Final Environmental Assessment of a Low-Energy Marine Geophysical Survey by the R/V *Roger Revelle* in the Northeastern Pacific Ocean, September 2017

Prepared for

Scripps Institution of Oceanography
8602 La Jolla Shores Dr.
La Jolla, CA 92037

and

National Science Foundation
Division of Ocean Sciences
4201 Wilson Blvd., Suite 725
Arlington, VA 22230

by

LGL Ltd., environmental research associates
22 Fisher St., POB 280
King City, Ont. L7B 1A6

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ABSTRACT

Researchers from Texas A&M University (TAMU), Oregon State University (OSU), and Rutgers University (Rutgers), with funding from the U.S. National Science Foundation (NSF), propose a chief scientist training cruise that would involve low-energy seismic surveys in the northeastern Pacific Ocean off the coasts of Oregon and Washington during September 2017. The surveys would be conducted on the R/V *Roger Revelle* (Revelle), which is operated by Scripps Institution of Oceanography (SIO). The seismic surveys would use a pair of low-energy Generator-Injector (GI) airguns with a total discharge volume of ~90 in^3. The seismic survey would take place outside of U.S. territorial waters within the Exclusive Economic Zone (EEZ) in water depths 130–2600 m.

NSF, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The Proposed Action involves the training of early career seismic chief scientists and the collection of data to address questions about earthquake hazards and paleoclimate records in basins. The Proposed Action has been identified as a NSF program priority.

This Final Environmental Assessment (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) for the proposed NSF federal action. SIO, on behalf of itself, NSF, TAMU, OSU, and Rutgers, is requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental, i.e., not intentional, harassment of small numbers of marine mammals should this occur during the seismic survey. The analysis in this document also supports the IHA application process and provides information on marine species that are not addressed by the IHA application, including seabirds, sea turtles, and fish that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered/threatened species was included, this document will be used to support ESA Section 7 consultations with NMFS and U.S. Fish and Wildlife Service (USFWS). Alternatives addressed in this Final EA consist of a corresponding program at a different time with issuance of an associated IHA and the no action alternative, with no IHA and no seismic survey. This document tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF-USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS.

Numerous species of marine mammals inhabit the proposed project area in the northeastern Pacific. Under the U.S. ESA, several of these species are listed as ***endangered***, including the North Pacific right, humpback (Central America Distinct Population Segment or DPS), sei, fin, blue, sperm, and killer whales (Southern Resident DPS). The Mexico DPS of the humpback whale could also occur in the proposed project area and is listed as ***threatened*** under the ESA. ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback and loggerhead turtles, and the ***threatened*** green and olive ridley turtles. ESA-listed seabirds that could be encountered in the area include the ***endangered*** short-tailed albatross and the ***threatened*** marbled murrelet and western snowy plover. In addition, several ESA-listed fish species occur in the area, including the ***threatened*** Pacific eulachon Southern DPS), the ***threatened*** green sturgeon (Southern DPS), and numerous DPSs or evolutionarily significant units (ESU) of chinook, chum, coho, and sockeye salmon, and steelhead trout.

Potential impacts of the seismic survey on the environment would be primarily a result of the operation of the pair of GI airguns. A multibeam echosounder and a sub-bottom profiler would also be operated during the surveys. Impacts from the Proposed Action would be associated with increased

underwater sound, which could result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned survey is a monitoring and mitigation program designed to minimize potential impacts of the proposed activities on marine animals present during the proposed cruise, and to document as much as possible, the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airguns including high-energy airgun arrays, and also are not likely to be caused by the other types of sound sources to be used. However, despite the relatively low levels of sound emitted by a pair of GI airguns, a precautionary approach would still be taken. The planned monitoring and mitigation measures would reduce the possibility of injurious effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals, sea turtles, and seabirds would include the following: ramp ups; typically two, but a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers 30 min before and during ramp ups during the day; no start ups during poor visibility or at night unless at least one airgun has been operating; and shut downs when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. Additional mitigation measures per the IHA and ITS (Incidental Take Statement) would be followed, including monitoring a 200-m buffer zone and shut downs for non-traveling aggregations of large whales (i.e., baleen and/or sperm whales), large whale with a calf, and killer whales, and North Pacific right whales observed at any distance. Per the IHA and ITS, seismic operations would not need to cease for bowriding small delphinids. The acoustic source would also be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated exclusion zones. Observers would also watch for any impacts the acoustic sources may have on fish. SIO and its contractors are committed to applying these measures in order to minimize effects on marine mammals, sea turtles, seabirds, and fish, and other environmental impacts. Survey operations would be conducted in accordance with all applicable U.S. federal regulations, including IHA and ITS requirements.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal and turtle that could be encountered would be expected to be limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals may be interpreted as falling within the U.S. MMPA definition of “Level B Harassment” for those species managed by NMFS; however, NSF was required to request, and NMFS issued, Level A takes for some marine mammal species. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish, the populations to which they belong, or their habitats.

LIST OF ACRONYMS

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AMVER	Automated Mutual-Assistance Vessel Rescue
BC	British Columbia (Canada)
BIA	Biologically Important Areas
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
CPS	Coastal Pelagic Species
dB	decibel
DPS	Distinct Population Segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EHV	Endeavour Hydrothermal Vents
EIS	Environmental Impact Statement
ESA	(U.S.) Endangered Species Act
ESU	Evolutionarily Significant Units
EZ	Exclusion Zone
FM	Frequency-Modulated
FMP	Fishery Management Plan
GI	Generator-Injector
GIS	Geographic Information System
h	hour
HF	high frequency
hp	horsepower
Hz	Hertz
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
ISRP	Independent Scientific Review Panel
ITS	Incidental Take Statement
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
kHz	kilohertz
km	kilometer
kt	knot
L-DEO	Lamont-Doherty Earth Observatory of Columbia University
LF	low frequency
LFA	Low-Frequency Active (Sonar)
m	meter
MBES	multibeam echosounder
MCS	multi-channel seismic
MF	mid frequency
MFA	Mid-Frequency Active (Sonar)
min	minute
MMPA	(U.S.) Marine Mammal Protection Act

MPA	Marine Protected Area
ms	millisecond
M/V	motor vessel
n.mi.	nautical mile
NEPA	(U.S.) National Environmental Policy Act
NMFS	(U.S.) National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRC	(U.S.) National Research Council
NSF	National Science Foundation
NWR	National Wildlife Refuge
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OCNMS	Olympic Coast National Marine Sanctuary
OEIS	Overseas Environmental Impact Statement
OINWR	Oregon Islands National Wildlife Refuge
OSU	Oregon State University
OW	otariid underwater
p or pk	peak
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
PSVO	Protected Species Visual Observer
PW	phocid underwater
RL	Received level
rms	root-mean-square
R/V	research vessel
s	second
SBP	Sub-Bottom Profiler
SEL	Sound Exposure Level
SIO	Scripps Institution of Oceanography
SPL	Sound Pressure Level
SST	Sea Surface Temperature
SWFSC	Southwest Fisheries Science Center
TAMU	Texas A&M University
TTS	Temporary Threshold Shift
UNEP	United Nations Environment Programme
U.S.	United States of America
USC	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USIO	U.S. Implementing Organization
USN	U.S. Navy
µPa	microPascal
vs.	versus

I. PURPOSE AND NEED

The purpose of this Environmental Assessment (EA) is to provide the information needed to assess the potential environmental impacts associated with the Proposed Action, which includes the use of a pair of 45-in^3 Generator-Injector (GI) airguns during seismic surveys. This Final EA was prepared under the National Environmental Policy Act (NEPA) and tiers to the Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The Final EA provides details of the Proposed Action at the site-specific level and addresses potential impacts of the proposed seismic surveys on marine mammals, as well as other species of concern in the area, including sea turtles, seabirds, fish, and marine invertebrates. The Draft EA was used in support of an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) and Section 7 consultations under the Endangered Species Act (ESA). The issued IHA allows for the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals during the proposed seismic surveys conducted on the R/V *Revelle* by Scripps Institution of Oceanography (SIO) in the northeastern Pacific off Oregon and Washington during September 2017. Per NMFS requirement, small numbers of Level A takes were requested and issued for the remote possibility of low-level physiological effects; however, because of the characteristics of the Proposed Action and proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely.

To be eligible for an IHA under the U.S. MMPA, the proposed "taking" (with mitigation measures in place) must not cause serious physical injury or death of marine mammals, must have negligible impacts on the species and stocks, must "take" no more than small numbers of those species or stocks, and must not have an unmitigable adverse impact on the availability of the species or stocks for legitimate subsistence uses.

Mission of NSF

The National Science Foundation (NSF) was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. Further details on the mission of NSF are described in § 1.2 of the PEIS.

Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. The Proposed Action involves an Early Career Seismic Chief Scientist Training Cruise which aims to train scientists on how to effectively plan seismic surveys, acquire data, and manage activities at sea, and to understand the sediment and crustal structure within the Cascadia continental margin. During the cruise, high-resolution multi-channel seismic (MCS) profiles would be collected off the coast of Oregon and Washington in the northeastern Pacific. The survey region is on the active continental margin of the west coast of the U.S., where a variety of sedimentary and tectonic settings are available, which would provide many targets of geologic interest to a wide range of research cruise participants. Potential targets are the subducting plate and overlying accretionary prism offshore Oregon and Washington, as well as accretionary ridges hosting gas hydrate, the sedimentary cover around seamounts, and hemipelagic sediment containing paleo-oceanographic information on the Juan de Fuca plate. All of these targets have implications for addressing important societally relevant questions, such as earthquake hazards and the long-term history of climate change as recorded in the ocean. In addition to a training cruise and providing a critical data set for understanding the Cascadia margin, the data collected during the survey would support NSF's need to foster a better understanding of Earth processes. The Proposed Action has been identified as an NSF program priority.

Background of NSF-funded Marine Seismic Research

The background of NSF-funded marine seismic research is described in § 1.5 of the PEIS.

Regulatory Setting

The regulatory setting of this EA is described in § 1.8 of the PEIS, including

- National Environmental Protection Act (NEPA);
- Marine Mammal Protection Act (MMPA);
- Endangered Species Act (ESA);
- Coastal Zone Management Act (CZMA); and
- Magnuson-Stevens Fishery Conservation and Management Act - Essential Fish Habitat (EFH)

II. ALTERNATIVES INCLUDING PROPOSED ACTION

In this EA, three alternatives are evaluated: (1) the proposed seismic surveys and issuance of an associated IHA, (2) corresponding seismic surveys at an alternative time, along with issuance of an associated IHA, and (3) no action alternative. Additionally, two Alternatives were considered but were eliminated from further analysis. A summary table of the proposed action, alternatives, and alternatives eliminated from further analysis is provided at the end of this section.

Proposed Action

The Proposed Action, including project objectives and context, activities, and monitoring and mitigation measures for planned seismic surveys, is described in the following subsections.

(1) Project Objectives and Context

Researchers from Texas A&M University (TAMU), Oregon State University (OSU), and Rutgers University (Rutgers) propose to conduct an Early Career Seismic Chief Scientist Training Cruise involving low-energy seismic surveys on the *Revelle* in the northeastern Pacific off the coasts of Oregon and Washington (Fig. 1). The proposed surveys would take place on the active continental margin of the west coast of the U.S. where a variety of sedimentary and tectonic settings are available, providing many targets of geologic interest to a wide range of research cruise participants. To achieve the program's goals, the Principal Investigators (PIs), Drs. M. Tominaga (TAMU), Drs. A. Trehu and M. Lyle (OSU), and G. Mountain (Rutgers), propose to collect low-energy, high-resolution MCS profiles. In addition to the PIs, a number of early career researchers and students would participate in the survey activities.

(2) Proposed Activities

(a) Location of the Survey Activities

The surveys would take place off the Oregon continental margin out to 127.5°W and between ~43 and 46.5°N (see Fig. 1). Although the proposed activities could take place anywhere within the project area as shown in Figure 1, two survey sites have been proposed within this area—the Astoria Fan and the Southern Oregon survey areas. Representative survey tracklines are shown in Figure 1; however, some deviation in actual track lines could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. The seismic surveys would be conducted within the EEZ of the U.S., in water depths ranging from ~130 to 2600 m.

(b) Description of the Activities

The procedures to be used for the seismic surveys would be similar to those used during previous seismic surveys conducted by SIO and would use conventional seismic methodology. The surveys would involve one source vessel, the *Revelle*. The *Revelle* would deploy a pair of 45-in^3 GI airguns as an energy source with a total volume of ~90 in^3. The receiving system would consist of one 800-m hydrophone streamer. As the airguns are towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system.

Two potential survey sites off the Oregon continental margin have been proposed, and are depicted by the boxes in Fig. 1. One survey option (Astoria Fan) is located off northern Oregon off the mouth of the Columbia River and near the Astoria Canyon; the other (southern Oregon) is located off the southern Oregon margin. Each of the proposed surveys has several science targets. The southern Oregon survey includes the paleo objectives, a long plate transect that crosses Diebold Knoll, and a detailed survey of the megaslump segment of the Cascadia subduction zone, which has no previous seismic data. The Astoria Fan survey includes flexure, accretionary wedge mechanisms and gas hydrates as objectives; it covers a major seismic gap. The scientists on board would be responsible for modifying the survey to fit the allocated cruise length while meeting the project objectives, including choosing which survey or what portion of each survey to conduct.

The total line km for the Southern Oregon survey is 1013 km, ~5% of which are in intermediate water (100–1000 m), with the remainder in water deeper than 1000 m. The total length for the Astoria Fan survey is 1057 km, with ~23% of line km in intermediate water and the remainder in water >1000 m. No effort during either survey would occur in shallow water <100 m deep. The total track distance to be surveyed is estimated to be no greater than ~1057 km which is the line km of the longest survey. There would be additional seismic operations in the survey area associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard. In our calculations [see § IV(3)], 25% has been added for those additional operations.

In addition to the operations of the airgun array, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated from the *Revelle* continuously throughout the seismic survey, but not during transits to and from the survey areas. All planned data acquisition and sampling activities would be conducted by SIO with on-board assistance by the scientists who have proposed the project. The vessel would be self-contained, and the crew would live aboard the vessel for the entire cruise.

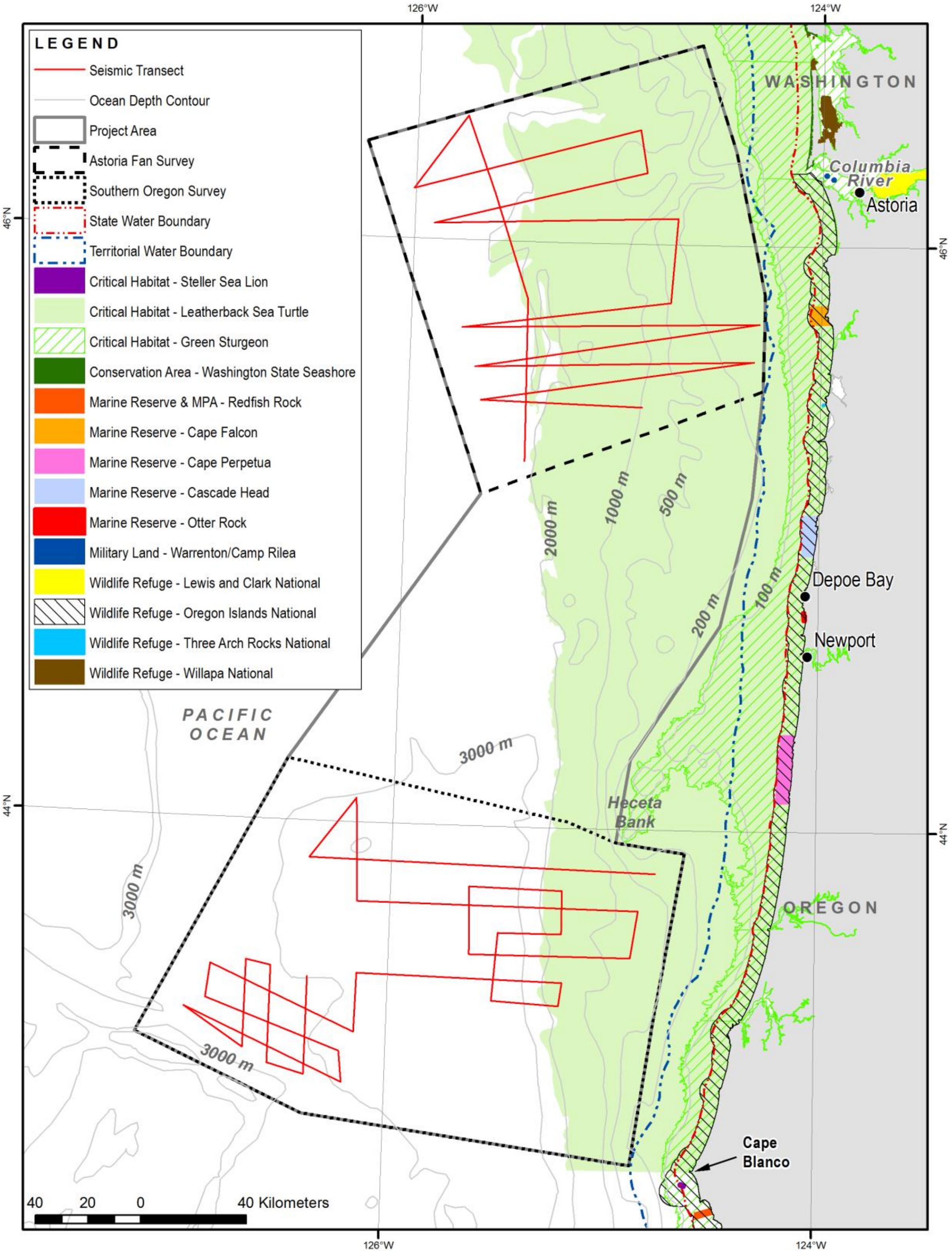

FIGURE 1. Locations of the proposed low-energy seismic surveys in the northeastern Pacific Ocean, September 2017.

(c) Schedule

The *Revelle* would likely depart from Newport, OR, on or about 26 September 2017 and would return to Newport on or about 2 October. Some deviation in timing could result from unforeseen events such as weather or logistical issues. Seismic operations would take ~4 to 5 days, and the transit to and from Newport would take ~2 days.

SIO strives to schedule its operations in the most efficient manner possible; schedule efficiencies are achieved when regionally occurring research projects are scheduled consecutively and non-operational transits are minimized. Because of the nature of the long timeline associated with the ESA Section 7 consultation and IHA processes, not all research projects or vessel logistics are identified at the time the consultation documents are submitted to federal regulators; typically, however, these types of details, such as port arrival/departure locations, are not a substantive component of the consultations.

(d) Vessel Specifications

The *Revelle* has a length of 83 m, a beam of 16.0 m, and a maximum draft of 5.2 m. The ship is powered by two 3000-hp Propulsion General Electric motors and a 1180-hp azimuthing jet bow thruster. An operation speed of ~8.3–9.3 km/h (~4.5–5 kt) would be used during seismic acquisition. When not towing seismic survey gear, the *Revelle* cruises at 22.2–23.1 km/h (12–12.5 kt) and has a maximum speed of 27.8 km/h (15 kt). It has a normal operating range of ~27,780 km.

The *Revelle* would also serve as the platform from which vessel-based protected species visual observers (PSVO) would watch for marine mammals and sea turtles before and during airgun operations. The characteristics of the *Revelle* that make it suitable for visual monitoring are described in § II(3)(a).

Other details of the *Revelle* include the following:

Owner:	U.S. Navy
Operator:	Scripps Institution of Oceanography of the University of California
Flag:	United States of America
Date Built:	1996
Gross Tonnage:	3180
Compressors for Air Guns:	Price Air Compressors, 300 cfm at 1750 psi
Accommodation Capacity:	22 crew plus 37 scientists

(e) Airgun Description

The *Revelle* would tow a pair of 45-in^3 GI airguns and an 800-m streamer containing hydrophones along predetermined lines. Seismic pulses would be emitted at intervals of ~8–10 s (20–25 m).

The generator chamber of each GI gun, the one responsible for introducing the sound pulse into the ocean, is 45 in^3. The larger (105 in^3) injector chamber injects air into the previously generated bubble to maintain its shape, and does not introduce more sound into the water. The two 45-in^3 GI guns would be towed 21 m behind the *Revelle*, 2 m apart side by side, at a depth of 3 m.

GI Airgun Specifications

Energy Source	Two GI guns of 45 in^3
Source output (downward)	0-peak is 3.6 bar-m (230.8 dB re 1 μPa·m); peak-peak is 6.6 bar-m (236.4 dB re 1 μPa·m)
Towing depth of energy source	3 m
Air discharge volume	Approx. 90 in^3
Dominant frequency components	0–188 Hz
Gun positions used	Two inline airguns 2 m apart
Gun volumes at each position (in^3)	45, 45

As the airguns are towed along the survey lines, the towed hydrophone array in the 800-m streamer would receive the reflected signals and transfer the data to the on-board processing system. Given the relatively short streamer length behind the vessel, the turning rate of the vessel with gear deployed would be much higher than the limit of 5º per minute for a seismic vessel towing a streamer of more typical length (>>l km), ~20º. Thus, the maneuverability of the vessel would not be limited much during operations.

As the dimension of the source is small (2 airguns separated by 2 m), the array can be considered as a point source. Thus, we do not expect source array effects in the near field. The source levels can thus be directly derived from the modeled farfield source signature, which is estimated using the PGS Nucleus software. In the case of small source dimension, the source levels obtained from the farfield source signature and maximum modeled source level in the near field are nearly identical.

The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source. Actual levels experienced by any organism more than 1 m from either GI airgun would be significantly lower.

A further consideration is that the rms[1] (root mean square) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (p or 0–p) or peak to peak (p–p) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received sound pressure level (SPL) of 160 dB re 1 μPa_{rms} in the far field would typically correspond to ~170 dB re 1 μPa_{p} or 176–178 dB re 1 $\mu Pa_{p\text{-}p}$, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise difference between rms and peak or peak-to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

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[1] The rms (root mean square) pressure is an average over the pulse duration.

