kalama River, Lewis River, East Fork of the Lewis River, Quinault River and Elwha River in Washington.

These areas contain physical or biological features essential to the conservation of the DPS, including (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival. We expect that the propagation of acoustic signals from survey tracklines in closer proximity to the shoreline may expose critical habitat within the Umpqua River, Tenmile Creek and Quinault River to acoustic signals.

In each of these critical habitats the only primary constituent element that is necessary for the conservation of these species that will be exposed to acoustic signals from the survey activities is the nearshore/offshore marine foraging habitat featuring sufficient quantities of quality, available prey to support one or more stages of survival. Prey species for leatherback sea turtles includes primarily scyphomedusae, while the limited information on green sturgeon diets indicates that they are benthic feeders ingesting invertebrates including shrimp, mollusks, amphipods, and even small fish (Moyle et al. 1992). Eulachon diets include a variety of prey items, including phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, and worm larvae while adults feed on zooplankton, chiefly eating crustaceans such as copepods and euphausiids.

As discussed earlier in this Opinion (see *Effects on Prey*), seismic surveys could have indirect, adverse effects on leatherback sea turtles, green sturgeon and eulachon by reducing the abundance or availability of prey or changing the structure or composition of the fish community. If fish or invertebrates experience lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution in response to acoustic energy produced by seismic surveys, then the conservation value of critical habitat could decline.

Several studies indicate that seismic airgun activity has the potential to affect fish and invertebrates. Fish appear to exhibit startle responses and avoidance of seismic sources, recovering or habituating after a short time period. Squid also appear to exhibit alarm responses and avoidance of seismic sources. Zooplankton that are very close to the source may react to the airgun's shock wave. These animals have an exoskeleton and no air sacs; therefore, little or no mortality is expected. Many crustaceans can make sounds and some crustacea and other invertebrates have some type of sound receptor. However, the reactions of zooplankton to sound are not known but would only be relevant if it caused a concentration of zooplankton to scatter. Pressure changes of sufficient magnitude to cause this type of reaction would probably occur only very close to the source, so few zooplankton concentrations would be affected.

Limited data on the physiological effects of seismic sound on fish and invertebrates indicate these effects are short-term and most apparent after exposure at very close range. However, with the limited spatial and temporal scale of the proposed seismic activities, only a small fraction of available habitat would be ensonified at any one time and prey species would be expected to return to their pre-exposure behavior once seismic firing ceased. Thus, we expect such responses would have temporary effects on the feeding ability of leatherback sea turtles, green sturgeon and eulachon in the immediate survey area. Such reductions in feeding ability are not expected to reduce an individual animal's overall feeding success.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources are not likely to decline as a result of being exposed to survey activities nor likely to exclude leatherback sea turtles, green sturgeon or eulachon from designated critical habitat or alter the primary constituent elements of their critical habitat.

Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered by this Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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

Integration and Synthesis of Effects

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

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). As a result, if the assessment indicates listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment. If possible reductions in individuals' fitness are likely to occur, the assessment considers the risk posed to population(s) and then to the species to which those individuals belong. For critical habitat, risks to the habitat are measured using changes to the conservation "value" of the designated area – i.e., declines in the availability, quantity or quantity of a primary constituent element or other physical, biological or chemical changes to the habitat.

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

Whales

At present, there are several factors that may be affecting whale survival and recovery in the action area, although the significance of any effects remains largely unknown. Natural factors include circulation and productivity patterns affecting prey distribution and habitat quality; as well as natural mortality of whales, which we assume includes predation biotoxins, parasites, and disease. Anthropogenic factors include degradation of habitat resulting from pollution/

contaminants, anthropogenic noise, risk of ship strikes and entanglement or entrapment in fishing gear. Conservation and management efforts are also ongoing but any positive effect on whales in the action area will hopefully increase in the future.

We assume that blue whales, fin whale, sei whales, humpback whales and sperm whales may occur during in the Action Area during the proposed activities. Hearing in blue, fin and sei whales is believed to be in the low-frequency range while hearing in humpback and sperm whales spans low- to mid-frequencies.

Information available regarding blue whales indicates that whales in the Action Area during the survey period are part of the eastern North Pacific population. From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual whales that might be exposed to survey activities. We expect, however, that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Information available regarding fin whales indicates that whales in the Action Area during the survey period are part of the California/Oregon/Washington population. We expect that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Information available regarding sei whales indicates that whales in the Action Area during the survey period are part of the eastern north Pacific population. We expect that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Information available regarding humpback whales indicates that whales in the Action Area during the survey period are part of the California/Oregon/Washington population that forages off those states during the survey period. From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the individual whales that might be exposed to survey activities. We expect, however, that individuals within the Action Area would be foraging individuals representing all age classes and both sexes.

Information available regarding sperm whales indicates that whales in the Action Area during the survey period are part of the California/Oregon/Washington population.

After reviewing the available information, the proposed activities are likely to produce the following potential stressors for listed whales: (1) acoustic energy from the airgun array and (2) acoustic energy from the MBES and SBPs. We believe an individual whale would have a low probability of being exposed to acoustic energy produced by the seismic airguns that will be used during the proposed action at received levels above 180 dB re 1 μPa. Using the model prepared by L-DEO (LGL Ltd. 2012), which estimates propagation distances for given received levels, seismic airgun levels of 180 dB re 1 μPa or greater might propagate from 0.04 km to 0.29 km for the 40 in^3 airgun and between 0.94 and 2.14 km for the survey and these distances fall within the visibility (i.e., monitoring) range from the *Langseth*.

Although this consultation is primarily concerned with exposure to sound levels above 180 dB re 1 μPa, the estimates for listed whale exposure consider received levels at or greater than 160 dB re 1 μPa. Using the total area that would be ensonified ≥ 160 dB during the proposed activities, the estimated number of whales that might be exposed to seismic pulses at these levels along with the percentage of the regional population are listed in Table 3 again below for ease of reference. Individuals could be exposed up to two times on average. These estimates do not account for possible avoidance of seismic sounds by whales or for mitigation measures to be used during the studies that would reduce the risk of exposure to levels above 180 dB re 1 μPa. Although seismic pulses may propagate substantial distances beyond the isopleth for 160 dB re 1 μPa, we do not expect incidental harassment of listed species at those lower received levels.

Exposure of listed whales to the MBES and SBP sonars is expected to be minimal, given the brief ping duration, the beam width of the sonars, and the fact that the vessel will be in transit. The probability of a whale swimming through an area ensonified by a MBES or SBP sonar is considered small. Any exposures that may occur are expected to be brief, and individuals are likely to exhibit avoidance. The potential for exposure to MBES and SBP sources is further reduced by the mitigation measures for minimizing exposure to seismic airguns within the 180 dB radius.

Although recent stranding events involving beaked whales have been associated with the operation of naval mid-frequency sonar, the characteristics of the MBES and SBPs are significantly different, including a shorter pulse duration, general downward-orientation, significantly less sound energy that would be received, shorter exposure, and much smaller zone of influence close to the vessel. The probability of TTS occurring is considered very small, and masking is not expected to occur due to the short pulse duration and low likelihood of exposure. It is not likely that the use of the MBES and SBPs during the proposed activities poses a significant risk to humpback and sperm whales.

Table 4: Take Estimates for the Juan de Fuca Survey

Survey	Species	Take Estimate	Percent of Regional Population
Juan de Fuca	Blue	4	0.17
	Fin	30	0.18
	Sei	4	0.03
	Humpback	19	0.09
	Sperm	24	0.10
	Steller sea lions	303	0.46

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

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

Exposure to seismic activities may result in behavioral responses by listed whales, but responses are variable. Available information indicates that baleen whales generally tend to avoid operating airguns, with variable avoidance distances. However, some individual humpback whales are noted to approach airguns to distances where the received level was 179 dB re 1μPa (rms). Some sperm whales appear to tolerate seismic sound. Sperm whales are also reported to avoid standard, non-seismic vessels, and we expect individuals may also show some avoidance of seismic vessels, given accounts of possible avoidance of seismic vessels in other locations. A few observations indicate possible behavioral responses including avoidance or cessation of calling by sperm whales. However, studies indicate considerable tolerance of seismic activity, with whales continuing to call and maintaining their distribution and pre-exposure behavior. This suggests variable responses, with some sperm whales exhibiting considerable tolerance and others avoidance behavior. Although the proposed activities could overlap with foraging whales, given the limited duration of the proposed seismic activities (18 days), the vastness of the survey site and the mitigation measures to minimize the risk of exposure at received levels of concern, we do not anticipate that behavioral responses to the proposed activities would significantly result in reduced foraging opportunities. Because of these reasons, we do not expect these responses to reduce the fitness of blue, fin, sei, humpback or sperm whales that occur in the Action Area.