(f) Multibeam Echosounder and Sub-bottom Profilers

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the seismic survey, but not during transits. The ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sources are described in § 2.2.3.1 of the PEIS.

(3) Monitoring and Mitigation Measures

Standard monitoring and mitigation measures for seismic surveys are described in § 2.4.4.1 of the PEIS and would occur in two phases: pre-cruise planning and during operations. The following sections describe the efforts during both stages for the proposed action.

(a) Planning Phase

As discussed in § 2.4.1.1 of the PEIS, mitigation of potential impacts from the proposed activities begins during the planning phase of the proposed activities. Several factors were considered during the planning phase of the proposed activities, including

***Energy Source*.—**Part of the considerations for the proposed survey was to evaluate what source level was necessary to meet the research objectives. It was decided that the scientific objectives could be met using a low-energy source consisting of two 45-in^3 GI guns (total volume of 90 in^3) at a tow depth of ~3 m. The SIO portable MCS system's energy source level is one of the smallest source levels used by the science community for conducting seismic research.

***Survey Timing*.—**The PIs worked with SIO and NSF to identify potential times to carry out the survey, taking into consideration key factors such as environmental conditions (e.g., the seasonal presence of marine mammals), weather conditions, equipment, and optimal timing for other proposed research cruises. Some marine mammal species are expected to occur in the area year-round, so altering the timing of the proposed project likely would result in no net benefits for those species.

***Mitigation Zones*.—**During the planning phase, mitigation zones for the proposed marine seismic surveys were not derived from the farfield signature but calculated based on modeling by Lamont-Doherty Earth Observatory (L-DEO) for both the exclusion zones (EZ) for Level A takes and safety zones (160 dB re 1µPa$_{rms}$) for Level B takes. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS), as a function of distance from the airguns, for the two 45-in^3 GI guns. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from a 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

For deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth (~2000 m) for marine mammals. Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with two 45-in^3 GI guns at a tow depth of 3 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Fig. 2). The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the PEIS).

Table 1 shows the distances at which the 160- and 175-dB re 1µPa$_{\text{rms}}$ sound levels are expected to be received for the two 45-in^3 GI guns at 3-m tow depth. The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated Level B takes for marine mammals; a 175-dB level is used by NMFS to determine behavioral disturbance for sea turtles.

A recent retrospective analysis of acoustic propagation of *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, preliminary analysis by Crone (2017, L-DEO, pers. comm.) of data collected during a survey off New Jersey in 2014 and 2015 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by the *Langseth* hydrophone streamer were similarly 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[2] have

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[2] L-DEO surveys off the Yucatán Peninsula in 2004 (Barton et al. 2006; Diebold et al. 2006), in the Gulf of Mexico in 2008 (Tolstoy et al. 2009; Diebold et al. 2010), off Washington and Oregon in 2012 (Crone et al. 2014), and off New Jersey in 2014 and 2015 (Crone 2017, L-DEO, pers. comm.).

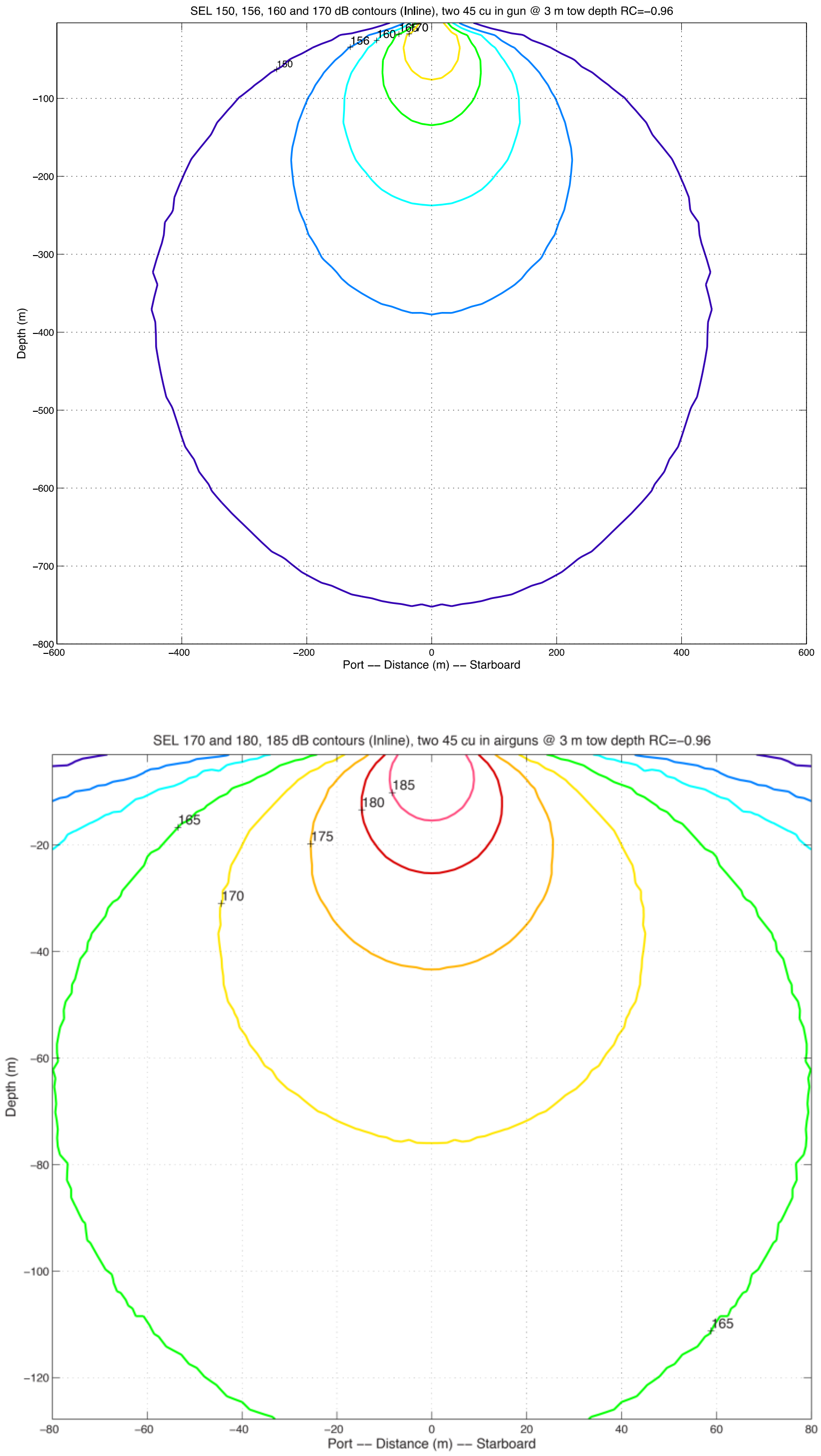


FIGURE 2. Modeled deep-water received sound exposure levels (SELs) from the two 45-in^3 GI guns planned for use during the proposed surveys in the northeast Pacific Ocean at a 3-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The lower plot is a zoomed-in version of the upper plot.

TABLE 1. Level B. Predicted distances to the 160 dB re 1 µPa$_{rms}$ and 175-dB sound levels that could be received from two 45-in^3 GI guns (at a tow depth of 3 m) that would be used during the seismic survey in the northeastern Pacific Ocean during September 2017 (model results provided by L-DEO). The 160-dB criterion applies to all marine mammals; the 175-dB criterion applies to sea turtles.

Water depth	**Predicted distances (in m) to various received sound levels**	
	160 dB re 1 µPa$_{rms}$	**175 dB re 1 µPa$_{rms}$**
>1000 m	448[1]	80[1]
100–1000 m	672[2]	120[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 x correction factor between deep and intermediate water depths.

confirmed that the L-DEO model generated conservative exclusion zones, resulting in significantly larger safety zones than necessary.

In July 2016, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a). The new guidance established new thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The new noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. Onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL$_{cum}$ and SPL$_{flat}$, respectively. For impulsive sounds, such airgun pulses, the new guidance incorporates marine mammal auditory weighting functions (Fig. 3) and dual metrics of cumulative sound exposure level (SEL$_{cum}$ over 24 hours) and peak sound pressure levels (SPL$_{flat}$). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by NMFS (2016a), the largest distance of the dual criteria (SEL$_{cum}$ or Peak SPL$_{flat}$) was used to calculate takes and Level A threshold distances. SEL$_{cum}$ was used for LF cetaceans, and Peak SPL was used for all other hearing groups. In this analysis, Level A threshold distances are based on the distances to the thresholds with a high-pass filter applied. However, NMFS subsequently concluded that it was more appropriate to use the distances (radii) to the thresholds without applying a high-pass filter. The new guidance did not alter the current threshold, 160 dB re 1µPa$_{rms}$, for Level B harassment (behavior).

The SEL$_{cum}$ and Peak SPL for the *Revelle* array are derived from calculating the modified farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance (right) below the array (e.g., 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, it has been recognized that the source level from the theoretical farfield signature is never physically achieved at the source when the source is an array of multiple airguns separated in space (Tolstoy et al. 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the

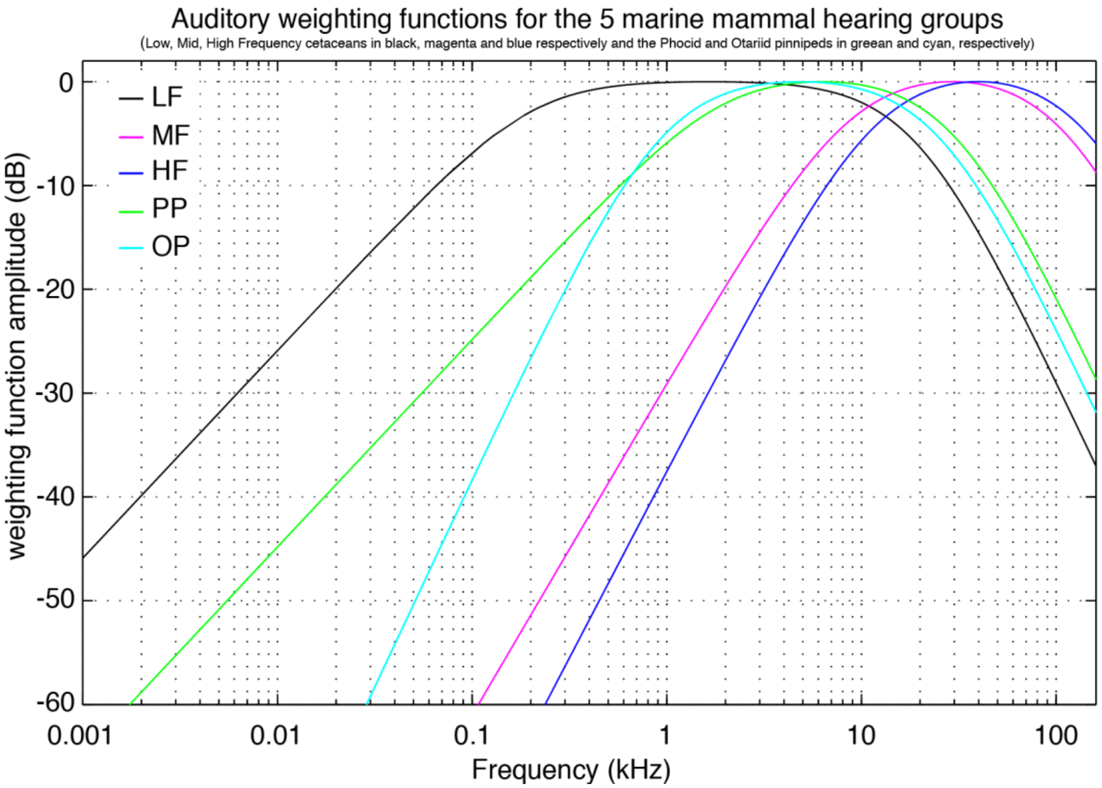


FIGURE 3. Auditory weighting functions from NMFS technical guidance.

source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy et al. 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the large array effect near the source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for large arrays. For this smaller array, the modified farfield changes will be correspondingly smaller as well but we use this method for consistency across all array sizes.

To estimate $\mathrm{SEL_{cum}}$ and Peak SPL, we used the acoustic modeling developed at L-DEO (same as used for Level B takes) with a small grid step in both the inline and depth directions. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays which we do using the NUCLEUS software to estimate the notional signature and the MATLAB software to calculate the pressure signal at each mesh point of a grid.

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on override of default values and calculating individual adjustment factors (dB) and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of $\mathrm{SEL_{cum}}$ isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014). The methodology (input) for calculating the distances to the $\mathrm{SEL_{cum}}$ PTS thresholds (Level A) for the airgun array is shown below.

SEL_{cum} Methodology Parameters (Sivle et al. 2014) †

Source Velocity (meters/second)	2.572222
1/Repetition rate^ (seconds)	7.775377

† Methodology assumes propagation of 20logR. ^ Time between onset of successive pulses. Activity duration (time) independent. The source velocity and 1/Repetition rate were used as inputs to the NMFS User Spreadsheet.

For the LF cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest. We first ran the modeling for a single shot without applying any weighting function; the maximum 183 dB SEL_{cum} isopleth was located at 14.15 m from the source. We then ran the modeling for a single shot with the LF cetacean weighting function applied to the full spectrum; the maximum 183 dB SEL_{cum} isopleth was located at 7.10 m from the source. The difference between 14.15 m and 7.10 m gives an adjustment factor of 5.98 dB assuming a propagation of $20\log_{10}$(Radial distance) (Table 2).

For MF and HF cetaceans, and OW and PW pinnipeds, the modeling for a single shot with the weighted function applied leads to 0-m isopleths; the adjustment factors thus cannot be derived the same way as for LF cetaceans. Hence, for MF and HF cetaceans, and OW and PW pinnipeds, the difference between weighted and unweighted spectral source levels at each frequency up to 3 kHz was integrated to actually calculate these adjustment factors in dB. These calculations also account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014).

For the two GI guns, the results for single shot SEL source level modeling are shown in Table 2. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds are shown in Table 3. Figure 4 shows the impact of weighting functions by hearing group. Figures 5–6 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure 7 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

The thresholds for Peak SPL_{flat} for the two GI guns, as well as the distances to the PTS thresholds, are shown in Table 4. Figures 8–10 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot, with a high-pass filter applied for each hearing group. Figures 11–12 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot, without applying a high-pass filter.

NSF/USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 μPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m EZ for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS that approach is used here for the pair of 45-in^3 GI airguns. The 100-m EZ would also be used as the EZ for sea turtles, although current guidance by NMFS suggests a Level A criterion of 195 dB re 1 μPa_{rms} or an EZ <14 m (9 m in deep water; 13.5 m in intermediate water) for the pair of 45-in^3 GI airguns (see Fig. 2). If marine mammals or sea turtles are detected in or about to enter the appropriate EZ, the airguns would be shut down immediately.

TABLE 2. Table showing the results for one single SEL source level modeling without and with applying weighting function to the five hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation is of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	**183**	**185**	**155**	**185**	**203**
Distance (m) **(no weighting function)**	14.1522	11.1735	370.845	11.1735	1.55
Modified Farfield SEL	206.0165	205.9638	206.384	205.9638	206.806
Distance (m) **(with weighting function)**	7.1051	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	- 5.98	N.A.	N.A.	N.A.	N.A.

N.A. means not applicable or not available.

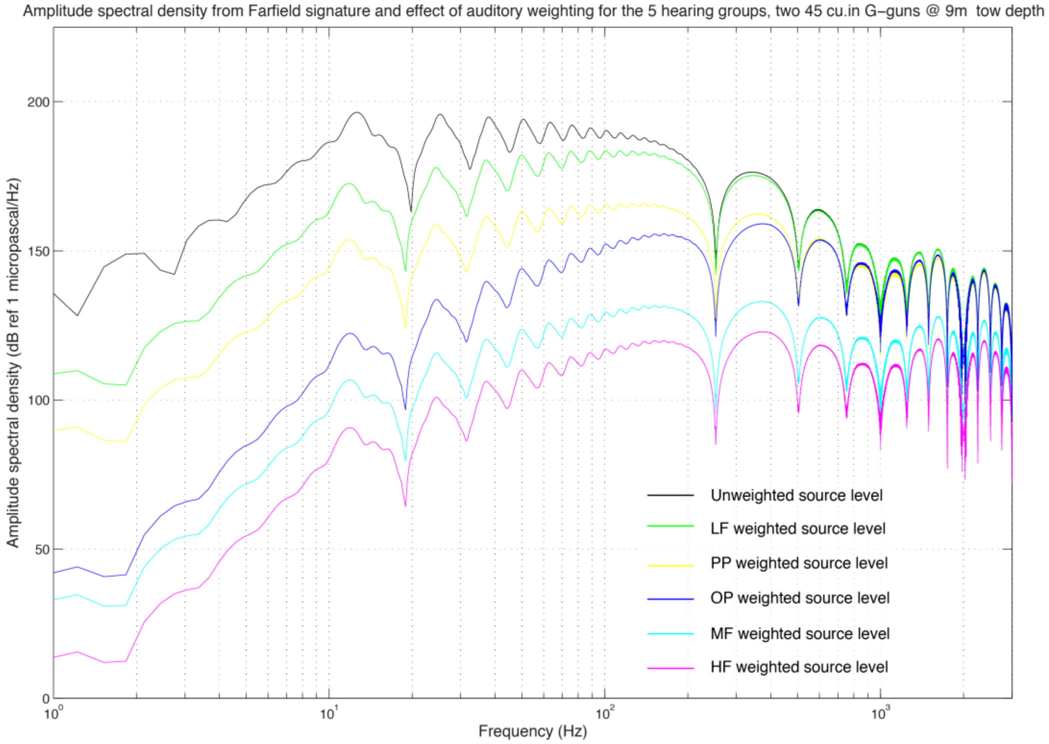
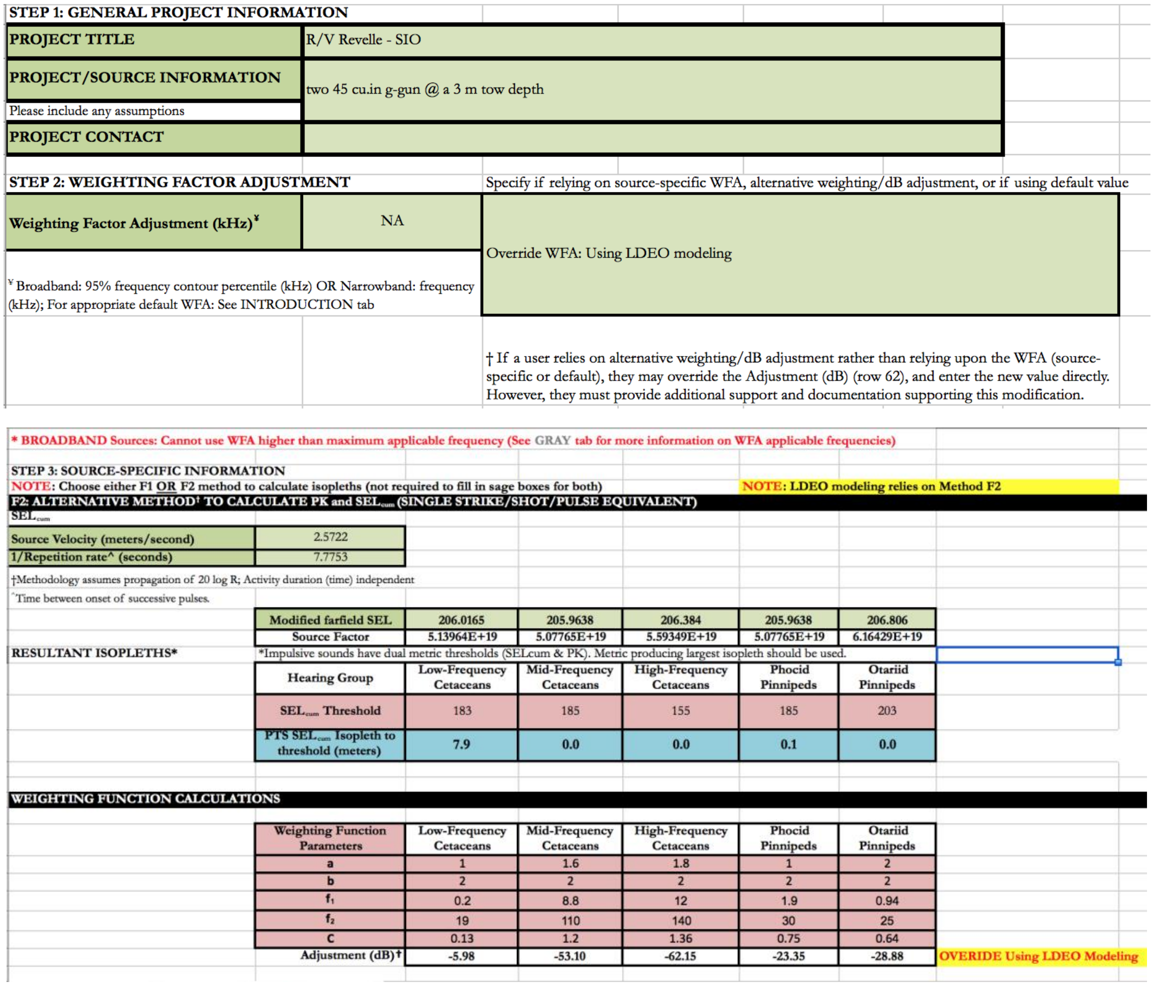


FIGURE 4. Modeled amplitude spectral density of the two GI guns farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

TABLE 3. NMFS User Spreadsheet. Results for single shot SEL source level modeling for the two GI guns with weighting function calculations for the $\mathrm{SEL}_{\mathrm{cum}}$ criteria, as well as resulting isopleths to thresholds for various hearing groups.



STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V Revelle - SIO
PROJECT/SOURCE INFORMATION Please include any assumptions	two 45 cu.in g-gun @ a 3 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	NA	Override WFA: Using LDEO modeling

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and $\mathrm{SEL}_{\mathrm{cum}}$ (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

$\mathrm{SEL}_{\mathrm{cum}}$

Source Velocity (meters/second)	2.5722
1/Repetition rate^ (seconds)	7.7753

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	206.0165	205.9638	206.384	205.9638	206.806
Source Factor	5.13964E+19	5.07765E+19	5.59349E+19	5.07765E+19	6.16429E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
$\mathrm{SEL}_{\mathrm{cum}}$ Threshold	183	185	155	185	203
PTS $\mathrm{SEL}_{\mathrm{cum}}$ Isopleth to threshold (meters)	7.9	0.0	0.0	0.1	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-5.98	-53.10	-62.15	-23.35	-28.88	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 4).

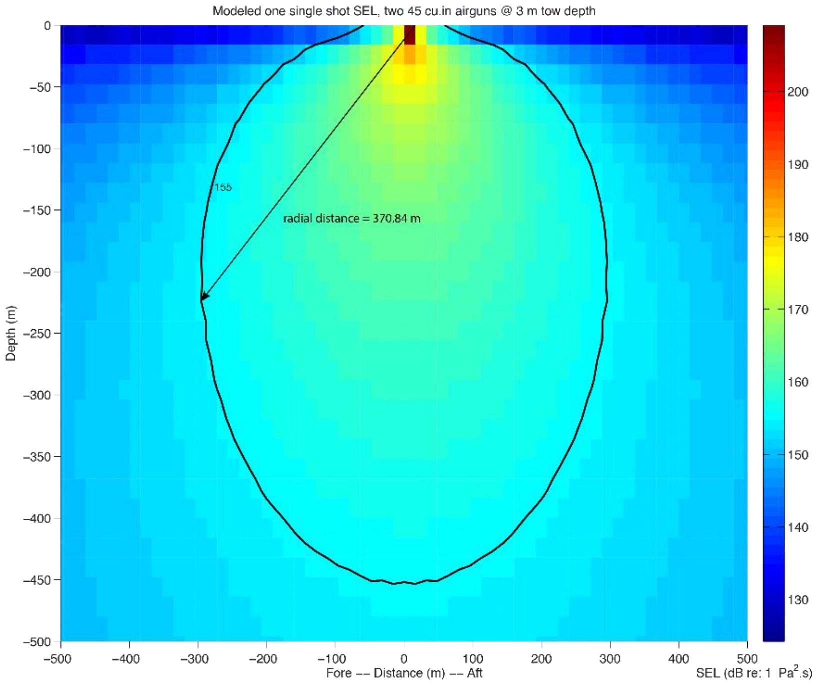


FIGURE 5. Modeled received sound levels (SELs) in deep water from the two 45 in^3 GI guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (370.84 m).

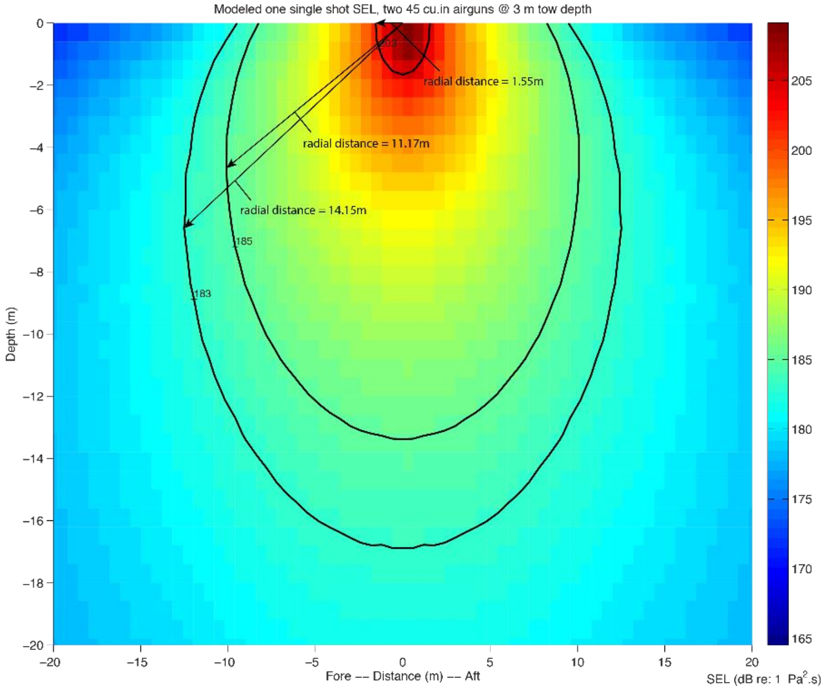


FIGURE 6. Modeled received sound levels (SELs) in deep water from the two 45 in^3 GI guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183-, 185-, and 203-dB SEL isopleths.

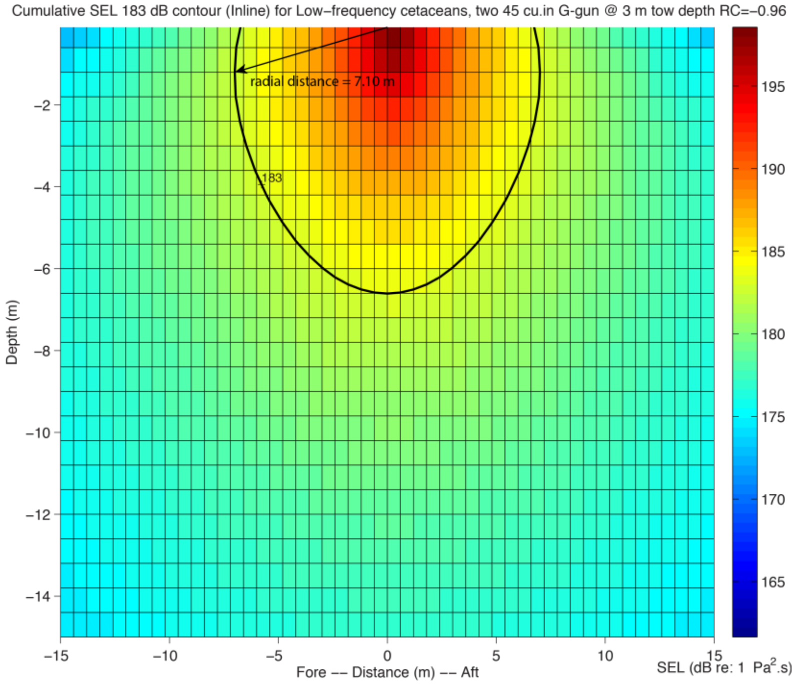


Figure 7. Modeled received sound exposure levels (SELs) from the two 45 in^3 GI guns at a 3-m tow depth, after applying the auditory weighting function for the LF cetaceans following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. 6 (254.58 m) and this figure (2.29 m) allows us to estimate the adjustment in dB.

Table 4. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the two GI guns during the proposed seismic surveys in the northeastern Pacific Ocean.

Hearing Group	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
PK Threshold	219	230	202	218	232
Radial distance to threshold (m) ^	4.901	0.987	34.943	5.222	0.436
Modified Farfield Peak SPL*	232.805	229.89	232.867	232.356	224.7897
Distance (m) to threshold (HP filter) †	4.68	N.A.	12.49	3.87	N.A.
Adjustment (dB)	-0.40	N.A.	- 8.93	- 2.61	N.A.

N.A. means not applicable or not available. HP = High-Pass Filter.

^ The distance to threshold (no filter) is equivalent to the PTS PK isopleth to threshold; used by NMFS to calculate takes. Except for HF cetaceans, the radial distance vs. radius to threshold is the same for all hearing groups; for HF cetaceans, the radius is 33.764 m.

† The radial distance to threshold, with a HP filter, was used in this EA as the PTS PK isopleth to threshold and to calculate takes.

* Propagation of 20logR.

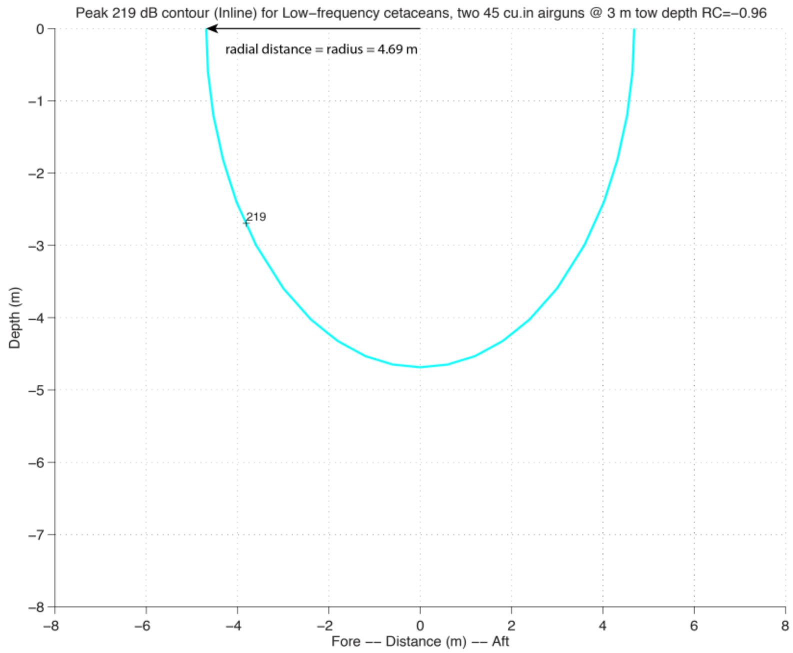


FIGURE 8. Modeled deep-water received Peak SPL from the two 45-in^3 GI guns at 3-m tow depth after applying a high-pass filter of 7 Hz for LF cetaceans as described in the NMFS Acoustic Guidance. The plot provides the radius to the 219-dB Peak SPL isopleth for one airgun shot that corresponds to the PTS Peak SPL threshold for LF cetaceans.

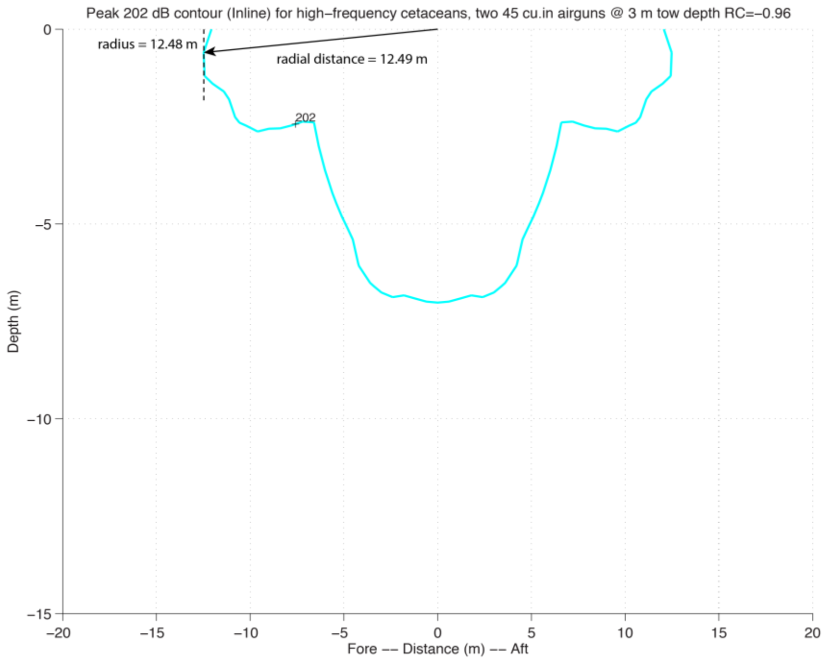


FIGURE 9. Modeled deep-water received Peak SPL from the two 45-in^3 GI guns at 3-m tow depth after applying a high-pass filter of 275 Hz for HF cetaceans as described in the NMFS Acoustic Guidance. The plot provides the radius to the 202-db Peak SPL isopleth for one shot that corresponds to the PTS Peak SPL threshold for HF cetaceans.

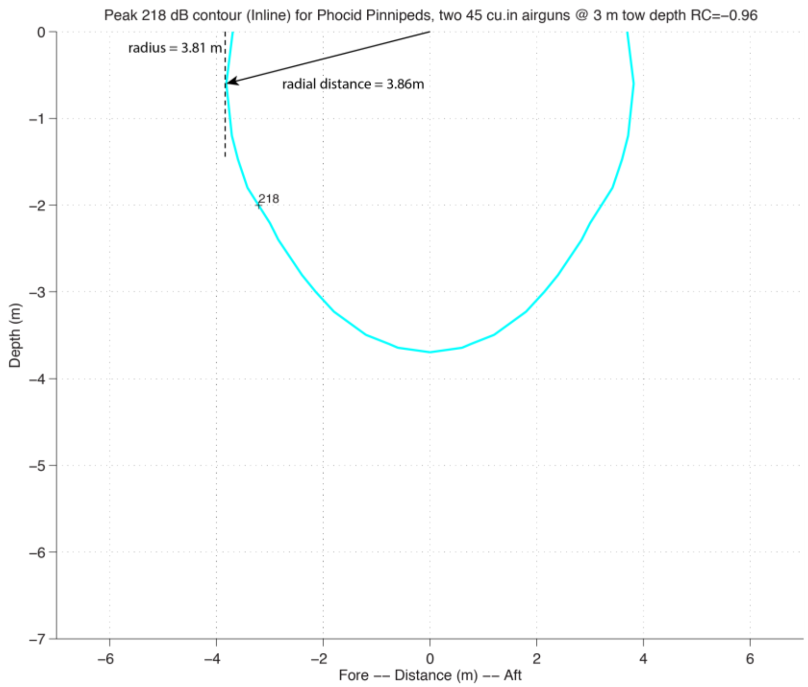


FIGURE 10. Modeled deep-water received Peak SPL from the two 45-in^3 GI guns at 3-m tow depth after applying a high-pass filter of 50 Hz for Phocids Underwater as described in the NMFS Acoustic Guidance. The plot provides the radius to the 218-dB Peak SPL isopleth for one shot that corresponds to the PTS Peak SPL threshold for Phocids.

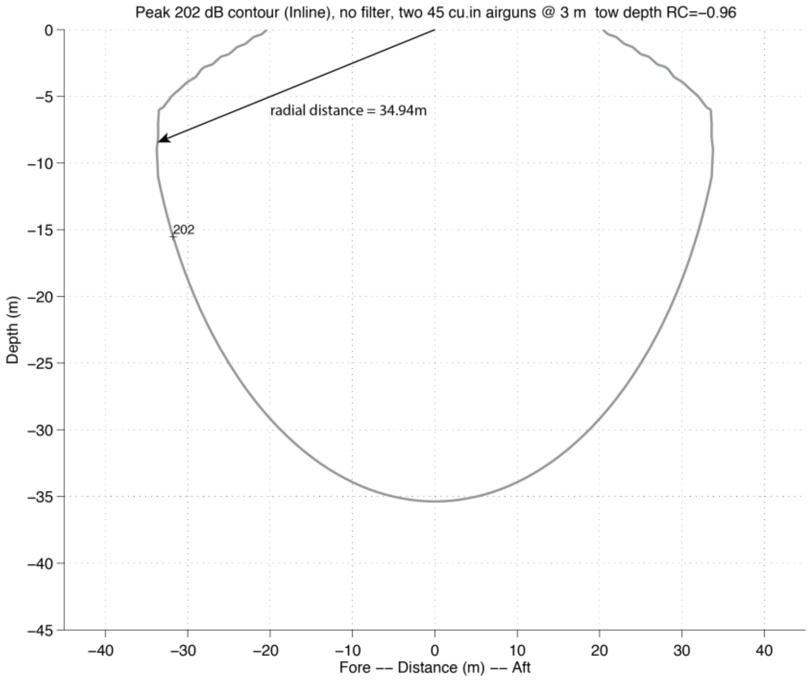


FIGURE 11. Modeled deep-water received Peak SPL from two 45-in^3 GI guns at a 3-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB peak isopleth (34.94 m).

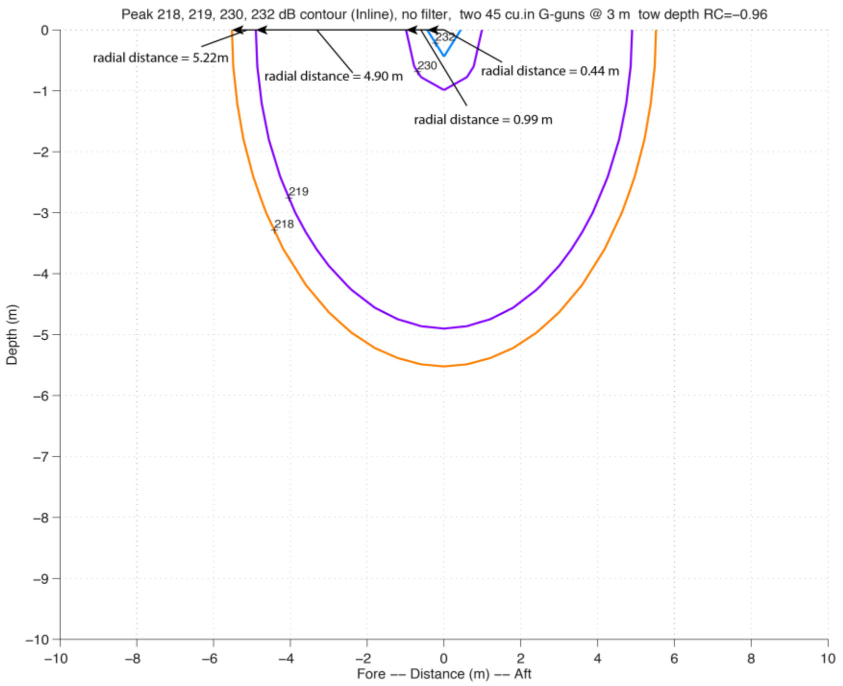


FIGURE 12. Modeled deep-water received Peak SPL from two 45-in^3 GI guns at a 3-m tow depth. The plot provides the radial distances from the source geometrical center to the 218-, 219-, 230-, and 232-dB Peak isopleths.

Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. A fixed 160-dB "Safety Zone" was not defined for the same suite of low-energy sources in the NSF/USGS PEIS; therefore, L-DEO model results for 45-in^3 GI guns are used here to determine the 160-dB radius for the pair of 45-in^3 GI airguns (see Table 1).

This IHAA has been prepared in accordance with the current NOAA acoustic practices, and procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), and Wright and Cosentino (2015).

(a) Operational Phase

SIO's operational mitigation measures are described in § 2.4.1.1 of the PEIS and include

- monitoring by PSVOs for marine species (including marine mammals, sea turtles, ESA-listed seabirds diving near the vessel, and observing for potential impacts of acoustic sources on fish);
- PSVO data and documentation; and
- mitigation during operations (speed or course alteration; power-down, shut-down, and ramp-up procedures; and special mitigation measures for rare species, species concentrations, and sensitive habitats).

The proposed operational mitigation measures are standard for all low energy seismic cruises, per the PEIS, and therefore are not discussed further here. Special mitigation measures were considered for this cruise. It is unlikely that concentrations of large whales would be encountered, but if so, they would be avoided. Additional mitigation measures per the IHA and ITS would be followed, including monitoring a 200-m buffer zone and shut downs for non-traveling aggregations of large whales (i.e., baleen and/or sperm whales), large whale with a calf, and killer whales, and North Pacific right whales observed at any distance. Per the IHA and ITS, seismic operations would not need to cease for bowriding small delphinids.

Marine mammals and sea turtles are known to occur in the proposed survey area. However, the number of individual animals expected to be approached closely during the proposed activities would be relatively small in relation to regional population sizes. With the proposed monitoring and mitigation provisions, potential effects on most if not all individuals would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individual marine mammals and on the associated species and stocks. Survey operations would be conducted in accordance with all applicable U.S. federal regulations, including IHA and ITS requirements.

Alternative 1: Alternative Survey Timing

An alternative to issuing the IHA for the period requested and to conducting the project then would be to conduct the project at an alternative time, implementing the same monitoring and mitigation measures as under the Proposed Action, and requesting an IHA to be issued for that alternative time (Table 5). The proposed time for the cruise in September 2017 is the most suitable time logistically for the *Revelle* and the participating scientists. If the IHA is issued for another period, it could result in significant delay and disruption not only of this cruise, but also of additional studies that are planned on the *Revelle* for 2017 and beyond. An evaluation of the effects of this Alternative Action is given in § IV.

Alternative 2: No Action Alternative

An alternative to conducting the proposed activities is the “No Action” alternative, i.e., do not issue an IHA and do not conduct the research operations (Table 5). Under the “No Action” alternative, NSF would not support SIO to conduct the proposed research operations. From NMFS’ perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the “No Action” alternative entails

NMFS denying the application for an IHA. If NMFS were to deny the application, SIO would not be authorized to incidentally take marine mammals. If the research operations were not conducted, the “No Action” alternative would result in no disturbance to marine mammals from the proposed activities. The purpose of the proposed action is to train early career chief seismic scientists and to cover seismic data gaps and address questions about earthquake hazards and paleoclimate records in basins off the Oregon continental margin.

The “No Action” alternative could also, in some circumstances, result in schedule impacts of other studies that would be planned on the *Revelle* for 2017 and beyond, depending on the timing of the decision. Not conducting this cruise (no action) would result in less data and support for the academic institutions involved. Data collection would be an essential first step for a much greater effort to analyze and report information for the significant topics indicated. The field effort provides material for years of analyses involving multiple professors, students, and technicians. The lost opportunity to collect valuable scientific information would be compounded by lost opportunities for support of research infrastructure, training, and professional career growth. Effects of this Alternative Action are evaluated in § IV.

TABLE 5. Summary of Proposed Action, Alternatives Considered, and Alternatives Eliminated.