Stress responses may occur as a result of exposure, given the importance of sound and hearing to listed whales. Although the magnitude and biological significance of any stress responses that might occur remain unknown, we assume that stress responses would be minimized because exposure to seismic sources would be limited in duration and whales may show some avoidance of seismic sources. In addition, mitigation measures and monitoring would help minimize the risk to listed whales. Other non-auditory physical or physiological effects are considered unlikely to occur, given the limited duration of any exposure and the possibility of at least some avoidance of seismic pulses. Although two stranding events involving beaked whales are known to have occurred concurrent with seismic surveys (Gentry 2002; Gordon *et al.* 2003), no causal link is established for those events and no such records exist for listed whale species.

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

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

Steller Sea Lions

The Eastern Steller sea lion DPS is threatened through its range. The primary cause for depletion was the historic commercial hunting of both DPSs. Available abundance estimates indicate that the eastern DPS appears to be growing such that it may be a candidate for removal from the list of threatened and endangered species.

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

In the action area Steller sea lions may occur during the proposed activities. Hearing in Steller sea lions is believed to span low to mid-frequencies. After reviewing the available information, the proposed activities are likely to produce two potential stressors for listed Steller sea lions: (1) acoustic energy from the airgun array and (2) acoustic energy from the MBES and SBP sonars.

Steller sea lions are likely to be exposed to received levels greater than 170 dB re 1 µPa (rms), produced by acoustic signals from survey activities. This received level would constitute harassment for Steller sea lions. The maximum distance from airguns where received levels might meet the shut-down criterion of 190 dB (i.e., from the full 36-gun array and the single airgun) are estimated as 2.750 km for the 36 airgun array and 0.04 km for the 40 in^3 single airgun. Received levels above the 190 dB radius (the shut-down criterion) will not always reach these distances, as shorter radii will occur during the use of smaller numbers of airguns (e.g., the use of a single airgun during turns or power-down procedures).

These maximum distances all fall within the visibility range from the *Langseth.* However, based on these maximum propagation distances, our concern is the probability of Steller sea lions occurring within this range from the *R/V Langseth* during seismic operations.

Steller sea lions likely to be exposed to received levels greater than 170 dB re 1 µPa (rms), would be male and female juveniles and adults from the Eastern DPS. As Steller sea lions can breed as early as two weeks after giving birth, we expect that breeding animals would also be present during survey activities. Mitigation measures and monitoring activities during the proposed survey include visual and passive acoustic monitoring, an exclusion zone within the

180 dB isopleths for cetaceans and leatherback sea turtles, an exclusion zone within the 190 dB isopleths for Steller sea lions, speed and course alterations when practicable, power-down and shut-down procedures, an emergency shut-down provision, and ramp-up procedures for airguns. These measures are expected to reduce the risk that Steller sea lions would occur within the 190 dB radius; therefore, any exposures that might occur are more likely to involve Steller sea lions at received levels less than 190 dB re 1 μPa.

Based on the hearing abilities of Steller sea lions we would expect that sound pulses from the multi-beam and sub-bottom sonar would be audible to individuals of this species within the narrow extent of a transmitted sound beam. However, Kremser *et al.* (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal would have to pass at close range and be swimming at speeds similar to the vessel to be subjected to sound levels that could cause temporary threshold shifts. Similarly for Steller sea lions, we would expect the probability of swimming through the area of exposure when such sources emit a pulse is also small.

Base on the hearing capabilities of Steller sea lions and the frequencies of the sound pulses from the OBS, we expect that individuals of this species would hear the acoustic release transponder and the response but because these signals will be used very intermittently, it is unlikely that Steller sea lions would respond to these signals.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from more prolonged (non-pulse) exposures suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001). The TTS threshold for pulsed sounds has been indirectly estimated as being an SEL of ~171 dB re 1 μPa^2 s (Southall et al. 2007), which would be equivalent to a single pulse with received level ~181–186 dB re 1 μPa(rms), or a series of pulses for which the highest rms values are a few dB lower. Mitigation measures mentioned above for whales would also apply to Steller sea lions and would help reduce the received level of any exposures that may occur and further minimize the risk of PTS or TTS.