Proposed Action	Description/Analysis
Proposed Action: Conduct marine geophysical surveys and associated activities in the northeastern Pacific Ocean	Under this action, the use of a low-energy seismic source is proposed. When considering mobilization, demobilization, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed activities would be expected to be completed in ~8 days. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in Sections III, IV, and V, respectively. The standard monitoring and mitigation measures identified in the NSF PEIS would apply. Additionally, NMFS requires that a 200-m buffer zone, in addition to the 100 m EZ, should be monitored, as specified in the IHA. Per the IHA for this survey, NMFS also requires shut downs for non-traveling aggregations of large whales (i.e., baleen and/or sperm whales), large whale with a calf, and killer whales, and North Pacific right whales observed at any distance.
Alternatives	Description/Analysis
Alternative 1: Alternative Survey Timing	Under this Alternative, SIO would conduct survey operations at a different time of the year to reduce potential impacts on marine resources and users, and improve monitoring capabilities. However, except for some baleen whales, most marine mammal species are likely year-round residents in the survey area, so altering the timing of the proposed project likely would result in no net benefits for those species. Further, consideration would be needed for constraints for vessel operations and availability of equipment (including the vessel) and personnel. Limitations on scheduling the vessels include the additional research studies planned on the vessel for 2017 and beyond. The standard monitoring and mitigation measures identified in the PEIS would apply and are described in further detail in this document (Section II [3]) along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternative 2: No Action	Under this Alternative, no proposed activities would be conducted and seismic data would not be collected. Whereas this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the proposed action. The training of scientists, collection of new data, interpretation of these data, and introduction of new results into the greater scientific community would not be achieved. Geological data of scientific value and relevance to increasing our understanding of Earth processes would not be collected. No permits and authorizations, including an IHA, would be requested from regulatory bodies as the proposed action would not be conducted.
Alternatives Eliminated from Further Analysis	Description/Analysis
Alternative E1: Alternative Location	The study sites off the Oregon continental margin have been specifically selected as key locations to address seismic data gaps and to address questions about earthquake hazards and paleoclimate records in basins. The survey locations would allow the PIs, early career scientists, and students involved to reach sites of high scientific interest in a cost effective and timely manner, allowing more time and effort to focus on the research and training aspects of the proposed activities.
Alternative E2: Alternative Survey Techniques	Under this alternative, SIO would use alternative survey techniques, e.g., marine vibroseis that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the PEIS, § 2.6. At the present time, however, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need.

Alternatives Considered but Eliminated from Further Analysis

(1) Alternative E1: Alternative Location

The Astoria Fan and southern Oregon survey sites have been specifically selected as key locations to cover seismic data gaps and to collect data to address questions about earthquake hazards and paleoclimate records in basins. The survey locations would also allow the PIs, early career scientists, and students involved to reach sites of high scientific interest in a cost effective and timely manner, allowing more time and effort to focus on the research and training aspects of the proposed activities.

(2) Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the PEIS, alternative technologies to the use of airguns were investigated to conduct marine geophysical research. At the present time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. Additional details about these technologies are given in the Final USGS EA (RPS 2014a). Table 5 provides a summary of the proposed action, alternatives, and alternatives eliminated from further analysis.

III. AFFECTED ENVIRONMENT

As described in the PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) has focused mainly on those related to marine biological resources, as the proposed short-term activities have the potential to impact marine biological resources within the project area. These resources are identified in Section III, and the potential impacts to these resources are discussed in Section IV. Initial review and analysis of the proposed Project activities determined that the following resource areas did not require further analysis in this Final EA:

- *Transportation*—Only one vessel, the *Revelle*, would be used during the marine seismic survey. Therefore, projected increases in vessel traffic attributable to implementation of the proposed activities would constitute only a negligible portion of the total existing vessel traffic in the analysis area;
- *Air Quality/Greenhouse Gases*—Project vessel emissions would result from the proposed activities; however, these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the survey area;
- *Land Use*—All activities are proposed to occur in the marine environment. Therefore, no changes to current land uses or activities within the project area would result from the proposed Project;
- *Safety and Hazardous Materials and Management*—No hazardous materials would be generated or used during proposed activities. All Project-related wastes would be disposed of in accordance with Federal and international requirements;
- *Geological Resources (Topography, Geology and Soil)*—The proposed project would not result in any disturbances to seafloor sediments. The proposed activities, therefore, would not adversely affect geologic resources;

- *Water Resources*—No discharges to the marine environment are proposed within the project area that would adversely affect marine water quality. Therefore, there would be no impacts to water resources resulting from the proposed Project activities;
- *Terrestrial Biological Resources*—All proposed project activities would occur in the marine environment and would not impact terrestrial biological resources;
- *Socioeconomic and Environmental Justice*—Implementation of the proposed project would not affect, beneficially or adversely, socioeconomic resources, environmental justice, or the protection of children. No changes in the population or additional need for housing or schools would occur. Although there are a number (at least 17) of shore-accessible SCUBA diving sites along the Oregon coast (ShoreDiving.com 2017), the proposed activities would occur in water depths >130 m, outside the range for recreational SCUBA diving. Human activities in the area around the survey vessel would be limited to fishing activities, other vessel traffic, and possibly whale watching; however, no significant impacts on fishing would be anticipated particularly because of the short duration of the proposed activities (~1 week). Fishing and potential impacts to fishing are described in further detail in Sections III and IV, respectively. No other socioeconomic impacts would be anticipated as result of the proposed activities;
- *Visual Resources*—No visual resources would be anticipated to be negatively impacted as the area of operation is outside of the land and coastal view shed; and
- *Cultural Resources*—Although the Columbia River Bar is nicknamed the *Graveyard of the Pacific* with ~2000 shipwrecks (TheOregonCoast.info 2017), the Astoria Fan survey area is located >50 km from the mouth of the Columbia River and would occur beyond 12 n.mi. from the coastline; thus, there are no known cultural resources within the proposed project area. Furthermore, the proposed activities would not involve seafloor disturbances, including placement of equipment on the seafloor. Therefore, no impacts to cultural resources, including shipwrecks, would be anticipated.

Oceanography

The proposed survey area occurs in the northeastern Pacific Ocean off the coasts of Oregon and Washington. In the North Pacific Ocean, there is a clockwise flow of the central subtropical gyre, and to the north of it, the subarctic gyre flows counterclockwise (Escorza-Treviño 2009). The convergence zone of the subarctic and central gyres, known as the Subarctic Boundary, crosses the western and central North Pacific Ocean at 42ºN (Escorza-Treviño 2009). It is in that area that the change in abundance of cold-water *vs*. warm-water species is the greatest (Escorza-Treviño 2009). Along the U.S. west coast, the Alaska Current flows north along the southeastern coast of Alaska and the Aleutian Peninsula, and the California Current flows south along the coast of California (Escorza-Treviño 2009). The California Current system nutrifies offshore waters by mixing with water from the shelf edge (Buchanan et al. 2001).

Acoustic backscatter surveys within ~550 km of the U.S. west coast showed that fish and zooplankton are associated with shallow bathymetry in this area; the highest densities were located in waters <4000 m deep (Philbrick et al. 2003). During winter through fall, 2015–2016, average sea surface temperatures within the survey area were 9.6, 11.3, 13.6 and 12.0ºC, respectively, with minimum and maximum values of 8.8ºC and 17.0ºC (data unavailable for June and October–December 2016) (ERDDAP 2017a). From July–December 2001, offshore primary productivity ranged up to ~250 mgC·m^{-2}·d^{-1} in the euphotic zone (Philbrick et al. 2003). Overall, primary production within the survey area is highest from May through September; the chlorophyll concentration in sea water peaked at 280,764 mg·m^{-3}·d^{-1} during August 2016 (ERDDAP 2017b,c).

A climatic phenomenon called the "Pacific Decadal Oscillation" (PDO) is evident in the Pacific Ocean (Mantua 1999). The PDO is similar to a long-lived El Niño-like pattern of climate variability; it is mainly evident in the North Pacific/North American area, whereas El Niños are typical in the tropics (Mantua 1999). El Niño events do not always influence conditions as far north as Oregon and Washington; during less intense episodes, California is the northern limit of El Niño conditions (Buchanan et al. 2001). PDO "events" persist for 20–30 years, whereas typical El Niño events persist for 6–18 months (Mantua 1999). In the past century, there have been two PDO cycles: "cool" PDO regimes during 1890–1924 and 1947–1976, and "warm" PDO regimes during 1925–1946 and 1977–the mid 1990s (Mantua et al. 1997; Minobe 1997).

A mass of warm water, referred to as "the Blob", formed in the Gulf of Alaska during autumn 2013 and grew and spread across the majority of the North Pacific and Bering Sea during spring and summer 2014, resulting in sea surface temperature anomalies ≥4ºC across the region (Peterson et al. 2016). During autumn 2014, decreased upwelling winds caused a portion of this warm water to travel eastward towards the continental shelf off eastern Alaska and the Pacific Northwest, making the sea surface temperature pattern associated with the Blob resemble a "warm" or "positive" PDO pattern (Peterson et al. 2016). As of May 2016, sea surface temperature anomalies in the outer shelf waters off Oregon remained 2ºC higher, with indications the trend would likely continue well into 2017 (Peterson et al. 2016). Changes in the eastern North Pacific Ocean marine ecosystem have been correlated with changes in the PDO. Warm PDOs showed increased coastal productivity in Alaska and decreased productivity off the U.S. west coast, whereas the opposite north-south pattern of marine ecosystem productivity was seen during cold PDOs (Mantua 1999).

Protected Areas

(1) Critical Habitat for ESA-listed Species

Several areas near the proposed survey area have been specifically identified as important to ESA-listed species, including critical habitat for marine mammals, sea turtles, seabirds, and fish. Only those areas within 50 km of the proposed survey area are shown on Figure 1.

Steller Sea Lion Critical Habitat.—Federally designated critical habitat for Steller sea lions includes all rookeries and major haulouts including those in southern Oregon (NMFS 1993). Although the Eastern Distinct Population Segment (DPS) was delisted from the ESA in 2013, the designated critical habitat remains valid (NOAA 2017a). The designated critical habitats in Oregon are located along the coast at Rogue Reef (Pyramid Rock) and Orford Reef (Long Brown Rock and Seal Rock; see Fig. 1). The critical habitat areas include aquatic zones that extend 0.9 km seaward and air zones extending 0.9 km above these terrestrial and aquatic zones (NMFS 1993). The southeastern boundary of the Southern Oregon survey area is located ~20 km and ~55 km from Orford Reef and Rogue Reef critical habitats, respectively.

Southern Resident Killer Whale Critical Habitat.—Critical habitat for the Eastern North Pacific Southern Resident Stock of killer whales is defined in detail in the Code of Federal Regulations (see NMFS 2006). Critical habitat currently includes three specific marine areas of Puget Sound, Washington: the Summer Core Area, Puget Sound, and the Strait of Juan de Fuca. The critical habitat includes all waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 m relative to extreme high water. The western boundary of the Strait of Juan de Fuca Area is Cape Flattery, Washington (48.38°N; 124.72°W), located ~190 km from the northern portion of the Astoria Fan survey area. In January 2014 the NMFS received a petition requesting an expansion to the Southern Resident killer whale critical habitat to include Pacific Ocean marine waters along the US west coast from Cape Flattery, WA to Point Reyes, CA, extending ~76 km offshore; the NMFS released a 12-month finding in February 2015 accepting the validity of a critical habitat expansion and anticipates developing a new proposed rule during 2017 (NMFS 2015a).

Critical Habitat for Leatherback Turtles.—In January 2012, NMFS designated critical habitat for leatherback sea turtles along the west coast of the U.S. (NMFS 2012a). The critical habitat includes marine areas of ~43,798 km^2 off California and ~64,760 km^2 from Cape Flattery, Washington, to Cape Blanco, Oregon (NMFS 2012a). The Astoria Fan and Southern Oregon survey areas east of the 2000-m contour occur in the critical habitat (see Fig. 1). The majority of the Astoria Fan survey area and the eastern portion of the Southern Oregon survey area occur in the critical habitat (see Fig. 1).

Western Snowy Plover Critical Habitat.—Critical habitat for the Pacific Coast population of the western snowy plover includes sandy beaches and dune systems immediately inland from the active beach face as well as salt flats, mud flats, and gravel bars. These areas should be above high tides and below the heavily vegetated areas, and have minimal disturbance from humans (USFWS 2011). Critical habitat in Washington and Oregon covers 2460 ha and 856 ha, respectively (see Fig. 1) (NMFS 2012b). Segments of this critical habitat are located ~20 km to the east of the proposed survey areas (Fig. 13).

Marbled Murrelet Critical Habitat.—Federally designated critical habitat for marbled murrelets includes nesting habitat with the presence of suitable nesting platforms (including large branches, deformities, mistletoe infestations), canopy cover, landscape condition, and distance to the ocean; nesting platforms are typically at least 10 m off the ground (USFWS 2016a). The critical habitat includes 3,698,100 acres in Washington, Oregon, and California (USWFS 2016a). The nearest segments of this critical habitat are ~23 km to the east of the survey areas (see Fig.13).

Green Sturgeon Critical Habitat.—Coastal U.S. marine Critical Habitat for the ***Threatened*** Southern DPS of North American green sturgeon includes waters within ~109 m (60 fathoms) depth from Monterey Bay, California, north to Cape Flattery, Washington, to its U.S. boundary, encompassing 29,581 km^2 of marine habitat (NMFS 2009). Although this critical habitat is adjacent to the proposed project area, no critical habitat occurs within the survey areas (see Figure 1).

Freshwater critical habitats have been designated for a number of ESA-listed fish species within Washington and Oregon, east or northeast of the proposed survey area; however, none of these habitats extend into marine waters. The species include:

- Pacific eulachon/smelt (Southern DPS; ***Threatened*****)**
- Chinook salmon
  - Lower Columbia River Evolutionary Significant Unit (ESU; ***Threatened***)
  - Puget Sound ESU (***Threatened***)
  - Upper Columbia River ESU (spring-run; ***Endangered***)
  - Upper Willamette River ESU (***Threatened***)

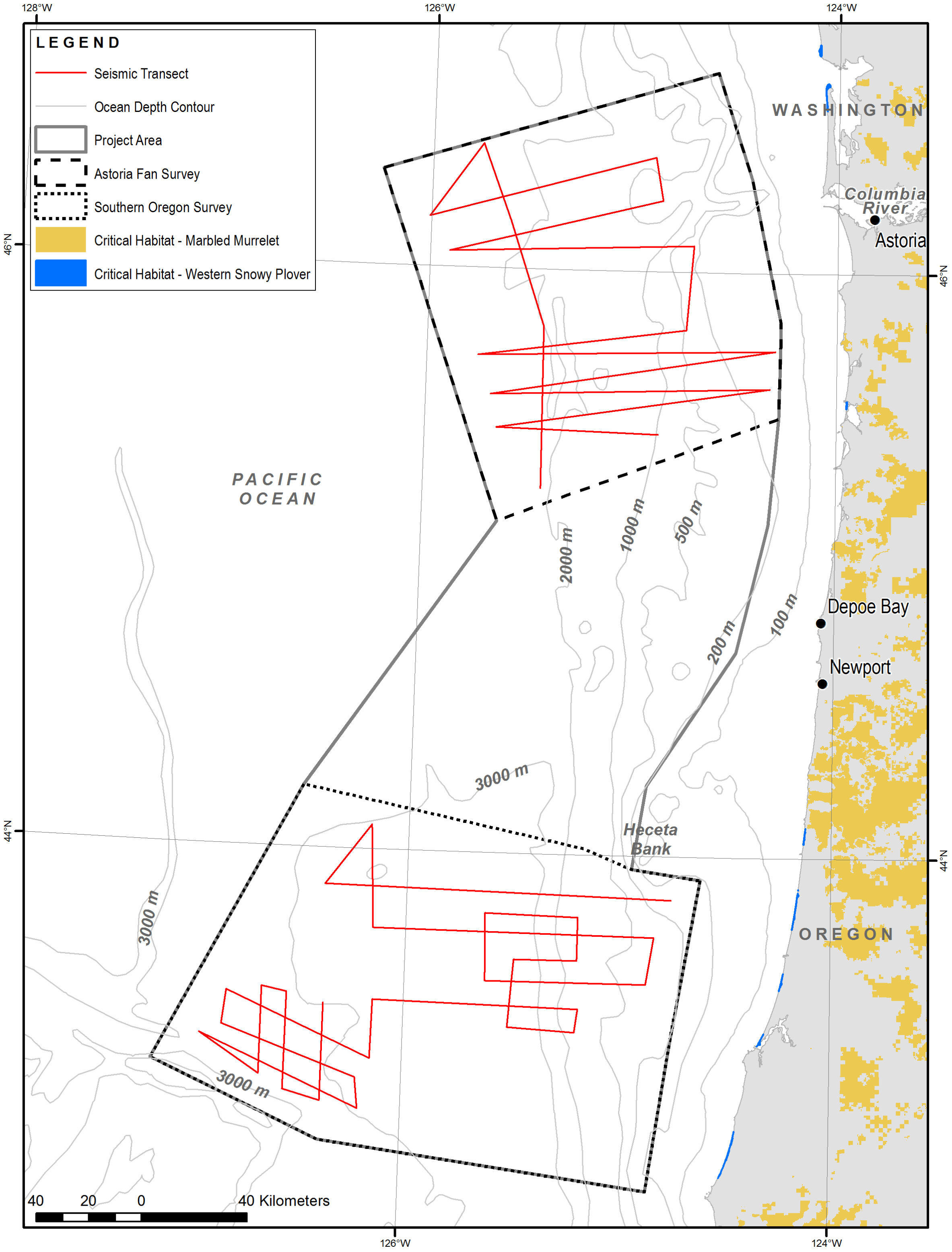


FIGURE 13. Critical habitat for ESA-listed seabirds near the proposed project area in the northeastern Pacific.

- Chum salmon
    - Columbia River ESU (***Threatened***)
    - Hood Canal (summer-run; ***Threatened***)
- Coho salmon
    - Lower Columbia River ESU (***Threatened***)
    - Oregon Coast (***Threatened***)
- Sockeye salmon (Ozette Lake ESU; ***Threatened***)
- Steelhead
    - Lower Columbia River DPS (***Threatened***)
    - Middle Columbia River DPS (***Threatened***)
    - Puget Sound DPS (***Threatened***)
    - Snake River Basin DPS (***Threatened***)
    - Upper Columbia River DPS (***Endangered***)
    - Upper Willamette River DPS (***Threatened***)
- Yelloweye rockfish (Puget Sound/Georgia Basin DPS; ***Threatened***); includes marine portions within Puget Sound/Georgia Basin

(2) Other Protected Areas

There are two portions of U.S. military land which are closed to access near the mouth of the Columbia River, referred to as Warrenton/Camp Rilea (USGS 2016). The nearest of these two areas is ~30 km east of the Astoria Fan survey area (see Fig. 1).

Endeavour Hydrothermal Vents Marine Protected Area.—The Endeavour Hydrothermal Vents (EHV) were designated as the first Marine Protected Area under Canada's Oceans Act in 2003. The EHV area is located on the Juan de Fuca Ridge, 250 km offshore from Vancouver Island, 2250 m below the ocean's surface. Under the Canadian Oceans Act, underwater activities that may result in the disturbance, damage, destruction, or removal of the seabed, or any living marine organism or any part of its habitat, are prohibited (SOR 2003-87). The EHV area is located ~280 km from the northwestern portion of the Astoria Fan survey area.

Washington Island National Wildlife Refuges.—The Washington Islands National Wildlife Refuges (NWRs) are located along 161 km of the outer coast of the Olympic Peninsula, encompassing more than 600 islands, sea stacks, rocks, and reefs. The area is comprised of three NWRs: Copalis NWR (47.13–47.48°N), Quillayute Needles NWR (47.63–48.03°N), and Flattery Rocks NWR (48.03–48.38°N). The refuges do not include islands that are part of designated Native American reservations. Along much of the coastline adjacent to the islands lies the ONP. In 1970, all three of the Washington Islands NWRs were designated as Wilderness Areas, except for Destruction Island in Quillayute Needles NWR. As many as 500 Steller sea lions haul out and 150,000 pelagic birds nest annually on these islands (USFWS 2007). The OCNMS incorporates the entire area surrounding the islands and rocks of all three Refuges. (USFWS 2007). The northeastern extremity of the Astoria Fan survey area is located ~60 km southwest of the Copalis NWR boundary.

Olympic Coast National Marine Sanctuary.—The Olympic Coast National Marine Sanctuary (OCNMS), designated in 1994, includes 8259 km^2 of marine waters off the Washington coast, extending 40–72 km seaward and covering much of the continental shelf and several major submarine canyons (NOAA 2011a). The sanctuary protects a productive upwelling zone with high productivity and a diversity of marine life (NOAA 2011a). This area also has numerous shipwrecks. The OCNMS management plant provides a framework for the sanctuary to manage potential threats to the sanctuary's marine resources under the National Marine Sanctuaries Act. Federal law provides national marine sanctuaries the authority to adopt regulations and issue permits for certain activities, including taking any marine mammal, sea turtle, or seabird in or above the sanctuary, except as authorized by the MMPA, the ESA, and the Migratory Bird Treaty Act. The southern boundary of the OCNMS is ~50 km north of the Astoria Fan survey area.

The OCNMS shares an overlapping boundary in the intertidal zone with the Olympic National Park (ONP). The ONP, designated in 1938, is a zone of exclusive federal jurisdiction encompassing 3734 km^2 and including some of the beaches and headlands along the coast (USFWS 2007). Approximately 75% of the coastal strip is in Congressionally designated wilderness, which is afforded additional protections under the Wilderness Act. The OCNMS is a partner in the management of the ONP marine resources.

Lewis and Clark National Wildlife Refuge.—The Lewis and Clark National Wildlife Refuge includes ~20 islands stretching over 43.5 km of the Columbia River, from the mouth upstream to nearly Skamakowa, Washington (USFWS 2012). This refuge was established in 1972 to preserve the fish and wildlife habitat of the Columbia River estuary, and supports large numbers of waterfowl, gulls, terns, wading birds, shorebirds, raptors, and songbirds. It is located ~50 km east of the Astoria Fan survey area (see Fig. 1).

Willapa National Wildlife Refuge.—The Willapa National Wildlife Refuge is located within Willapa Bay and Columbia River, Washington. It was established in 1973 by President Franklin D. Roosevelt to protect migrating birds and their habitat (USFWS 2013). It consists of multiple segments, with the nearest ~30 km east of the Astoria Fan survey area (see Fig. 1).