Interference, or masking, generally occurs when the interfering noise is of a similar frequency and louder than the auditory signal received by an animal processing echolocation signals or listening for acoustic information from other individuals. Male Steller sea lions usually produce low frequency roars (Loughlin et al. 1987; Schusterman et al. 1970). The calls of females range from 30 Hz to 3 kHz, with peak frequencies from 150 Hz to 1 kHz; typical duration is 1.0 to 1.5 sec (Campbell et al. 2002). Although the frequencies of seismic pulses overlap the range of Steller sea lion communication, the strongest spectrum levels of airguns are below 200 Hz (0-188 Hz for the *Langseth* airguns). The proposed seismic survey could mask some Steller sea lion calls, however, any masking that might occur would likely be temporary because seismic sources are discontinuous and the seismic vessel would continue to transit.

Visual monitoring from seismic vessels has shown slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. However, previous telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Although the proposed activities are expected to overlap with breeding and foraging sea lions, given the limited duration of the proposed seismic activities and the mitigation measures to minimize the risk of exposure at received levels of concern, we do not anticipate that behavioral responses to the proposed activities would significantly result in reduced foraging or breeding opportunities. Even if sea lion responses upon exposure to acoustic sounds during the survey are as strong as those evident in the telemetry study mentioned above (Thompson et al. 1998), any behavioral responses or disruptions in Steller sea lion behavior are expected to be temporary, with sea lions expected to resume their behavior after the seismic vessel has moved out of their immediate area without impairment of feeding, breeding or other behaviors.

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

Seismic surveys could have indirect, adverse effects on Steller sea lions through reductions in the abundance or availability of prey or changing the structure or composition of the fish community. If prey fish experience lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution in response to acoustic energy produced by seismic surveys there may be adverse consequences for Steller sea lions foraging in the Action Area.

Studies indicate that fish appear to exhibit startle responses and avoidance of seismic sources, recovering or habituating after a short time period. Limited data on the physiological effects of seismic sound on fish indicate these effects are short-term and most apparent after exposure at very close range. With the limited spatial and temporal scale of the proposed seismic activities, only a small fraction of available habitat would be ensonified at any one time, and prey species would be expected to return to their pre-exposure behavior once seismic firing ceased. We expect such responses would have only minor, temporary effects on the feeding ability of Steller sea lions in the immediate survey area. Such reductions in feeding ability are not expected to reduce an individual animal's overall feeding success.

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

Leatherback Sea Turtles
The primary causes for depletion of sea turtles were overexploitation and incidental capture in fishing gear. Reliable estimates of overall historic and current abundance for sea turtles are not available; however, information on nesting trends is available from many locations. Declines in abundance are reported for leatherback sea turtles in the North pacific. The population structure of sea turtles is complex both spatially and genetically, with individuals exhibiting natal homing to nesting beaches and mixing of nesting aggregations on foraging grounds.

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

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

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

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

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

The proposed activities are anticipated to occur during migration and foraging activities, however, exposure to airgun sounds are not expected to reduce foraging opportunities to levels that would reduce the fitness of individual sea turtles nor result in lost opportunities to nest.

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

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

Southern Green Sturgeon and Pacific Eulachon

Southern green sturgeon currently consist of a single population that occurs in San Francisco Bay and the river systems associated with the bay. Southern green sturgeon are primarily threatened by reductions in the area of spawning habitat associated with the construction of dams in the Sacramento River system (e.g., Oroville, Shasta and Keswick dams). We assume that green sturgeon are responsive to sounds ranging in frequency from 100 to 500 Hz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. Eulachon is an anadromous species that spawns in the lower portions of certain rivers draining into the northeastern Pacific Ocean. They are primarily threatened by increasing temperatures in the marine, coastal, estuarine, and freshwater environments. We assume that the eulachon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz.

From the information available, we expect that Southern green sturgeon may be exposed to activities conducted during the survey. Individuals within the Action Area would be either foraging or ascending their natal rivers to spawn (March to July) during time period for the survey. Exposed individuals represent juveniles, subadults and adults of both sexes. Southern Pacific eulachon may also be exposed to activities conducted during the survey. Individuals within the Action Area would be foraging during the survey time period and represent juveniles, subadults and adults of both sexes.

This consultation identified two possible stressors associated with the proposed seismic activities: disturbance from acoustic energy associated with airguns and sonars (multi-beam echosounder, sub-bottom profiler), and disturbance from sounds generated by vessel engines.

In studies in which fish species were found to have incurred TTS, hearing returned to normal within 24 hrs after the end of exposure (e.g., Smith et al. 2004a, 2006). Fish seem to be able to regenerate lost hair cells and recover from TTS quickly with no permanent damage (e.g., Smith et al. 2006). Behavioral changes such as those demonstrated by marine mammals upon exposure to approaching vessels (e.g., avoidance, altered swimming speed and direction) also occur in fish. Masking may occur in fish if green sturgeon and eulachon produce biologically significant sounds, however, we do not have enough information to determine the extent of any masking, should it occur. Although data are limited, we assume that some green sturgeon and eulachon may experience a stress response if exposed to seismic pulses at various levels of intensity during the proposed activities at close range for unusually long periods of time (LGL, Ltd 2011); this is not anticipated to occur during the proposed activities. Green sturgeon and eulachon prey species may experience disturbance which may produce negative effects for these species foraging in the Action Area. However, with the limited spatial and temporal scale of the proposed seismic activities, only a small fraction of available habitat would be ensonified at any one time and prey species would be expected to return to their pre-exposure behavior once seismic firing ceased and there would be only temporary effects on their feeding abilities in the immediate survey area. The evidence available leads us to conclude that exposure to seismic pulse energy in the proposed survey is not likely to cause a reduction in an individual green sturgeon’s or eulachon’s growth, survival, annual reproductive success, or lifetime reproductive success (i.e., fitness). As a result, we do not expect the proposed action to have an effect on the extinction risk of the populations these individuals represent or the species those fish populations comprise.

Critical Habitat

Leatherback sea turtle critical habitat, green sturgeon critical habitat and Pacific eulachon critical habitat may be exposed to stressors associated with the proposed survey. In each of these critical habitats the only primary constituent element that is necessary for the conservation of these species that will be exposed to acoustic signals from the survey activities is the nearshore/offshore marine foraging habitat featuring available prey of sufficient quantity and quality to support one or more stages of survival. If fish or invertebrates experience lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution in response to acoustic energy produced by seismic surveys, then the conservation value of critical habitat could decline. Fish appear to exhibit startle responses and avoidance of seismic sources, recovering or habituating after a short time period. Squid also appear to exhibit alarm responses and avoidance of seismic sources. Zooplankton that are very close to the source may react to the airgun's shock wave. These animals have an exoskeleton and no air sacs; therefore, little or no mortality is expected. Many crustaceans can make sounds and some crustacea and other invertebrates have some type of sound receptor. However, the reactions of zooplankton to sound are not known but would only be relevant if it caused a concentration of zooplankton to scatter. Pressure changes of sufficient magnitude to cause this type of reaction would probably occur only very close to the source, so few zooplankton concentrations would be affected. Limited data on the physiological effects of seismic sound on fish and invertebrates indicate these effects are short-term and most apparent after exposure at very close range. However, with the limited spatial and temporal scale of the proposed seismic activities, only a small fraction of available habitat would be ensonified at any one time and prey species would be expected to return to their pre-exposure behavior once seismic firing ceased. Thus, we expect such responses would have temporary effects on the feeding ability of leatherback sea turtles, green sturgeon and eulachon in the immediate survey area. Such reductions in feeding ability are not expected to reduce an individual animal's overall feeding success.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources are not likely to decline as a result of being exposed to survey activities nor likely to exclude leatherback sea turtles, green sturgeon or eulachon from designated critical habitat or alter the primary constituent elements of their critical habitat; therefore the conservation value of critical habitat is not reduced, and critical habitat is not likely to be destroyed or adversely modified.

Conclusion

After reviewing the current status of blue, fin, sei, humpback and sperm whales, Steller sea lions, leatherback sea turtles, southern green sturgeon and Pacific eulachon; the environmental baseline for the Action Area; the anticipated effects of the proposed activities; and the cumulative effects, it is NMFS' biological opinion that the proposed actions, as described in this Opinion, are not likely to jeopardize the continued existence of these species. Similarly, it is NMFS' biological opinion that the issuance of an IHA by NMFS' Office of Protected Resources Permits and Conservation Division for harassment that would occur incidental to the proposed action is not likely to jeopardize the continued existence of these species. It is also NMFS opinion that the proposed actions, as described are not likely to destroy or adversely modify leatherback sea turtle, southern green sturgeon or Pacific eulachon designated 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 NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

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

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

NMFS anticipates the incidental harassment of blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*) sei whales (*Balaenoptera borealis*), sperm whales (*Physeter macrocephalus*), Steller sea lions (*Eumetopias jubatus*), as well as leatherback sea turtles (*Dermochelys coriacea*) during the proposed survey activities.