Oregon Islands National Wildlife Refuge.—The Oregon Islands National Wildlife Refuge (OINWR) spans 515 km of the Oregon coast from the Oregon-California border to Tillamook Head (~45.9°N) and includes all rocks and islands above the line of mean high tide, except for rocks and islands of the Three Arch Rocks NWR. All of the island acreage is designated National Wilderness, with the exception of Tillamook Rock (USFWS 2016c). The OINWR is located ~25 km east of the nearest portions of the proposed survey areas (see Fig. 1).

Three Arch Rocks National Wildlife Reserve.—Three Arch Rocks NWR consists of 60 m^2 on three large and six small rocky islands located ~1 km from shore. It is one of the smallest designated wilderness areas in the U.S., and is the only northern Oregon pupping site for the Steller sea lion (USFWS 2016b). The Astoria Fan survey area is located ~20 km northwest from the NWR (see Fig. 1).

Washington State Seashore Conservation Area.—The Washington State Seashore Conservation Area includes all seashore between the line of ordinary high tide and the line of extreme low tide between Cape Disappointment (~46°18'N) and Griffiths Priday State Park (~47°07'N). The Conservation Area is under the jurisdiction of the Washington state parks and recreation commission (RCW 79A.05.605). The Seashore Conservation Area is ~25 km east of the northeastern portion of the Astoria Fan survey area (see Fig. 1).

Cape Falcon Marine Reserve.—The Cape Falcon Marine Reserve combines a marine reserve and two marine protected areas located at ~45.7ºN, 124ºW. The entire marine protected area extends ~7 km along the coast of Oregon (see Fig. 1) and out to ~7 km (OOI 2017a). The reserve and marine protected area portions are 32 km^2 and 19.7 km^2, respectively. The Cape Falcon Marine Reserve is located ~15 km east of the Astoria Fan survey area (see Fig. 1).

Cascade Head Marine Reserve.—This site includes a marine reserve surrounded by three marine protected areas, and is located off the central Oregon coast at ~45°N, 124ºW. The entire marine protected area extends 16 km along the coast (see Fig. 1) and out to 5.6 km (OOI 2017a), with total areas of 25.1 km^2 and 59.7 km^2 for the marine reserve and marine protected areas portions, respectively. Cascade Head Marine Reserve is located ~20 km east of the proposed project area (see Fig. 1).

Otter Rock Marine Reserve.—The Otter Rock Marine Reserve was established on 15 November 2011. Otter Rock encompasses 3.4 km^2 of nearshore water at ~44.72–44.75°N (OAR 141-142-0030). The Otter Rock Marine Reserve is located ~30 km east of the proposed project area (see Fig. 1).

Cape Perpetua Marine Reserve.—This site combines a marine reserve, two marine protected area, and a seabird protection area. It is located off the central Oregon coast at ~44.2ºN, 124.1ºW. The entire protected area extends ~26.5 km along the coast (see Fig. 1, and out to ~5 km, with total areas of 36.5 km^2 and 48.7 km^2 for the reserve and marine protected area portions, respectively (OOI 2017a). The Southern Oregon survey area is located ~40 km southwest from the Cape Perpetua Marine Reserve boundary (see Fig. 1).

Redfish Rock Marine Reserve and Marine Protected Area.—The Redfish Rock Marine Reserve and Marine Protected Area were established on 15 November 2011 at ~42.67–44.70°N (OAR 141-142-0035; OAR 141-142-0035). The marine reserve encompasses 6.7 km^2 of nearshore water. The adjacent marine protected area covers an additional ~13 km^2. Redfish Rock Marine Reserve is located ~30 km southeast of the Southern Oregon survey area (see Fig. 1).

Marine Mammals

Thirty-two marine mammal species could occur or have been documented to occur in the marine waters off Oregon and Washington, excluding extralimital sightings or strandings (Fiscus and Niggol 1965; Green et al. 1992, 1993; Barlow 1997, 2003; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999; Barlow and Taylor 2001; Buchanan et al. 2001; Calambokidis et al. 2004a; Calambokidis and Barlow 2004). The species include 7 mysticetes (baleen whales), 19 odontocetes (toothed whales, such as dolphins), 5 pinnipeds (seals), and the sea otter (Table 6). Seven of the species that could occur in the proposed survey area are listed under the ESA as ***Endangered***, including the sperm, humpback (Central America DPSs), sei, fin, blue, North Pacific right, and killer whales (Southern Resident DPS). The ***Threatened*** Mexico DPS of the humpback whale could also occur in the proposed survey area. It is possible although very unlikely that individuals from the ***Endangered*** Western North Pacific gray whale population could occur in the proposed survey area.

The proposed Astoria Fan and southern Oregon survey areas are located at least 23 km from the east coast of the U.S. over water depths ~130–2600 m (see Fig. 1). The sea otter is not expected in the proposed survey areas because its occurrence off Washington and Oregon is limited to very shallow (<30 m depth), coastal (<4 km from shore) waters (Laidre et al. 2009). Vagrant ringed seals, hooded seals, and ribbon seals have been sighted or stranded on the coast of California (see Mead 1981; Reeves et al. 2002) and presumably passed through Oregon waters. A vagrant beluga whale was seen off the coast of Washington (Reeves et al. 2002). In addition, records exist for Perrin's beaked whale (*M. perrini*) and the lesser beaked whale (*M. peruvianus*) and gingko-toothed beaked whale (*M. ginkgodens*) off the coast of California and/or Baja California (MacLeod et al. 2006). These seven species are unlikely to be seen in the proposed survey area and are not addressed in the summaries below.

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. One of the

TABLE 6. The habitat, abundance, and conservation status of marine mammals that could occur in or near the proposed seismic survey area in the northeastern Pacific Ocean off Washington and Oregon.

Species	Occurrence in Area	Habitat	Abundance[1]	U.S. ESA[2]	IUCN[3]	CITES[4]
Mysticetes						
North Pacific right whale	Rare	Coastal, shelf, offshore	31[5]	EN	EN	I
Gray whale	Uncommon	Coastal, shelf	21,210[6]	DL/EN[18]	LC	I
Humpback whale	Common	Mainly nearshore and banks	21,808[7]	EN/T[19]	LC	I
Minke whale	Uncommon	Nearshore, offshore	9000[8]	NL	LC	I
Sei whale	Rare	Mostly pelagic	12,620[9]	EN	EN	I
Fin whale	Common	Slope, pelagic	8499[10]	EN	EN	I
Blue whale	Uncommon	Pelagic and coastal	1146[10]	EN	EN	I
Odontocetes						
Sperm whale	Common	Pelagic, steep topography	24,000[11]	EN	VU	I
Pygmy sperm whale	Rare	Deep, off shelf	4111[10,12]	NL	DD	II
Dwarf sperm whale	Rare	Deep, shelf, slope	4111[10,12]	NL	DD	II
Cuvier's beaked whale	Common	Pelagic	3359[10]	NL	LC	II
Baird's beaked whale	Common	Pelagic	6552[10]	NL	DD	I
Blainville's beaked whale	Rare	Pelagic	1099[10,13]	NL	DD	II
Hubb's beaked whale	Rare	Slope, offshore	1099[10,13]	NL	DD	II
Stejneger's beaked whale	Uncommon	Slope, offshore	1099[10,13]	NL	DD	II
Common bottlenose dolphin	Rare	Coastal, shelf, deep	1924[10]	NL	LC	II
Striped dolphin	Rare	Off continental shelf	29,211[10]	NL	LC	II
Short-beaked common dolphin	Uncommon	Shelf, pelagic, mounts	969,861[10]	NL	LC	II
Pacific white-sided dolphin	Common	Offshore, slope	26,556[10]	NL	LC	II
Northern right whale dolphin	Common	Slope, offshore waters	54,604[10]	NL	LC	II
Risso's dolphin	Common	Shelf, slope, mounts	6336[10]	NL	LC	II
False killer whale	Rare	Pelagic	N.A.	NL	DD	II
Killer whale	Common	Widely distributed	452[10]	EN/NL[20]	DD	II
Short-finned pilot whale	Rare	Pelagic, high-relief	836[10]	NL	DD	II
Harbor porpoise	Uncommon	Coastal and inland waters	57,256[14]	NL	LC	II
Dall's porpoise	Common	Shelf, slope, offshore	25,750[10]	NL	LC	II
Pinnipeds						
Northern fur seal	Common	Pelagic, offshore	662,584[15]	NL	VU	N.A.
California sea lion	Uncommon	Coastal, shelf	296,750	NL	LC	N.A.
Steller sea lion	Common	Coastal, shelf	60,131-74,448[16]	DL[21]	NT[22]	N.A.
Harbor seal	Common	Coastal	24,732	NL	LC	N.A.
Northern elephant seal	Common	Coastal, pelagic in migration	179,000[17]	NL	LC	N.A.

N.A. - Data not available or species status was not assessed.

[1] Abundance for the California/Oregon/Washington, Eastern North Pacific, or U.S. stock (Carretta et al. 2016a), unless otherwise stated.

[2] U.S. Endangered Species Act (NMFS 2017): EN = Endangered, T = Threatened, DL = Delisted, NL = Not listed.

[3] Classification from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2016); EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient.

[4] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2017): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.

[5] Bering Sea (Wade et al. 2011).

[6] California migration estimate for eastern North Pacific population (Durban et al. 2015).

[7] Barlow et al. (2011).

[8] North Pacific (Wada 1976).

[9] North Pacific (Tillman 1977).

[10] California/Oregon/Washington; means of the 2008 and 2014 abundance estimates (Barlow 2016).

[11] Eastern Temperate North Pacific (Whitehead 2002).

[12] Combined *Kogia* spp.

[13] All mesoplodont whales.

[14] Northern Oregon/Washington Coast and Northern California/Southern Oregon stocks combined (Forney et al. 2014).

[15] Eastern Pacific stock numbers 648,534 (Muto et al. 2016) plus California stock of 14,050 (Carretta et al. 2016a).

[16] Eastern U.S. stock (Muto et al. 2016).

[17] California breeding stock (Carretta et al. 2016a).

[18] Eastern North Pacific population was delisted in 2013; Western North Pacific population is listed as endangered.

[19] The Central America DPS is endangered; the Mexico DPS is threatened.

[20] The Southern Resident stock is listed as endangered; no other stocks listed.

[21] Eastern DPS delisted; Western Pacific DPS listed as endangered.

[22] Globally listed as near threatened; eastern population is designated as least concern.

qualitative analysis areas (QAAs) defined in the PEIS, the BC Coast, is located to the north of the proposed survey area. The general distribution of mysticetes, odontocetes, and pinnipeds off the BC Coast is discussed in § 3.6.3.2, § 3.7.3.2, and § 3.8.3.2 of the PEIS, respectively. In addition, one of the detailed analysis areas (DAAs), S California, is located to the south of the proposed survey area. The general distribution of mysticetes, odontocetes, and pinnipeds off southern California is discussed in § 3.6.2.3, § 3.7.2.3, and § 3.8.2.3 of the PEIS, respectively. The rest of this section deals specifically with species distribution in the proposed survey area off Oregon and Washington.

(1) Mysticetes

North Pacific Right Whale (*Eubalaena japonica*)

The North Pacific right whale is one of the most endangered species of whale in the world (Brownell et al. 2001; NMFS 2013a). It summers in the northern North Pacific and Bering Sea, apparently feeding off southern and western Alaska from May to September (e.g., Tynan et al. 2001). The wintering areas for the population are unknown, but have been suggested to include the Hawaiian Islands and the Ryukyu Islands (Allen 1942; Banfield 1974; Gilmore 1978; Reeves et al. 1978; Herman et al. 1980). Whaling records indicate that right whales once ranged across the entire North Pacific north of 35ºN and occasionally occurred as far south as 20ºN (Kenney 2009). Although right whales were historically reported off the coast of Oregon, occasionally in large numbers (Scammon 1874; Rice and Fiscus 1968), extensive shore-based and pelagic commercial whaling operations never took large numbers of the species south of Vancouver Island (Rowlett et al. 1994). Nonetheless, Gilmore (1956) proposed that the main wintering ground for North Pacific right whales was off the Oregon coast and possibly northern California, postulating that the inherent inclement weather in those areas discouraged winter whaling (Rice and Fiscus 1968).

In the eastern North Pacific Ocean south of 50ºN, only 29 reliable sightings were recorded from 1900 to 1994 (Scarff 1986, 1991; Carretta et al. 1994). Rowlett et al. (1994) photographically identified one right whale off Washington on 24 May 1992, 65 km west of Cape Elizabeth, over a water depth of ~1200 m; the same whale was subsequently photographically identified again ~6 h later 48 km west of Destruction Island, in water ~500 m deep. Despite many miles of systematic aerial and ship-based surveys for marine mammals off the coasts of Washington/Oregon/California over the years, only seven documented sightings of right whales were made from 1990 to 2000 (Waite et al. 2003). Two Pacific right whale calls were detected on a bottom-mounted hydrophone off the Washington coast on 29 June 2013; no calls by this species were detected at this site in previous years (Širović et al. 2014).

Because of the small population size and the fact that North Pacific right whales spend the summer feeding in high latitudes, it is unlikely that any would be present in the proposed project area during the period of operations in September.

Gray Whale (*Eschrichtius robustus*)

In the North Pacific, gray whales have distinct Eastern and Western stocks, although the distinction between these two populations has been recently debated owing to evidence that whales from the western feeding area also travel to breeding areas in the eastern North Pacific (Weller et al. 2012). Thus, it is possible that whales from both the *endangered* Western and delisted Eastern populations could occur along the U.S. west coast (Calambokidis et al. 2015).

Gray whale populations were severely reduced by whaling and the western population has remained highly depleted, but the eastern North Pacific population is considered to have recovered. Punt and Wade (2012) estimated the eastern North Pacific population to be at 85% of its carrying capacity in 2009. The eastern North Pacific gray whale breeds and winters in Baja, California, and migrates north to summer feeding grounds in the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1971; Jefferson et al. 2015). Gray whales are found primarily in shallow water; most follow the coast during migration, staying close to the shoreline except when crossing major bays, straits, and inlets (Braham 1984).

A small portion of the population also summers along the Pacific coast from northern Vancouver Island, British Columbia (BC) to central California (Rice and Wolman 1971; Nerini 1984; Calambokidis and Quan 1999) from June to November (Calambokidis et al. 2002, 2010, 2015). There is recent genetic evidence indicating the existence of this Pacific Coast Feeding Group as a distinct local subpopulation (Frasier et al. 2011; Lang et al. 2014). It is estimated that the Pacific Coast Feeding group consists of ~200 individuals (Calambokidis et al. 2002, 2004b, 2010). Biologically Important Areas (BIAs) for feeding gray whales along the coast of Oregon were reported for Depoe Bay, Cape Blanco, and Orford Reef (Calambokidis et al. 2015). At least 28 gray whales were observed near Depoe Bay (~44.8°N), Oregon, for three successive summers (Newell and Cowles 2006). Resident gray whales have been observed foraging off the coast of Oregon from May to October (Newell and Cowles 2006), and off Washington from June through November (Scordino et al. 2014).

BIAs along the coast of Oregon and Washington have also been identified for migrating gray whales; although most whales travel within 10 km from shore, the BIAs were extended out to 47 km from the coastline (Calambokidis et al. 2015). Gray whales from the far north begin to migrate south to breeding grounds on the west coast of Baja California and the southeastern Gulf of California in October and November (Braham 1984; Rugh et al. 2001). Green et al. (1995) reported that the average distance from shore for migrating gray whales recorded during aerial surveys off the Oregon and Washington coasts were 9.2 km and 18.5 km, respectively; the farthest sighting occurred 43 km offshore during the southbound migration in January off Washington. Gray whales migrate closest to the Washington/ Oregon coastline during the spring months (April–June), when most strandings are observed (Norman et al. 2004).

Oleson et al. (2009) observed 116 gray whales off the outer Washington coast (~47ºN) during 42 small boat surveys from August 2004 through September 2008; mean distances from shore during the southern migration (December–January), northern migration (February–April), and summer feeding (May–October) activities were 29, 9, and 12 km, respectively; mean bottom depths during these activities were 126, 26, and 33 m, respectively. Ortega-Ortiz and Mate (2008) tracked the distribution and movement patterns of gray whales off Yaquina Head on the central Oregon coast (~44.7°N) during the southbound and northbound migration in 2008. The average distance from shore to tracked whales ranged from 200 m to 13.6 km; average bottom depth of whale locations was 12–75 m. The migration paths of tracked whales seemed to follow a constant depth rather than the shoreline.

According to predictive density distribution maps, low densities of gray whales could be encountered throughout the Astoria Fan and Southern Oregon survey areas (Menza et al. 2016). During aerial surveys over the shelf and slope off Oregon and Washington, gray whales were seen during the months of January, June–July, and September; one sighting was made within the Astoria Fan survey area in water >200 m during June 2011 (Adams et al. 2014). Two sightings of three whales were seen from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); sightings were made to the north of the Astoria Fan survey area.

Several human-caused gray whale deaths/entanglements from coastal fishery-related gear occurred during 2009–2010 off Oregon and Washington; there were also several deaths or injuries in the region as a result of vessel strikes during 2009 (Carretta et al. 2016b). Huggins et al. (2015a) observed five stranded gray whales during beach surveys conducted between ~46.7–47.3ºN during 2006–2011.

The proposed surveys would occur during the summer feeding season for gray whales in the Washington/Oregon region. Thus, gray whales could be encountered in the eastern portion of the proposed project area where the water is shallower.

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all of the oceans of the world (Clapham 2009). The worldwide population of humpbacks is divided into northern and southern ocean populations, but genetic analyses suggest some gene flow (either past or present) between the North and South Pacific (e.g., Baker et al. 1993; Caballero et al. 2001). Geographical overlap of these populations has been documented only off Central America (Acevedo and Smultea 1995; Rasmussen et al. 2004, 2007). Although considered to be mainly a coastal species, humpback whales often traverse deep pelagic areas while migrating (Clapham and Mattila 1990; Norris et al. 1999; Calambokidis et al. 2001).

Humpback whales migrate between summer feeding grounds in high latitudes and winter calving and breeding grounds in tropical waters (Clapham and Mead 1999). North Pacific humpback whales summer in feeding grounds along the Pacific Rim and in the Bering and Okhotsk seas (Pike and MacAskie 1969; Rice 1978; Winn and Reichley 1985; Calambokidis et al. 2000, 2001, 2008). Humpbacks winter in four different breeding areas: (1) along the coast of Mexico; (2) along the coast of Central America; (3) around the main Hawaiian Islands; and (4) in the western Pacific, particularly around the Ogasawara and Ryukyu islands in southern Japan and the northern Philippines (Calambokidis et al. 2008; Bettridge et al. 2015). These breeding areas have been designated as DPSs, but feeding areas have no DPS status (Bettridge et al. 2015; NMFS 2016b). Individuals from two DPSs (Central America and Mexico DPS) could be encountered in the proposed survey area. There is a low level of interchange of whales among the main wintering areas and among feeding areas (e.g., Darling and Cerchio 1993; Salden et al. 1999; Calambokidis et al. 2001, 2008).

The humpback whale is the most common species of large cetacean reported off the coasts of Oregon and Washington from May to November (Green et al. 1992; Calambokidis et al. 2000, 2004a). Shifts in seasonal abundance observed off Oregon and Washington suggest north–south movement (Green et al. 1992). The highest numbers have been reported off Oregon during May and June and during July–September off Washington; no humpbacks were reported for winter (Green et al. 1992; Calambokidis et al. 2000, 2004a). Green et al. (1992) reported the highest encounter rates off Oregon/Washington during June–August followed by September through November; highest densities typically occurred over the slope followed by shelf waters. Off Oregon/Washington, humpbacks occur primarily over the continental shelf and slope during the summer, with few reported in offshore pelagic waters (Green et al. 1992; Calambokidis et al. 2004a, 2015; Becker et al. 2012; Menza et al. 2016). In particular, humpbacks tend to concentrate off Oregon along the southern edge of Heceta Bank (~44°N, 125°W), in the Blanco upwelling zone (~43°N), and other areas associated with upwelling. During extensive systematic aerial surveys conducted up to ~550 km off the Oregon/ Washington coast, only one humpback whale was reported in offshore waters >2000 m deep; that sighting was ~70 km west of Cape Blanco during the spring (Green et al. 1992). Sightings have also been made near the proposed Astoria Fan and Southern Oregon survey areas, including near Astoria Canyon off the Columbia River mouth, between the 200 and 2000 m depth contours, and near Hecate Bank in water >200 m (Green et al. 1992).

BIAs for feeding humpback whales along the coast of Oregon were reported for Stonewall and Heceta Bank for May–November and just south of 42°S at Point St. George for July–November (Calambokidis et al. 2015).

There were multiple sighting locations within or adjacent to the proposed Astoria Fan and Southern Oregon survey sites during 1991–2005 surveys between Washington and California (Barlow and Forney 2007). Oleson et al. (2009) observed 147 humpback whales off the outer Washington coast (~47ºN) during small boat surveys from August 2004 through September 2008, with mean distance from shore and mean depth values of 35 km and 187 m, respectively. At least 12 humpback whale sightings were reported off Oregon/Washington during summer/fall surveys in 2008 (Barlow 2010). During aerial surveys over the shelf and slope off Oregon and Washington (Adams et al. 2014), humpback whales were seen during all survey months (January–February, June–July, September–October), including in winter, as well as near and within the proposed project area. One sighting was made in the Southern Oregon survey area during January 2011 in water >200 m deep, and another sighting was made in the Astoria Fan survey area in June 2011 near the 2000-m depth contour (Adams et al. 2014).

Six sightings of eight individuals were made from the *Langseth* seismic vessel off Washington/ Oregon during June–July 2012 (RPS 2012b), including near or within the Southern Oregon survey area. Thirty-four sightings totaling 83 individuals occurred from the *Langeth* during a survey off southern Washington during July 2012 (RPS 2012a); some sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north. In addition, 64 sightings totaling 130 individuals occurred from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); some sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north. Eleven sightings of 23 individuals were made from the *Langseth* seismic vessel off the coast of Oregon during a separate survey July 2012 (RPS 2012c); sightings were made throughout the proposed project area, including one sighting in the Southern Oregon survey area. A 2014 survey indicated an abundance of 2480 humpback whales off the coasts of Oregon and Washington (Barlow 2016).