Amount or Extent of Take

NMFS anticipates the proposed action to conduct a seismic survey in the eastern North Pacific Ocean might result in the incidental take of listed species. Blue whales, fin whales, humpback whales, sei whales, sperm whales, Steller sea lions, as well as leatherback sea turtles may be exposed to seismic sounds at received levels above 160 dB re 1 μPa. Table 1 below lists the numbers of whales and Steller sea lions that might be taken during conduct of the proposed activities.

Table 1 Number of Individuals by Species Taken by Harassment During Conduct of the Juan de Fuca Plate Survey.

Survey	Species	Number of Individuals Taken
Juan de Fuca	Blue	4
	Fin	30
	Sei	4
	Humpback	19
	Sperm	24
	Steller sea lions	303

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

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

Harassment of blue whales, fin whales, humpback whales, sei whales and sperm whales and Steller sea lions exposed to seismic surveys at levels less than 160 dB re 1 µPa, or of leatherback sea turtles at levels less than 166 dB re 1 µPa, is not expected. While Southern green sturgeon and Pacific eulachon may be disturbed by survey activities, we do not expect that this disturbance will rise to the level of harassment. We do not expect listed species to be taken by operation of the multibeam echosounder or the sub-bottom profiler. However, if overt adverse reactions (for example, dive reactions, or rapid departures from the area) by listed whales or pinnipeds or listed sea turtles are observed outside of the 160 dB re 1 µPa, or 166 dB re 1 µPa isopleths, respectively, while airguns are operating, incidental take may be exceeded. Additionally, if such reactions by listed species are observed while the multibeam echosounder, or the sub-bottom profiler are in operation, this may constitute take that is not covered in this Incidental Take Statement. If such overt adverse reactions are observed the LDEO and NMFS' Permits and Conservation Division must contact the Endangered Species Act Interagency

Cooperation Division within 48 hours of the incident at 301-427-8403 and/or by email to kellie.foster-taylor@noaa.gov to determine whether reinitation of consultation is required.

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

Reasonable and Prudent Measures

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

> The Lamont-Doherty Earth Observatory must implement and monitor the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of blue, fin, sei, humpback and sperm whales and Steller sea lions pursuant to section 101(a)(5)(D) of the MMPA and as specified below for leatherback sea turtles.

Terms and Conditions

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

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

<u>Mitigation and Monitoring Requirements</u>

1. L-DEO shall:

   (a) Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (PSVOs) (except during meal times and restroom breaks, when at least one PSVO shall be on watch) to visually watch for and monitor marine mammals and leatherback sea turtles near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew shall also assist in detecting marine mammals and leatherback sea turtles, when practicable. PSVOs shall have access to reticle binoculars (7 x 50 Fujinon), big-eye binoculars (25 x 150), laser range-finding binoculars, and thermal imaging cameras. PSVO shifts shall last no longer than 4 hours at a time. PSVOs shall also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

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

(c) Record the following information when a marine mammal or leatherback sea turtle is sighted:

> (i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and
>
> (ii) Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, and sun glare; and
>
> (iii) The data listed under Condition 6(c)(ii) shall also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

(d) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One NMFS-qualified Protected Species Observer (PSO) and/or expert bioacoustician (i.e., Protected Species Acoustic Observer [PSAO]) shall monitor the PAM at all times in shifts no longer than 6 hours. An expert bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

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

> (i) Notify the on-duty PSVO(s) immediately of the presence of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;
>
> (ii) Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection can also be recorded for further analysis.

(f) Visually observe the entire extent of the exclusion zone (EZ) (180 dB re 1 μPa [rms] for cetaceans and leatherback sea turtles and 190 dB re 1 μPa [rms] for Steller sea lions; see Table 1 [attached] for distances) using NMFS-qualified PSVOs, for at least 30 minutes prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the EZ, L-DEO must delay the seismic survey until the marine mammal(s) has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the PSVO shall wait 30 minutes. If the PSVO sees no marine mammals or leatherback sea turtles during that time, they should assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals or leatherback sea turtles are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), L-DEO may start the second airgun without observing the entire EZ for 30 minutes prior, provided no marine mammals or leatherback sea turtles are known to be near the EZ (in accordance with Condition 1[h] below).