Humpbacks could be encountered in shelf and slope waters of the proposed project area.

Minke Whale (*Balaenoptera acutorostrata*)

The minke whale has a cosmopolitan distribution that spans from tropical to polar regions in both hemispheres (Jefferson et al. 2015). In the Northern Hemisphere, the minke whale is usually seen in coastal areas, but can also be seen in pelagic waters during northward migrations in spring and summer, and southward migration in autumn (Stewart and Leatherwood 1985). In the North Pacific, the summer range of the minke whale extends to the Chukchi Sea; in the winter, the whales move farther south to within 2º of the Equator (Perrin and Brownell 2009).

The International Whaling Commission (IWC) recognizes three stocks of minke whales in the North Pacific: the Sea of Japan/East China Sea, the rest of the western Pacific west of 180ºN, and the remainder of the Pacific (Donovan 1991). Minke whales are relatively common in the Bering and Chukchi seas and in the Gulf of Alaska, but are not considered abundant in any other part of the eastern Pacific (Brueggeman et al. 1990). In the far north, minke whales are thought to be migratory, but they are believed to be year-round residents in coastal waters off the U.S. west coast (Dorsey et al. 1990).

Sightings have been made off Oregon and Washington in shelf and deeper waters (Green et al. 1992; Adams et al. 2014; Carretta et al. 2016a). An estimated abundance of 211 minke whales was reported for the Oregon/Washington region based on sightings data from 1991–2005 (Barlow and Forney

2007), whereas a 2008 survey did not record any minke whales while on survey effort (Barlow 2010). The abundance for Oregon/Washington for 2014 was estimated at 507 mink whales (Barlow 2016). A single minke whale was observed off the outer Washington coast (~47ºN) during small boat surveys from August 2004 through September 2008, 14 km from shore with a bottom depth of 38 m (Oleson et al. 2009). One sighting was made near the Astoria Fan survey area at the 200-m isopleth off the mouth of the Columbia River in July 2012 (Adams et al. 2014). One minke was seen from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); the sighting was made just to the north of the Astoria Fan survey area. Minke whales strandings have been reported in all seasons in Washington; most strandings (52%) occurred in spring (Norman et al. 2004).

Minke whales could be encountered within the proposed project area during September.

Sei Whale (*Balaenoptera borealis*)

The distribution of the sei whale is not well known, but it is found in all oceans and appears to prefer mid-latitude temperate waters (Jefferson et al. 2015). The sei whale is pelagic and generally not found in coastal waters (Jefferson et al. 2015). It is found in deeper waters characteristic of the continental shelf edge region (Hain et al. 1985) and in other regions of steep bathymetric relief such as seamounts and canyons (Kenney and Winn 1987; Gregr and Trites 2001). On feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987) such as the cold eastern currents in the North Pacific (Perry et al. 1999a). 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 Gulf of Alaska and down to southern California, as well as in the western Pacific from Japan to Korea. Its winter distribution is concentrated at ~20°N (Rice 1998).

Sei whales are rare in the waters off California, Oregon, and Washington (Brueggeman et al. 1990; Green et al. 1992; Barlow 1994, 1997). Only nine confirmed sightings were reported for California, Oregon, and Washington during extensive surveys from 1991–2008, including two within or near the westernmost portion of the Southern Oregon survey area (Green et al. 1992, 1993; Hill and Barlow 1992; Carretta and Forney 1993; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999; Barlow 2003; Forney 2007; Barlow 2010; Carretta et al. 2016a). Based on surveys conducted in 1991–2008, the estimated abundance of sei whales off the coasts of Oregon and Washington was 52 (Barlow 2010); for 2014, the abundance estimate was 468 (Barlow 2016). Two sightings of four individuals were made from the *Langseth* seismic vessel off Washington/Oregon during June–July 2012 (RPS 2012b), including within the proposed project area.

Sei whales could be encountered within the proposed project area during September.

Fin Whale (*Balaenoptera physalus*)

The fin whale is widely distributed in all the world's oceans (Gambell 1985b), but typically occurs in temperate and polar regions from 20–70° north and south of the Equator (Perry et al. 1999b). Northern and southern fin whale populations are distinct and are sometimes recognized as different subspecies (Aguilar 2009). Fin whales occur in coastal, shelf, and oceanic waters. Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily or because biological productivity is high along steep contours because of tidal mixing and perhaps current mixing. Stafford et al. (2009) noted that sea-surface temperature is a good predictor variable for fin whale call detections in the North Pacific.

Fin whales appear to have complex seasonal movements and are seasonal migrants; they mate and calve in temperate waters during the winter and migrate to feed at northern latitudes during the summer (Gambell 1985b). The North Pacific population summers from the Chukchi Sea to California and winters from California southwards (Gambell 1985b). 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; Edwards et al. 2015). Vocalizations from fin whales have also been detected year-round off northern California, Oregon, and Washington (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2007, 2009).

Edwards et al. (2015) predicted that average fin whale densities off Washington and Oregon would be zero during December–May, but that densities <0.003 whales/km^2 could occur there from June through November. Higher densities were predicted for waters off southern Oregon than for the rest of the proposed project area (Becker et al. 2012; Calambokidis et al. 2015). Based on surveys conducted in 1991–2008, the estimated abundance of fin whales off the coasts of Oregon and Washington was 416 (Barlow 2010); the estimate for 2014 was 3458 (Barlow 2016). At least 20 fin whale sightings were reported during the Oregon/Washington portions of the survey in 2008; several sightings occurred within or near the proposed survey area during 2008 and during surveys between 1991–2005 (Barlow and Forney 2007; Barlow 2010; Calambokidis et al. 2015; Carretta et al. 2016a). One fin whale was sighted north of the proposed project area during surveys between August 2004 and September 2008 (Oleson et al. 2009).

Twelve sightings of 26 individuals were made from the *Langseth* seismic vessel off the southern coast of Washington during July 2012 (RPS 2012a); some sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north. In addition, two individuals were seen from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); several sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north. Eight sightings of 19 individuals were made from the *Langseth* seismic vessel off Washington/Oregon during June–July 2012 (RPS 2012b), including in the Astoria Fan and Southern Oregon survey areas. Fin whales were also seen in the Southern Oregon survey area in July 2012 in water >2000 m deep during surveys by Adams et al. (2014).

Fin whales could be encountered throughout the proposed project area during September.

Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson et al. 2015). Although it has been suggested that there are at least five subpopulations of blue whales in the North Pacific (NMFS 1998), analysis of blue whale calls monitored from the U.S. Navy Sound Surveillance System (SOSUS) and other offshore hydrophones (see Stafford et al. 1999, 2001, 2007; Watkins et al. 2000a; Stafford 2003) suggest that there are two separate populations: one in the eastern and one in the western North Pacific (Sears 2009). Broad-scale acoustic monitoring indicates that blue whales occurring in the northeast Pacific during summer and fall may winter in the eastern tropical Pacific (Stafford et al. 1999, 2001).

The distribution of the species, at least during times of the year when feeding is a major activity, occurs in areas that provide large seasonal concentrations of euphausiids (Yochem and Leatherwood 1985). The eastern North Pacific stock feeds in California waters from June–November (Calambokidis et al. 1990; Mate et al. 1999). There are nine BIAs for feeding blue whales off the coast of California (Calambokidis et al. 2015), and core areas have also been identified there (Irvine et al. 2014). Although blue whales have been detected acoustically off Oregon (McDonald et al. 1995; Stafford et al. 1998; Von Saunder and Barlow 1999), few sightings have been reported there (Carretta et al. 2016a). Densities along the U.S. west coast including Oregon were predicted to be highest in shelf waters, with lower densities in deeper offshore areas (Becker et al. 2012; Calambokidis et al. 2015). Based on the absolute dynamic topography of the region, blue whales could occur in relatively high densities off Oregon during July–December (Pardo et al. 2015).

Barlow (2010) estimated 442 blue whales for California/Oregon/Washington, based on line-transect surveys conducted during summer and fall 2008. The estimate of population abundance off California/Oregon/Washington based on mark-recapture data collected in 2004–2006 was 2842 (Calambokidis et al. 2007). However, Buchanan et al. (2001) considered blue whales to be rare off Oregon and Washington. Based on surveys conducted in 1991–2008, the estimated abundance of blue whales off the coasts of Oregon/Washington was 58 (Barlow 2010), while the abundance was estimated at 221 blue whales for 2014 (Barlow 2016). One blue whale was observed off Washington in January 2009, in waters ~1000 m deep (Oleson et al. 2012). Five blue whale sightings were reported in the proposed project area off Oregon/Washington during 1991–2008; one sighting occurred within the nearshore portion of the proposed Astoria Fan survey area, and four sightings occurred nearshore, east of the Southern Oregon survey area (Carretta et al. 2016a). Hazen et al. (2016) examined blue whale tag data from 182 individuals along the western U.S. during 1993–2008; multiple tag data tracks were within the proposed project area, particularly between August and November. During aerial surveys over the shelf and slope off Oregon and Washington in 2011 and 2012, one sighting was made off Oregon during February in water deeper than 200 m, and several sightings were made on the Oregon shelf during September–October (Adams et al. 2014).

Blue whales could be encountered within the proposed project area during September.

(2) Odontocetes

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the largest of the toothed whales, with an extensive worldwide distribution (Rice 1989). Sperm whale distribution is linked to social structure: mixed groups of adult females and juvenile animals of both sexes generally occur in tropical and subtropical waters, whereas adult males are commonly found alone or in same-sex aggregations, often occurring in higher latitudes outside the breeding season (Best 1979; Watkins and Moore 1982; Arnbom and Whitehead 1989; Whitehead and Waters 1990). Males can migrate north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988). Mature male sperm whales migrate to warmer waters to breed when they are in their late twenties (Best 1979).

Sperm whales generally are distributed over large areas that have high secondary productivity and steep underwater topography, in waters at least 1000 m deep (Jaquet and Whitehead 1996; Whitehead 2009). They are often found far from shore, but can be found closer to oceanic islands that rise steeply from deep ocean waters (Whitehead 2009). Adult males can occur in water depths <100 m and as shallow as 40 m (Whitehead et al. 1992; Scott and Sadove 1997). They can dive as deep as ~2 km and possibly deeper on rare occasions for periods of over 1 h; however, most of their foraging occurs at depths of~300–800 m for 30–45 min (Whitehead 2003).

Sperm whales are distributed widely across the North Pacific (Rice 1989). Off California, they are occur year-round (Dohl et al. 1983; Barlow 1995; Forney et al. 1995), with peak abundance from April to mid-June and from August to mid-November (Rice 1974). Off Oregon, sperm whales are seen in every season except winter (Green et al. 1992). Moderate densities have been predicted to occur in the western portions of the proposed project area off Oregon and Washington (Becker et al. 2012). Based on surveys conducted in 1991–2008, the estimated abundance of sperm whales off the coasts of Oregon and Washington was 329 (Barlow 2010). At least five sightings during these surveys were within or adjacent to the Southern Oregon survey area, and one sighting was within the Astoria Fan survey area (Carretta et al. 2016a). Three sperm whale sightings were reported in water depths >2000 m off Oregon/Washington during 2008 (Barlow 2010). The abundance estimate based on survey data from 2014 was 25 individuals (Barlow 2016).

Sightings have been made in deep water of the Astoria Fan survey area, as well as near the Southern Oregon survey area (Green et al. 1992; Becker et al. 2012; Carretta et al. 2016a). During acoustic monitoring off Washington (north of the proposed Astoria Fan survey area) from August 2004 to September 2008, sperm whale calls were detected year-round at an offshore site with a peak occurrence from April to August; at an inshore site, calls were detected from April to November, with one detection in January (Oleson et al. 2009). Oleson et al. (2009) noted a significant diel pattern in the occurrence of sperm whale clicks at the offshore and inshore monitoring locations, whereby clicks were more commonly heard during the day at the offshore site and were more common at night at the inshore location, suggesting possible diel movements up and down slope in search of prey. Sperm whale acoustic detections were also reported at the inshore site from June through January 2009, with an absence of calls during February to May (Ŝirović et al. 2012). In addition, sperm whales were sighted during surveys off Washington in June 2011 and Oregon in October 2011 (Adams et al. 2014).

Sperm whales are most likely to be encountered in the deep waters of the Astoria Fan and Southern Oregon survey areas, particularly along the slope.

Pygmy and Dwarf Sperm Whales (*Kogia breviceps and K. sima*)

The pygmy sperm whale and dwarf sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown as most information on these species comes from strandings (McAlpine 2009). They are difficult to sight at sea, perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). The two species are difficult to distinguish from one another when sighted (McAlpine 2009).

Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf (Rice 1998; Wang et al. 2002; MacLeod et al. 2004). Barros et al. (1998), on the other hand, suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales. It has also been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the eastern tropical Pacific (Wade and Gerrodette 1993). This idea is also supported by the distribution of strandings in South American waters (Muñoz-Hincapié et al. 1998).

Barlow (2010) used data collected in 1991–2008 to estimate an abundance of 229 *Kogia* sp. off Oregon and Washington, all of which were thought to be pygmy sperm whales as no dwarf sperm whales had been identified on the west coast since the early 1970s. No *Kogia* sp. were sighted during surveys off Oregon and Washington in 2014 (Barlow 2016). No pygmy or dwarf sperm whales were reported within the U.S. EEZ off the coast of Oregon or Washington during 1991–2008; however, one sighting was reported in waters outside of the EEZ to the west of Oregon (Carretta et al. 2016a). Norman et al. (2004)

reported eight confirmed stranding records of pygmy sperm whales for Oregon and Washington, five of which occurred during autumn and winter (Norman et al. 2004).

It is possible that pygmy or dwarf sperm whales could be encountered within the proposed project area, although sightings of dwarf sperm whales would be more likely.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale is probably the most widespread of the beaked whales, although it is not found in polar waters (Heyning 1989). Cuvier's beaked whale appears to prefer steep continental slope waters (Jefferson et al. 2015) and is most common in water depths >1000 m (Heyning 1989). It is mostly known from strandings and strands more commonly than any other beaked whale (Heyning 1989). Its inconspicuous blows, deep-diving behavior, and tendency to avoid vessels all help to explain the infrequent sightings (Barlow and Gisiner 2006). The population in the California Current Large Marine Ecosystem seems to be declining (Moore and Barlow 2012).

MacLeod et al. (2006) reported numerous sightings and strandings along the Pacific coast of the U.S. Cuvier's beaked whale is the most common beaked whale off the U.S. west coast (Barlow 2010), and it is the beaked whale species that stranded most frequently on the coasts of Oregon and Washington. From 1942–2010, there were 23 reported Cuvier's beaked whale strandings in Oregon and Washington (Moore and Barlow 2013). Most (75%) Cuvier's beaked whale strandings reported occurred in Oregon (Norman et al. 2004).

The abundance for Oregon/Washington for 2014 was estimated at 432 (Barlow 2016). The abundance estimate for Oregon and Washington waters, based on data from 1991–2008, was 137 (Barlow 2010). Four beaked whale sightings were reported in water depths >2000 m off Oregon/Washington during surveys in 2008 (Barlow 2010), none was seen in 1996 or 2001 (Barlow 2003), and several were recorded from 1991 to 1995 (Barlow 1997). One Cuvier's beaked whale sighting was made west of the proposed Southern Oregon survey area during the 1991–2008 surveys (Carretta et al. 2016a). One sighting of three individuals was recorded in June 2006 during surveys off Washington during August 2004 through September 2008, north of the Astoria Fan survey area (Oleson et al. 2009). Acoustic monitoring in Washington offshore waters detected Cuvier's beaked whale pulses between January and November 2011 (Ŝirović et al. 2012b *in* USN 2015).

Cuvier's beaked whales could be encountered in deeper slope and offshore waters of the proposed project area.

Baird's Beaked Whale (*Berardius bairdii*)

Baird's beaked whale has a fairly extensive range across the North Pacific, with concentrations occurring in the Sea of Okhotsk and Bering Sea (Rice 1998; Kasuya 2009). In the eastern Pacific, Baird's beaked whale is reported to occur as far south as San Clemente Island, California (Rice 1998; Kasuya 2009). Baird's beaked whales that occur off the U.S. west coast are of the gray form unlike some *Berardius* spp. that are found in Alaska and Japan, which are of the black form, which could be a new species (Morin et al. 2016).

Baird's beaked whale is sometimes seen close to shore where deep water approaches the coast, but its primary habitat is over or near the continental slope and oceanic seamounts (Jefferson et al. 2015). Along the U.S. west coast, Baird's beaked whales have been sighted primarily along the continental slope (Green et al. 1992; Becker et al. 2012; Carretta et al. 2016a) from late spring to early fall (Green et al. 1992). The whales move out from those areas in winter (Reyes 1991). In the eastern North Pacific Ocean, Baird's beaked whales apparently spend the winter and spring far offshore, and in June, they move onto the continental slope, where peak numbers occur during September and October. Green et al. (1992) noted that Baird's beaked whales on the U.S. west coast were most abundant in the summer, and were not sighted in the fall or winter. MacLeod et al. (2006) reported numerous sightings and strandings of *Berardius* spp. off the U.S. west coast.

Green et al. (1992) sighted five groups during 75,050 km of aerial survey effort in 1989–1990 off Washington/Oregon spanning coastal to offshore waters: two in slope waters and three in offshore waters, all in Oregon near the Southern Oregon survey area. Barlow (2010) estimated an abundance of 380 Baird's beaked whales for Oregon/Washington waters, based on survey data collected in 1991–2008. Two groups were sighted during summer/fall 2008 surveys off Washington/Oregon, in waters >2000 m deep (Barlow 2010). During 1991–2008 surveys, several sightings were reported to the south and west of the Southern Oregon survey area, to the west of the Astoria Fan survey area, and within the eastern portion of the Astoria Fan survey area (Carretta et al. 2016a). One Baird's beaked whale was seen off southern Oregon in June 2011 near the 200-m isopleth (Adams et al. 2014). The abundance estimate for 2014 was 6314 (Barlow 2016). Predicted density modeling showed higher densities in slope waters off northern Oregon, near the Astoria Fan survey area, compared with southern Oregon (Becker et al. 2012).

Acoustic monitoring offshore Washington detected Baird's beaked whale pulses during January and November 2011, with peaks in February and July (Ŝirović et al. 2012b *in* USN 2015). Keating et al. (2015) analysed cetacean whistles recorded during 2000–2012; two acoustic detections of Baird's beaked whales were recorded west of the Astoria Fan and Southern Oregon survey areas. One whale stranded in Washington in 2003, with the cause of death attributed to a ship strike (Carretta et al. 2016a).

Baird's beaked whales could be encountered in deeper slope and offshore waters of the proposed project area.

Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans; it has the widest distribution throughout the world of all mesoplodont species and appears to be relatively common (Pitman 2009). Like other beaked whales, Blainville's beaked whales are generally found in waters 200–1400 m deep (Gannier 2000; Jefferson et al. 2015). Occasional occurrences in cooler, higher-latitude waters are presumably related to warm-water incursions (Reeves et al. 2002). McLeod et al. (2006) reported stranding and sighting records in the eastern Pacific ranging from 37.3°N to 41.5°S. However, none of the 36 beaked whale-stranding records in Oregon and Washington during 1930–2002 included Blainville's beaked whale (Norman et al. 2004). One Blainville's beaked whale was found stranded (dead) on the Washington coast in November 2016 (COASST 2016).

Blainville's beaked whale is unlikely to be encountered in the proposed project area, as its main distribution occurs to the south.

Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)

Stejneger's beaked whale occurs in subarctic and cool temperate waters of the North Pacific Ocean (Mead 1989). In the eastern North Pacific Ocean, it is distributed from Alaska to southern California (Mead et al. 1982; Mead 1989). Most stranding records are from Alaskan waters, and the Aleutian Islands appear to be its center of distribution (McLeod et al. 2006). After Cuvier's beaked whale, Stejneger's beaked whale was the second most commonly stranded beaked whale species in Oregon and

Washington (Norman et al. 2004). Stejneger's beaked whale calls were detected during acoustic monitoring offshore Washington between January and June 2011, with an absence of calls from mid-July to November 2011 (Ŝirović et al. 2012b *in* USN 2015).

Stejneger's beaked whale could be encountered in the proposed project area.

Hubb's Beaked Whale (*Mesoplodon carlhubbsi*)

Hubb's beaked whale occurs in temperate waters of the North Pacific (Mead 1989). Its distribution appears to be correlated with the deep subarctic current (Mead et al. 1982). Numerous strandings records have been reported for the west coast of the U.S. (McLeod et al. 2006). Most of the records are from California, but it has been sighted as far north as Prince Rupert, BC (Mead 1989). Two strandings are known from Washington/Oregon (Norman et al. 2004). Hubb's beaked whales are often killed in drift gillnets off California (Reeves et al. 2002).

Hubb's beaked whale could be encountered in the proposed project area.

Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2015). There are two distinct bottlenose dolphin types: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). Coastal common bottlenose dolphins exhibit a range of movement patterns including seasonal migration, year-round residency, and a combination of long-range movements and repeated local residency (Wells and Scott 2009).

Bottlenose dolphins occur frequently off the coast of California, and sightings have been made as far north as 41ºN, but few records exist for Oregon/Washington (Carretta et al. 2016a). Three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound since 2004 (Cascadia Research 2011 *in* USN 2015). It is possible that offshore bottlenose dolphins could be encountered in the proposed survey area during warm-water periods (see Carretta et al. 2016a), although none have been sighted in waters off Oregon (Barlow 2010). Adams et al. (2104) made one sighting in Washington, to the north of the Astoria Fan survey area, during September 2012.

Bottlenose dolphins are unlikely to be encountered during the proposed project.

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters (Perrin et al. 1994) and is generally seen south of 43ºN (Archer 2009). However, in the eastern North Pacific, its distribution extends as far north as Washington (Jefferson et al. 2015). The striped dolphin is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling (Archer 2009). However, it has also been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2015).

The abundance of striped dolphins off the U.S. west coast appears to be variable among years and could be affected by oceanographic conditions (Carretta et al. 2016a). Striped dolphins regularly occur off California (Becker et al. 2012), where they are seen 185–556 km from the coast (Carretta et al. 2016a). Very few sightings have been made off Oregon (Barlow 2016), and no sightings have been reported for Washington (Carretta et al. 2016a). However, strandings have occurred along the coasts of Oregon and Washington (Carretta et al. 2016a). During surveys off the U.S. west coast in 2014, striped dolphins were seen as far north as 44ºN; based on those sightings, Barlow (2016) calculated an abundance estimate of 13,171 striped dolphins for the Oregon/Washington region. The abundance estimates for 2001, 2005, and 2008 were zero (Barlow 2016). Becker et al. (2012) predicted densities of zero in the proposed project area.

There are 10 stranding records for Oregon and two for Washington during 1930–2002 (Norman et al. 2004), and one stranding in Oregon in 2006 (Carretta et al. 2016a). From 2003–2013, 14 striped dolphin strandings were reported for Oregon and two for Washington (Barre 2014 *in* USN 2015). In January 2016, one dolphin was found stranded on Cannon Beach, Oregon (east of the Astoria Fan survey area), and one washed up in Ocean Park, Washington, northeast of the Astoria Fan survey area (Blackman and Vespa 2016).

Striped dolphins are unlikely to be encountered during the proposed project.

Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Perrin 2009). It ranges as far south as 40°S in the Pacific Ocean, is common in coastal waters 200–300 m deep, and is also associated with prominent underwater topography, such as sea mounts (Evans 1994). Short-beaked common dolphins have been sighted as far as 550 km from shore (Barlow et al. 1997).

The distribution of short-beaked common dolphins along the U.S. west coast is variable and likely related to oceanographic changes (Heyning and Perrin 1994; Forney and Barlow 1998). It is the most abundant cetacean off California; however, few sightings have been made off Oregon, and no sightings exist for Washington waters (Carretta et al. 2016a). During surveys in 1991–2008, one sighting was made within the Astoria Fan survey area, and several records exist southwest of the Southern Oregon survey area (Carretta et al. 2016a). During surveys off the west coast in 2014, sightings were made as far north as 44°N (Barlow 2014). Based on the absolute dynamic topography of the region, short-beaked common dolphins could occur in relatively high densities off Oregon during July–December (Pardo et al. 2015). In contrast, habitat modeling predicted moderate densities of common dolphins off the Columbia River mouth during summer, with lower densities off southern Oregon (Becker et al. 2014).

Short-beaked common dolphins could be encountered within the proposed project area.

Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

The Pacific white-sided dolphin is found in cool temperate waters of the North Pacific from the southern Gulf of California to Alaska. Across the North Pacific, it appears to have a relatively narrow distribution between 38°N and 47°N (Brownell et al. 1999). In the eastern North Pacific Ocean, including waters off Oregon, the Pacific white-sided dolphin is one of the most common cetacean species, occurring primarily in shelf and slope waters (Green et al. 1993; Barlow 2003, 2010). It is known to occur close to shore in certain regions, including (seasonally) southern California (Brownell et al. 1999).

Results of recent aerial and shipboard surveys strongly suggest seasonal north–south movements of the species between California and Oregon/Washington; the movements apparently are related to oceanographic influences, particularly water temperature (Green et al. 1993; Forney and Barlow 1998; Buchanan et al. 2001). During winter, this species is most abundant in California slope and offshore areas; as northern waters begin to warm in the spring, it appears to move north to slope and offshore waters off Oregon/Washington (Green et al. 1992, 1993; Forney 1994; Forney et al. 1995; Buchanan et al. 2001; Barlow 2003). The highest encounter rates off Oregon and Washington have been reported during

March–May in slope and offshore waters (Green et al. 1992). Similarly, Becker et al. (2014) predicted relatively high densities off southern Oregon in shelf and slope waters.

Based on year-round aerial surveys off Oregon/Washington, the Pacific white-sided dolphin was the most abundant cetacean species, with nearly all (97%) sightings occurring in May (Green et al. 1992, 1993). Barlow (2003) also found that the Pacific white-sided dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996 and 2001 ship surveys, and it was the second most abundant species reported during 2008 surveys (Barlow 2010). Sightings have been made throughout the proposed project area, including the Astoria Fan and Southern Oregon survey area, during summer and fall (Forney 2007; Barlow 2010; Becker et al. 2014; Carretta et al. 2016a). Numerous Pacific white-sided dolphin sightings occurred during surveys offshore Washington during August 2004 to September 2008, north of the Astoria Fan survey area (Oleson et al. 2009). Oleson et al. (2009) also detected calls from June through March off Washington, with a notable absence of detections during April and May. Adams et al. (2014) also reported numerous offshore sightings off Oregon during summer, fall, and winter surveys in 2011 and 2012, including in the Southern Oregon survey area during September. Based on surveys conducted during 2014, the abundance was estimated at 20,711 for Oregon/Washington (Barlow 2016).

Fifteen sightings of 231 individuals were made from the *Langseth* seismic vessel off Washington/Oregon during June–July 2012 (RPS 2012b); sightings were made in the Astoria Fan and Southern Oregon survey areas. Nine sightings of 182 individuals were seen from the *Langseth* seismic vessel off the coast of Washington during July 2012 (RPS 2012a); sightings were made just to the north of the Astoria Fan survey area. In addition, 6 sightings totaling 280 individuals occurred from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); some sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north.

Pacific white-sided dolphins are likely to be encountered in the proposed project area during September.

Northern Right Whale Dolphin (*Lissodelphis borealis*)

The northern right whale dolphin is found in cool temperate and sub-arctic waters of the North Pacific, from the Gulf of Alaska to near northern Baja California, ranging from 30°N to 50°N (Reeves et al. 2002). In the eastern North Pacific Ocean, including waters off Oregon, the northern right whale dolphin is one of the most common marine mammal species, occurring primarily in shelf and slope waters ~100 to >2000 m deep (Green et al. 1993; Barlow 2003). The northern right whale dolphin comes closer to shore where there is deep water, such as over submarine canyons (Reeves et al. 2002).

Aerial and shipboard surveys suggest seasonal inshore–offshore and north–south movements in the eastern North Pacific Ocean between California and Oregon/Washington; the movements are believed to be related to oceanographic influences, particularly water temperature and presumably prey distribution and availability (Green et al. 1993; Forney and Barlow 1998; Buchanan et al. 2001). Green et al. (1992, 1993) found that northern right whale dolphins were most abundant off Oregon/Washington during fall, less abundant during spring and summer, and absent during winter, when this species presumably moves south to warmer California waters (Green et al. 1992, 1993; Forney 1994; Forney et al. 1995; Buchanan et al. 2001; Barlow 2003). Considerable interannual variations in abundance also have been found.

Becker et al. (2014) predicted relatively high densities off southern Oregon, and moderate densities off northern Oregon and Washington. Based on year-round aerial surveys off Oregon/Washington, the northern right whale dolphin was the third most abundant cetacean species, concentrated in slope waters but also occurring in water out to ~550 km offshore (Green et al. 1992, 1993). Barlow (2003, 2010) also found that the northern right whale dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996, 2001, 2005, and 2008 ship surveys. Several sightings were within and near the Astoria Fan and Southern Oregon survey areas during the summer and fall during surveys off California, Oregon, and Washington (Forney 2007; Barlow 2010; Becker et al. 2012; Carretta et al. 2016a). Three sighting locations (59 individuals) were located north of the Astoria Fan survey area, at a mean distance offshore Washington of 56 km in a mean water depth of 964 m during surveys from August 2004 to September 2008 (Oleson et al. 2009). Offshore sightings were made in the waters of Oregon during summer, fall, and winter surveys in 2011 and 2012, including several in and near the Astoria Fan survey area during September and October (Adams et al. 2014). Barlow (2016) provided an abundance estimate of 54,604 northern right whale dolphins based on 2014 surveys.

During a survey off Washington/Oregon June–July 2012, seven sightings of 231 individuals were made from the *Langseth* seismic vessel (RPS 2012b), including near the Southern Oregon survey area. Five sightings of 217 individuals were made from the *Langseth* seismic vessel off the southern coast of Washington during July 2012 (RPS 2012a); some sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north. In addition, three sightings totaling 61 individuals occurred from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); the sightings were made north of the Astoria Fan survey area.

Northern right whale dolphins are likely to be encountered within the proposed project area during September.

Risso’s Dolphin (*Grampus griseus*)

Risso’s dolphin is distributed worldwide in temperate and tropical oceans (Baird 2009), although it shows a preference for mid-temperate waters of the shelf and slope between 30° and 45° (Jefferson et al. 2014). Although it is known to occur in coastal and oceanic habitats (Jefferson et al. 2014), it appears to prefer steep sections of the continental shelf, 400–1000 m deep (Baird 2009), and is known to frequent seamounts and escarpments (Kruse et al. 1999). Off the U.S. west coast, Risso’s dolphin is believed to make seasonal north-south movements related to water temperature, spending colder winter months off California and moving north to waters off Oregon–Washington during the spring and summer as northern waters begin to warm (Green et al. 1992, 1993; Buchanan et al. 2001; Barlow 2003; Becker 2007).

The distribution and abundance of Risso’s dolphin is highly variable from California to Washington, presumably in response to changing oceanographic conditions on both annual and seasonal time scales (Forney and Barlow 1998; Buchanan et al. 2001). The highest densities were predicted along the coasts of Washington, Oregon, and central and southern California (Becker et al. 2012). Off Oregon and Washington, Risso’s dolphins are most abundant over continental slope and shelf waters during spring and summer, less so during fall, and rare during winter (Green et al. 1992, 1993). Green et al. (1992, 1993) reported most Risso’s dolphin groups off Oregon between ~45 and 47ºN. Several sightings were made east and south of the Southern Oregon survey area during surveys in 1991–2008, and at least nine sightings occurred within or near the Astoria Fan survey area (Carretta et al. 2016a). One sighting was southeast of the Astoria Fan survey area during the 2005 survey year (Forney 2007). Sightings during ship surveys in summer/fall 2008 were mostly between ~30 and 38ºN; none were reported in Oregon/Washington (Barlow 2010). Based on 2014 survey data, the abundance for Oregon/Washington was estimated at 430 (Barlow 2016)

Two sightings of 38 individuals were recorded north of the Astoria Fan survey area during surveys conducted offshore Washington from August 2004 to September 2008, at a mean distance from shore and water depth of 34 km and 129 m, respectively (Oleson et al. 2009). Risso's dolphins were sighted off Oregon, including near the Astoria Fan and Southern Oregon survey areas, in June and October 2011 (Adams et al. 2014). Two sightings of 21 individuals were made from the *Langseth* seismic vessel off the coast of Washington during July 2012 (RPS 2012a); sightings were made to the east and to the north of the Astoria Fan survey area. In addition, one group of 10 dolphins was seen from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); sightings were made north of the Astoria Fan survey area.

Risso's dolphin could be encountered within the proposed project area during September.

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found in all tropical and warmer temperate oceans, especially in deep, offshore waters (Odell and McClune 1999). However, it is also known to occur in nearshore areas (e.g., Stacey and Baird 1991). In the eastern North Pacific, it has been reported only rarely north of Baja California (Leatherwood et al. 1982, 1987; Mangels and Gerrodette 1994); however, the waters off the U.S. west coast all the way north to Alaska are considered part of its secondary range (Jefferson et al. 2015). Its occurrence in Washington/Oregon is associated with warm-water incursions (Buchanan et al. 2001). However, no sightings of false killer whales were made along the U.S. west coast during surveys conducted from 1986 to 2001 (Ferguson and Barlow 2001, 2003; Barlow 2003) or in 2005 and 2008 (Forney 2007; Barlow 2010). One pod of false killer whales occurred in Puget Sound for several months during the 1990s (USN 2015). Two were reported stranded along the Washington coast during 1930–2002, both in El Niño years (Norman et al. 2004). One sighting was made of southern California during 2014 (Barlow 2016).

False killer whales are unlikely to be encountered during the proposed project.

Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the world (Ford 2009). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). Currently, there are eight killer whale stocks recognized in the Pacific U.S.: (1) Alaska Residents, occurring from southeast Alaska to the Aleutians and Bering Sea; (2) Northern Residents, from BC through parts of southeast Alaska; (3) Southern Residents, mainly in inland waters of Washington State and southern BC; (4) Gulf of Alaska, Aleutians, and Bering Sea Transients, from Prince William Sound (PWS) through to the Aleutians and Bering Sea; (5) AT1 Transients, from PWS through the Kenai Fjords; (6) West Coast Transients, from California through southeast Alaska; (7) Offshore, from California through Alaska; and (8) Hawaiian (Carretta et al. 2016a). Individuals from the Southern Resident, Offshore, and West Coast Transient stocks could be encountered in the proposed project area (see Carretta et al. 2016a).

Green et al. (1992) noted that most groups seen during their surveys off Oregon and Washington were likely transients; during those surveys, killer whales were sighted only in shelf waters. Several sightings have been made within or near the Astoria Fan and Southern Oregon survey areas during 1991–2008 surveys off California, Oregon, and Washington (Forney 2007; Barlow 2010; Carretta et al. 2016a). Eleven sightings of ~536 individuals were reported off Oregon/Washington during the 2008 survey (Barlow 2010). The abundance estimate for 2014 was estimated at 19 killer whales for Oregon/ Washington (Barlow 2016).

Killer whales were sighted north of the Astoria Fan survey area, offshore Washington, during surveys from August 2004 to September 2008, at a mean of 36 km from shore and 342 m watch depth (Oleson et al. 2009). Keating et al. (2015) analysed cetacean whistles from recordings made during 2000–2012; several killer whale acoustic detections were made within or near the Astoria Fan survey area. Killer whales were sighted near the Astoria Fan survey area in July and September 2012 (Adams et al. 2014). Six of the 17 (35%) stranded killer whales in Washington and Oregon were confirmed as southern residents (Osborne 1999 *in* Norman et al. 2004), and two of the stranded killer whales in Oregon were confirmed as transient (Stevens et al. 1989 *in* Norman et al. 2004).

Killer whales could be encountered within the proposed project area during September.

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The short-finned pilot whale is found in tropical, subtropical, and warm temperate waters (Olson 2009); it is seen as far south as ~40ºS and as far north as ~50ºN (Jefferson et al. 2015). Pilot whales are generally nomadic, but may be resident in certain locations, including California and Hawaii (Olson 2009). Short-finned pilot whales were common off southern California (Dohl et al. 1980) until an El Niño event occurred in 1982–1983 (Carretta et al. 2016a). Few sightings were made off California/ Oregon/Washington in 1984–1992 (Green et al. 1992; Carretta and Forney 1993; Barlow 1997), and sightings remain rare (Barlow 1997; Buchanan et al. 2001; Barlow 2010). No short-finned pilot whales were seen during surveys off Oregon and Washington in 1989–1990, 1992, 1996, and 2001 (Barlow 2003). A few sightings were made off California during surveys in 1991–2008 (Barlow 2010). Carretta et al. (2016a) reported two sightings off Oregon during 1991–2008, both near the southern portion of the Astoria Fan survey area. Several stranding events in Oregon/southern Washington have been recorded over the past few decades, including March 1996, June 1998, and August 2002 (Norman et al. 2004).

Short-finned pilot whales are unlikely to be encountered during the proposed project.

Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore but is occasionally sighted in deeper offshore water (Jefferson et al. 2015); abundance declines linearly as depth increases (Barlow 1988). In the eastern North Pacific, its range extends from Point Barrow, Alaska, to Point Conception, California. Based on genetic data and density discontinuities, six stocks have been identified in California/Oregon/Washington: (1) Washington Inland Waters, (2) Northern Oregon/Washington Coast, (3) Northern California/Southern Oregon, (4) San Francisco-Russian River, (5) Monterey Bay, and (6) Morro Bay (Carretta et al. 2016a). Harbor porpoises from the Northern Oregon/Washington and the Northern California/Southern Oregon stocks could occur in the proposed project area (Carretta et al. 2016a).

Harbor porpoises inhabit coastal Oregon and Washington waters year-round, although there appear to be distinct seasonal changes in abundance there (Barlow 1988; Green et al. 1992). Green et al. (1992) reported that encounter rates were similarly high during fall and winter, intermediate during spring, and low during summer. Encounter rates were highest along the Oregon/Washington coast in the area from Cape Blanco (~43°N), east of the proposed Southern Oregon survey area, to California, from fall through spring. During summer, the reported encounter rates decreased notably from inner shelf to offshore waters. Green et al. (1992) reported that 96% of harbor porpoise sightings off Oregon/Washington occurred in coastal waters <100 m deep, with a few sightings on the slope near the 200-m isobath. Similarly, predictive density distribution maps show the highest in nearshore waters along the coasts of

Oregon/Washington, with very low densities beyond the 500-m isobath (Menza et al. 2016).

Oleson et al. (2009) reported 114 harbor porpoise sightings northeast of the Astoria Fan survey area, during August 2004 and September 2008, with a mean distance from the coast of 10 km and a mean water depth of 31 m. Sightings during the fall were significantly closer to shore, in shallower water, and farther from the shelf edge than during the summer (Oleson et al. 2009). Nearly 100 sightings were reported within or east of the proposed project area during aerial surveys in 2007–2012 (Forney et al. 2014). Adams et al. (2014) also reported numerous nearshore sightings during summer, fall, and winter surveys in 2011 and 2012. Two sightings of nine individuals were made from the *Langseth* seismic vessel off the southern coast of Washington during July 2012 (RPS 2012b); all sightings occurred nearshore and to the east of the Astoria Fan survey area.

In Oregon, harbor porpoises strand most commonly along the northern and central portions of the state, and strandings are concentrated within Puget Sound in Washington (Norman et al. 2004). During 1930–2002, there were 303 reported harbor porpoise strandings within these two states, with 162 in Oregon and 141 in Washington (Norman et al. 2004). Harbor porpoises stranded at ~20 locations along the Oregon and Washington coasts, east of the proposed project area, during an unusual mortality event in the U.S. Pacific northwest in 2006–2007 (Huggins et al. 2015b). There were ~20 harbor porpoise strandings per year along both the Oregon and Washington coasts during 2007–2011, with the exception of over 40 strandings in Washington in 2011 (Huggins et al. 2015b). Huggins et al. (2015a) observed 12 stranded harbor porpoises during beach surveys conducted between ~46.7º–47.3ºN (northeast of the Astoria Fan survey area) during 2006–2011, with one to five strandings observed per year during this period.

Given their preference for coastal waters, harbor porpoises could be encountered in shallower water in the easternmost portions of the proposed project area.

Dall's Porpoise (*Phocoenoides dalli*)

Dall's porpoise is found in temperate to subantarctic waters of the North Pacific and adjacent seas (Jefferson et al. 2015). It is widely distributed across the North Pacific over the continental shelf and slope waters, and over deep (>2500 m) oceanic waters (Hall 1979). It is probably the most abundant small cetacean in the North Pacific Ocean, and its abundance changes seasonally, likely in relation to water temperature (Becker 2007).

Off Oregon and Washington, Dall's porpoise is widely distributed over shelf and slope waters, with concentrations near shelf edges, but is also commonly sighted in pelagic offshore waters (Morejohn 1979; Green et al. 1992; Becker et al. 2014; Carretta et al. 2016a). Combined results of various surveys out to ~550 km offshore indicate that the distribution and abundance of Dall's porpoise varies between seasons and years. North–south movements are believed to occur between Oregon/Washington and California in response to changing oceanographic conditions, particularly temperature and distribution and abundance of prey (Green et al. 1992, 1993; Mangels and Gerrodette 1994; Barlow 1995; Forney and Barlow 1998; Buchanan et al. 2001). Becker et al. (2014) predicted high densities off southern Oregon throughout the year, with moderate densities to the north. According to predictive density distribution maps, the highest densities off southern Washington and Oregon occur along the 500-m isobath (Menza et al. 2016). Barlow (2016) provided an abundance estimate of 16,294 for waters off Oregon/Washington in 2014.

Encounter rates reported by Green et al. (1992) during aerial surveys off Oregon/Washington were highest in fall, lowest during winter, and intermediate during spring and summer. Encounter rates during the summer were similarly high in slope and shelf waters, and somewhat lower in offshore waters (Green et al. 1992). Dall's porpoise was the most abundant species sighted off Oregon/Washington during 1996, 2001, 2005, and 2008 ship surveys up to ~550 km from shore (Barlow 2003, 2010), with numerous other sightings within and near the Astoria Fan and Southern Oregon survey areas during the summer and fall (Becker et al. 2014; Carretta et al. 2016a). Oleson et al. (2009) reported 44 sightings of 206 individuals north of the Astoria Fan survey area off Washington during surveys form August 2004 to September 2008, at a mean distance from shore of 46 km in a mean water depth of 501 m. Dall's porpoise were seen in the waters off Oregon during summer, fall, and winter surveys in 2011 and 2012, including near the Southern Oregon survey area during September (Adams et al. 2014). During a survey off Washington/Oregon June–July 2012, 19 sightings of 144 individuals were made from the *Langseth* seismic vessel (RPS 2012b), including within the Astoria Fan and Southern Oregon survey areas. Nine sightings of 32 individuals were made from the *Langseth* seismic vessel off the southern coast of Washington during July 2012 (RPS 2012b), including a sighting within the Astoria Fan survey area. Dall's porpoise strandings were reported in every month in Washington and Oregon, with the highest numbers in spring (44%) and summer (34%; Norman et al. 2004). During 1930–2002, there were 107 stranding records in the region, with 14 in Oregon and 93 in Washington (Norman et al. 2004).

Dall's porpoises are likely to be encountered within the proposed project area during September.