(g) Establish a 180 dB re 1 μPa (rms) EZ for cetaceans and leatherback sea turtles and a 190 dB re 1 μPa (rms) EZ for Steller sea lions before the 4-string airgun array (6,600 in^3) is in operation; and a 180 dB re 1 μPa (rms) EZ for cetaceans and leatherback sea turtles and a 190 dB re 1 μPa (rms) EZ for Steller sea lions before a single airgun (40 in^3) is in operation, respectively.

(h) Ramp-up procedures at the start of seismic operations or after a shut-down - Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shut-down 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 shall increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the PSVOs shall monitor the 180 dB EZ for cetaceans and leatherback sea turtles or the 190 dB EZ for pinnipeds, and if marine mammals or leatherback sea turtles are sighted within or about to enter the relevant EZ, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from a shut-down or at the beginning of seismic operations requires that the PSVOs be able to view the full EZ as described in Condition 1(f).

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

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

(k) Following a power-down, if the marine mammal or leatherback sea turtle approaches the smaller designated EZ, the airguns must then be completely shut-down. Airgun activity shall not resume until the PSVO has visually observed the marine mammal(s) or leatherback sea turtle exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales), or the vessel has moved outside the EZ for turtles (e.g., about 8 minutes of travel if the turtle is sighted close to the vessel and the ship speed is 7.4 km/h). Following a shut-down, the *Langseth* may resume airgun operations following ramp-up procedures described in Condition 1(h).

(l) Procedures after an extended power-down – Monitor the full 180 dB EZ for cetaceans and leatherback sea turtle and the full 190 dB EZ for Steller sea lions. The *Langseth* may resume full power operations anytime after the entire array has been powered-down for more than 8 minutes. Resuming operations at full power after an extended power-down of more than 8 minutes requires that the PSVOs be able to view the full EZ as described in Condition 1(f). If the PSVO sees a marine mammal or leatherback sea turtle within or about to enter the relevant EZs, then the *Langseth* will implement a course/speed alteration or power-down.

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

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

(o) If a North Pacific right whale (*Eubalaena japonica*) is visually sighted, the airgun array shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting.

(p) If killer whales (*Orcinus orca*) are visually sighted or detected acoustically, the airguns array shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting or acoustic detection.

(q) To the maximum extent practicable, communicate with NMFS Northwest Regional Office and/or Orca Network for near real-time reporting of the whereabouts of killer whales.

(r) To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours and OBS operations (i.e., deploy/retrieve) to nighttime hours.

(s) To the maximum extent practicable, plan to conduct seismic surveys (especially when near land) from the coast (inshore) and proceed towards the sea (offshore) in order to avoid trapping marine mammals in shallow water.

Reporting Requirements

(2) L-DEO shall:

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

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

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

(iii) An estimate of the number (by species) of marine mammals and leatherback sea turtles that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) for cetaceans and leatherback sea turtles and 190 dB re 1 μPa (rms) for Steller sea lions with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on reported and corrected empirical values for the 36 airgun array and modeling measurements for the single airgun) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) for cetaceans and 190 dB re 1 μPa (rms) for pinnipeds with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

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

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

(c) In the unanticipated event that the specified activity clearly causes the take of a marine mammal or sea turtle in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), L-DEO shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov and the Northwest Regional Stranding Coordinator at 206-526-6550 (Brent.Norberg@noaa.gov). The report must include the following information:

> (i) Time, date, and location (latitude/longitude) of the incident; the name and type of vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal and sea turtle observations in the 24 hours preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

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

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), L-DEO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov). The report must include the same information identified in Condition 2(c)(i) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate.

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), L-DEO shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest

Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov) within 24 hours of the discovery. L-DEO shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

3. L-DEO is required to comply with the Terms and Conditions of the ITS corresponding to NMFS's Biological Opinion issued to both NSF and NMFS's Office of Protected Resources

CONSERVATION RECOMMENDATIONS

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

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

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

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

REINITIATION NOTICE

This concludes formal consultation on the proposed marine geophysical survey conducted by the Lamont-Doherty Earth Observatory on board the *R/V Langseth* in the eastern Pacific Ocean, and the issuance of an incidental harassment authorization for the proposed survey pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA). As provided in 50 CFR §402.16, control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of authorized take is exceeded, section 7 consultation must be reinitiated immediately.

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