(3) Pinnipeds

Northern Fur Seal (*Callorhinus ursinus*)

The northern fur seal is endemic to the North Pacific Ocean and occurs from southern California to the Bering Sea, Sea of Okhotsk, and Sea of Japan (Jefferson et al. 2015). The worldwide population of northern fur seals has declined from a peak of ~2.1 million in the 1950s to the present population estimate of 648,534 (Muto et al. 2016). They were subjected to large-scale harvests on the Pribilof Islands to supply a lucrative fur trade. Two stocks are recognized in U.S. waters: the Eastern Pacific and the California stocks. The Eastern Pacific stock ranges from southern California during winter to the Pribilof Islands and Bogoslof Island in the Bering Sea during summer (Carretta et al. 2016a; Muto et al. 2016). Abundance of the Eastern Pacific Stock has been decreasing at the Pribilof Islands since the 1940s and increasing on Bogoslof Island. The California stock is much smaller, estimated at 14,050 (Carretta et al. 2016a).

Most northern fur seals are highly migratory. During the breeding season (June–September), most of the world's population of northern fur seals occurs on the Pribilof and Bogoslof islands (NMFS 2007). Males are present in the Pribilof Island rookeries from around mid-May until August; females are present in the rookeries from mid-June to late October. Nearly all fur seals from the Pribilof Island rookeries are foraging at sea from fall through late spring. In November, females and pups leave the Pribilof Islands and migrate through the Gulf of Alaska to feeding areas primarily off the coasts of BC, Washington, Oregon, and California before migrating north again to the rookeries in spring (Ream et al. 2005; Pelland et al. 2014). Immature seals can remain in southern foraging areas year-round until they are old enough to mate (NMFS 2007). Adult males migrate only as far south as the Gulf of Alaska or to the west off the Kuril Islands (Kajimura 1984). Pups from the California stock also migrate to Washington, Oregon, and northern California after weaning (Lea et al. 2009).

The northern fur seals spends ~90% of its time at sea, typically in areas of upwelling along the continental slopes and over seamounts (Gentry 1981). The remainder of its life is spent on or near rookery islands or haulouts. The main breeding season is in July (Gentry 2009). Adult males usually occur on shore from May to August, though some may be present until November; females are usually found ashore from June to November (Carretta et al. 2016a). While at sea, northern fur seals usually occur singly or in pairs, although larger groups can form in waters rich with prey (Antonelis and Fiscus 1980; Gentry 1981). Northern fur seals dive to relatively shallow depths to feed: 100–200 m for females, and <400 m for males (Gentry 2009). Tagged adult female fur seals were shown to remain within 200 km of the shelf break (Pelland et al. 2014).

Bonnell et al. (1992) noted the presence of northern fur seals year-round off Oregon/Washington, with the greatest numbers (87%) occurring in January–May. Northern fur seals were seen as far out from the coast as 185 km, and numbers increased with distance from land; they were 5–6 times more abundant in offshore waters than over the shelf or slope (Bonnell et al. 1992). The highest densities were seen in the Columbia River plume (~46°N) and in deep offshore waters (>2000 m) off central and southern Oregon (Bonnell et al. 1992). The waters off Washington are a known foraging area for adult females, and concentrations of fur seals were also reported to occur near Cape Blanco, Oregon, at ~42.8°N (Pelland et al. 2014). Tagged adult fur seals were tracked from the Pribilof Islands to the waters off Washington/Oregon/California, with recorded movement throughout the proposed project area (Pelland et al. 2014). During a survey off Washington/Oregon June–July 2012, 31 sightings of 63 individuals were made from the *Langseth* seismic vessel (RPS 2012b); including in deep water near the Southern Oregon survey area and north of the Astoria Fan survey area. Five sightings of individual fur seals occurred from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); sightings were made north of the Astoria Fan survey area.

Northern fur seals could be encountered in the proposed project area in September.

California Sea Lion (*Zalophus californianus*)

The primary range of the California sea lion includes the coastal areas and offshore islands of the eastern North Pacific Ocean from BC, Canada, to central Mexico, including the Gulf of California (Jefferson et al. 2015). However, its distribution is expanding (Jefferson et al. 2015), and its secondary range extends into the Gulf of Alaska where it is occasionally recorded (Maniscalco et al. 2004) and southern Mexico (Gallo-Reynoso and Solórzano-Velasco 1991). California sea lion rookeries are on islands located in southern California, western Baja California, and the Gulf of California (Carretta et al. 2016a). Five genetically distinct geographic populations have been identified: (1) Pacific Temperate (includes rookeries in U.S. waters and the Coronados Islands to the south), (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California (Schramm et al. 2009). Animals from the Pacific Temperate population occur in the proposed project area.

In California and Baja California, births occur on land from mid-May to late June. Females are ready to breed and actively solicit mates ~3 weeks after giving birth (Odell 1984; Trillmich 1986). During August and September, after the mating season, the adult males migrate northward to feeding areas in Oregon, Washington, and BC (Lowry et al. 1992). They remain there until spring (March–May), and then migrate back to the breeding colonies (Lowry et al. 1992; Weise et al. 2006). The distribution of juvenile California sea lions is less well known, but some make northward migrations that are shorter in length than the migrations of adult males (Huber 1991). Most females and pups remain near the rookeries for most of the year (Lowry et al. 1992).

California sea lions are coastal animals that often haul out on shore throughout the year. Off Oregon and Washington, peak numbers occur during the fall. During aerial surveys off the coasts of Oregon and Washington during 1989–1990, California sea lions were sighted at sea during the fall and winter, but no sightings were made during June–August (Bonnell et al. 1992). Numbers off Oregon decrease during winter, as animals travel further north (Mate 1975 *in* Bonnell et al. 1992). King (1983) noted that sea lions are rarely found more than 16 km offshore. During fall and winter surveys off Oregon and Washington, mean distance from shore was ~13 km and most were observed in water <200 m deep; however, sightings were made in water as deep as 356 m (Bonnell et al. 1992). Weise et al. (2006) reported that males normally forage almost exclusively over the continental shelf, but during anomalous climatic conditions they can forage farther out to sea (up to 450 km offshore). Adams et al. (2014) reported sightings more than 60 km off the coast of Oregon.

During aerial surveys over the shelf and slope off Oregon and Washington (Adams et al. 2014), California sea lions were seen during all survey months (January–February, June–July, September–October). Although most sightings occurred on the shelf, during February 2012, one sighting was made near the 2000-m depth contour between the two proposed survey sites, and during June 2011 and July 2012, sightings were made along the 200-m isobath near southern Oregon survey area (Adams et al. 2014). During October 2011, sightings were made off the Columbia River near the 200-m isopleth, and on the southern Oregon shelf; during September 2012, sightings occurred in nearshore waters off Washington and in shelf waters along the coast of Oregon (Adams et al. 2014). California sea lions were also taken as bycatch within the Astoria Fan and Southern Oregon survey areas in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

California sea lions could be encountered in the proposed project area in September.

Steller Sea Lion (*Eumetopias jubatus*)

The Steller sea lion ranges along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984). There are two DPSs of Steller sea lions – the Western and the Eastern DPS (NMFS 2017). The Eastern DPS was listed as *threatened* under the ESA but was delisted in 2013 (NMFS 2013b). Rookeries of Steller sea lions from the Eastern DPS are located in southeast Alaska, BC, Oregon, and California; there are no rookeries in Washington (NMFS 2013c; Muto et al. 2016). Breeding adults occupy rookeries from late May to early July (NMFS 2008a). Males arrive at rookeries in May to establish their territory and are soon followed by females. Non-breeding adults use haulouts or occupy sites at the periphery of rookeries during the breeding season (NMFS 2008a). Pupping occurs from mid-May to mid-July (Pitcher and Calkins 1981) and peaks in June (Pitcher et al. 2002).

Territorial males fast and remain on land during the breeding season (NMFS 2008a). 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 2008a). 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). Tagged juvenile sea lions showed localized movements near shore (Briggs et al. 2005). During the non-breeding season, sea lions may disperse great distances from the rookeries (e.g., Mathews 1996; Raum-Suryan 2001).

Steller sea lions typically inhabit waters from the coast to the outer continental shelf and slope throughout their range; they are not considered migratory, although foraging animals can travel long distances (Loughlin et al. 2003; Raum-Suryan et al. 2002). Loughlin et al. (2003) reported that most (88%) of at-sea movements of juvenile Steller sea lions in the Aleutian Islands were short (<15 km) foraging trips. The mean distance of juvenile sea lion trips at sea was 16.6 km and the maximum trip distance recorded was 447 km. Long-range trips represented 6% of all trips at sea, and trip distance and duration increase with age (Loughlin et al. 2003; Call et al. 2007).

Three rookeries and seven haul-out sites are located in Oregon (NMFS 2008a). Two rookeries in southern Oregon, Orford Reef and Rogue Reef, are designated as critical habitat; the rookey in northern Oregon, Three Arch Rocks, is not. Several haul-out sites are also located in Washington (NMFS 2008a). Jeffries et al. (2000) identified four haul-out sites in the Split Rock area (47.4°N) in Washington; animals at these haulout locations are assumed to be immatures and non-breeding adults associated with rookeries in Oregon and BC (Pitcher et al. 2007). The mean count of non-pups at Washington haul-out sites during 2011 was 1749 (Muto et al. 2016). A total of 4761 non-pups and 1418 pups were counted in Oregon during 2013 and 2009, respectively (Muto et al. 2016).

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 and near or in waters <200 m deep; the farthest sighting occurred ~40 km from shore, and the deepest sighting location was 1611 m deep. Sightings were made along the 200-m depth contour within and near the proposed Astoria Fan and Southern Oregon survey sites throughout the year (Bonnell et al. 1992). During aerial surveys over the shelf and slope off Oregon and Washington, one Steller sea lion was seen on the Oregon shelf during January 2011, and two sightings totaling eight individuals were made on September 2012 near the Southern Oregon survey area (Adams et al. 2014). During a survey off Washington/Oregon June–July 2012, two Steller sea lions were seen from the *Langseth* seismic vessel (RPS 2012b) near the Southern Oregon survey area. Eight sightings of 11 individuals were made from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); sightings were made north of the Astoria Fan survey area. Steller sea lions were also taken as bycatch near the Southern Oregon survey area in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

Steller sea lions could be encountered in the proposed project areas, especially in the waters closer to shore.

Harbor Seal (*Phoca vitulina*)

The harbor seal is distributed in the North Atlantic and North Pacific. Two subspecies occur in the Pacific: *P.v. stejnegeri* in the northwest Pacific Ocean and *P.v. richardsi* in the eastern Pacific Ocean. *P.v. richardsi* occurs in nearshore, coastal, and estuarine areas ranging from Baja California, Mexico, north to the Pribilof Islands in Alaska (Carretta et al. 2016a). Five stocks of harbor seals are recognized along the U.S. west coast: (1) Southern Puget Sound, (2) Washington Northern Inland Waters Stock, (3) Hood Canal, (4) Oregon/Washington Coast, and (5) California (Carretta et al. 2016a). The Oregon/Washington stock occurs in the proposed survey area. The most recent estimate for the Oregon/Washington coastal stock is 24,732 (based on counts in 1999), but no best population estimates are currently available (Carretta et al. 2016a).

Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows. They are generally non-migratory, but move locally with the tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows; pups are born from May to mid-July. When molting, which occurs primarily in late August, seals spend the majority of the time hauled out on shore, glacial ice, or other substrates. Juvenile harbor seals can travel significant distances (525 km) to forage or disperse, whereas adults were generally found within 190 km of their tagging location in Prince William Sound, Alaska (Lowry et al. 2001). The smaller home range used by adults is suggestive of a strong site fidelity (Pitcher and Calkins 1979; Pitcher and McAllister 1981; Lowry et al. 2001). Pups tagged in the Gulf of Alaska most commonly undertook multiple return trips of more than 75 km from natal areas, followed by movements of <25 km from the natal area (Small et al. 2005). Pups tagged in Prince William Sound traveled a mean maximum distance of 43.2 km from their tagging location, whereas those tagged in the Gulf of Alaska moved a mean maximum distance of 86.6 km (Small et al. 2005). Most (40–80%) harbor seal dives in the Gulf of Alaska were to depths <20 m and less than 4 min in duration. Dives of 50–150 m were also recorded, as well as dives as deep as ~500 m (Hastings et al. 2004).

Harbor seals haul out on rocks, reefs, and beaches along the U.S. west coast (Carretta et al. 2016a). Jeffries et al. (2000) documented several harbor seal rookeries and haulouts along the Washington coastline; it is the only pinniped species that breeds in Washington. Pupping in Oregon and Washington occurs from April to July (Brown 1988). Bonnell et al. (1992) noted that most harbor seals sighted off Oregon and Washington were ≤20 km from shore, with the farthest sighting 92 km from the coast. Menza et al. (2015) also showed the highest predicted densities nearshore. During surveys off the Oregon and Washington coasts, 88% of at-sea harbor seals occurred over shelf waters <200 m deep, with a few sightings near the 2000-m contour, and only one sighting over deeper water (Bonnell et al. 1992). Most (68%) at-sea sightings were recorded in September and November (Bonnell et al. 1992). Harbor seals were only seen in nearshore areas during surveys on the shelf and slope in 2011 and 2012 (Adams et al. 2014). Twelve sightings occurred from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); sightings were made in shallower water to the east of the Astoria Fan survey area. Harbor seals were also taken as bycatch east of the Southern Oregon survey area in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

Given their preference for coastal waters, harbor seals could be encountered in the easternmost parts of the proposed project area.

Northern Elephant Seal (*Mirounga angustirostris*)

The northern elephant seal breeds in California and Baja California, primarily on offshore islands, from Cedros off the west coast of Baja California, north to the Farallons in Central California (Stewart et al. 1994). Pupping has also been observed at Shell Island (~43.3°N) off southern Oregon, suggesting a range expansion (Bonnell et al. 1992; Hodder et al. 1998). The California breeding population was estimated at 179,000 in 2010 (Lowry et al. 2014).

Adult elephant seals engage in two long northward migrations per year, one following the breeding season, and another following the annual molt (Stewart and DeLong 1995). Between the two foraging periods, they return to land to molt, with females returning earlier than males (March–April *vs.* July–August). After the molt, adults then return to their northern feeding areas until the next winter breeding seasons. Breeding occurs from December to March (Stewart and Huber 1993). Females arrive in late December and January and give birth within ~1 week of their arrival. Pups are weaned after just 27 days and are abandoned by their mothers. Juvenile elephant seals typically leave the rookeries in April or May and head north, traveling an average of 900–1000 km. Hindell (2009) noted that traveling likely takes place at depths >200 m. Most elephant seals return to their natal rookeries when they start breeding (Huber et al. 1991).

When not at their breeding rookeries, adults feed at sea far from the rookeries. Males may feed as far north as the eastern Aleutian Islands and the Gulf of Alaska, whereas females feed south of 45ºN (Le Boeuf et al. 1993; Stewart and Huber 1993). Adult male elephant seals migrate north via the California current to the Gulf of Alaska during foraging trips, and could potentially be passing through the area off Washington in May and August (migrating to and from molting periods) and November and February (migrating to and from breeding periods), but likely their presence there is transient and short-lived. Adult females and juveniles forage in the California current off California to BC (Le Boeuf et al. 1986, 1993, 2000). Bonnell et al. (1992) reported that northern elephant seals were distributed equally in shelf, slope, and offshore waters during surveys conducted off Oregon and Washington, as far as 150 km from shore, in waters >2000 m deep. Telemetry data indicate that they range much farther offshore than that (Stewart and DeLong 1995).

Off Washington, most elephant seal sightings at sea were during June, July, and September; off Oregon, sightings were recorded from November through May (Bonnell et al. 1992). Several seals were seen off Oregon during summer, fall, and winter surveys in 2011 and 2012, including one near the Southern Oregon survey area during October 2011 (Adams et al. 2014). Five sightings occurred from the *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a); some sightings were made in the Astoria Fan survey area, but most of the survey effort occurred farther north. Northern elephant seals were also taken as bycatch within the Astoria Fan and Southern Oregon survey areas in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

Northern elephant seals could be encountered in the proposed project area in September.

Sea Turtles

Since 1985, four species of sea turtles have been documented off the coasts of Oregon and/or Washington: the leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and olive ridley (*Lepidochelys olivacea*) turtles (Green et al. 1992; Bowlby et al. 1994; Buchanan et al. 2001). Under the ESA, the leatherback turtle and the North Pacific Ocean DPS of the loggerhead turtle are listed as ***Endangered***, the olive ridley population on the Pacific coast of Mexico is listed as ***Endangered*** whereas other populations are listed as ***Threatened***, and the East Pacific DPS of the green turtle is listed as ***Threatened***.

The leatherback turtle is the only sea turtle likely to occur in the waters of the proposed project area. The other three species have been documented off the coasts of Oregon or Washington as strandings and are considered extralimital occurrences of those generally warm-water species (Bowlby et al. 1994; Buchanan et al. 2001). Strandings have increased in recent years, particularly for olive ridley sea turtles, possibly due to warmer ocean conditions or El Niño (Boyer 2017). However, green, loggerhead, and olive ridley sea turtles are still considered accidental in Oregon (OFWC 2013). Those three species are not addressed further here.

(1) Leatherback Turtle

The leatherback is the largest and most widely distributed sea turtle, ranging far from its tropical and subtropical breeding grounds to feed (Plotkin 2003). The leatherback turtle is listed as ***Endangered*** under the ESA and is listed in CITES Appendix I (UNEP-WCMC 2017). Globally, the leatherback turtle is designated as ***Vulnerable*** on the IUCN Red List of Threatened Species, but the East Pacific Ocean subpopulation and the West Pacific Ocean subpopulation are considered ***Critically Endangered*** (IUCN 2016). There have been significant declines and some extirpations of nesting populations in the Pacific (Spotila et al. 2000; Dutton et al. 2007). A recent estimate of the North Atlantic population is 34,000–94,000 adults (TEWG 2007), and nesting beaches in the western Pacific have 2700–4500 breeding females (NMFS and USFWS 2013).

The largest remaining nesting sites for leatherbacks in the Pacific Ocean occur on the beaches of Birdshead Peninsula in Papua, Indonesia (Dutton et al. 2007; Hitipeuw et al. 2007; Benson et al. 2008). In the western Pacific, leatherbacks also nest in New Guinea, the Solomon Islands, and Vanuatu, with fewer nesting in Fiji, Malaysia, and Australia (NMFS and USFWS 2013). Nesting leatherbacks have also been discovered in Japan (Kamezaki et al. 2002). In the eastern Pacific, leatherbacks nest along the west coast of Mexico and Central America (Marquez 1990).

Leatherbacks are highly migratory and feed in areas of high productivity, such as convergence zones, and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale et al. 1994; Eckert 1995). Adult leatherbacks appear to migrate along bathymetric contours from 200 to 3500 m (Morreale et al. 1994). Adults spend the majority of their time in water >1000 m deep and possibly swim more than 10,000 km each year (Eckert 1995). They appear to use the Kuroshio Extension during migrations from Indonesia to the high seas and eastern Pacific (Benson et al. 2008). Frair et al. (1972) and Greer et al. (1973) reported that leatherback turtles have evolved physiological and anatomical adaptations to cold water, allowing them to venture into higher latitudes than other species of turtle. After nesting, female leatherbacks typically migrate from tropical waters to temperate areas, where higher densities of jellyfish occur in the summer (NOAA 2016).

Hatchling leatherbacks are pelagic, but nothing is known about their distribution for the first four years (Musick and Limpus 1997). Leatherback turtles undertake long migrations from the western, central, or South Pacific toward the California Current Large Marine Ecosystem (Block et al. 2011; Bailey et al. 2012). After analyzing some 363 records of sea turtles sighted along the Pacific coast of North America, Stinson (1984) concluded that the leatherback was the most common sea turtle in U.S. waters north of Mexico. Roe et al. (2014) also predicted high densities off the northwest coast of the U.S. from July–December. Sightings and incidental capture data indicate that leatherbacks are found as far north as 60°N, and documented encounters extend southward through the waters of BC, Washington, Oregon, and California (NMFS and USFWS 1998; Green et al. 1992; Bowlby et al. 1994). 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. Satellite tracking has shown that leatherbacks from the western Pacific population travel to Washington and Oregon waters (including the proposed survey area) to feed in continental shelf and slope waters, particularly near the Columbia River Plume; individuals occurred in the area from July through December (Benson et al. 2011). Other sightings have also been made in water 200–2000 m deep in the Astoria Fan survey area and just south of there (Green et al. 1992; Bowlby et al. 1994).

In the Pacific Ocean, Critical Habitat has recently been designated that includes ~108,600 km^2 of marine habitat off the U.S. west coast, including an area stretching along the California coast, and an area stretching from Cape Flattery, Washington, to Cape Blanco, Oregon, east of a line approximating the 2000-m depth contour. Both the Astoria Fan and southern Oregon survey sites occur in designated critical habitat.

Seabirds

Three bird species that are listed under the Endangered Species Act (ESA) could occur in or near the proposed survey areas. Only two of the three species nest in the area. The marbled murrelet (*Brachyramphus marmoratus*) is fairly common or regular along the Pacific Coast, but are unlikely to occur far offshore (beyond 5 km). The marbled murrelet is listed as ***Threatened***. The ***Endangered*** short-tailed albatross (*Phoebastria albatrus*) could occur as a seasonal visitor to the project area. The

Threatened western snowy plover (*Charadrius alexandrinus nivosus*) is a coastal species and would not be encountered offshore.

In addition, the brown pelican is listed as *endangered* by both Washington and Oregon states but was delisted from the ESA in 2009 because of its recovery (USFWS 2009). In Washington, Cassin's auklet and the common murre are candidates for designation by the Washington Department of Fish and Wildlife, and the tufted puffin is considered *endangered* (WDFW 2008). In Oregon, the tufted puffin, rhinoceros auklet, and Cassin's auklet are considered vulnerable sensitive species that, although not currently imperiled with extirpation could become so if threats to populations and habitats were to continue (OBIC 2016).

(1) Short-tailed Albatross

The short-tailed albatross, which breeds on islands off the coast of Japan and is listed as ***Endangered*** under the ESA, occasionally visits Pacific Coast waters during the non-breeding season. It is listed as ***Vulnerable*** on the IUCN Red List of Threatened Species (IUCN 2016). Historically, millions of short-tailed albatrosses bred in the western North Pacific Ocean on islands off the coast of Japan. This species was the most abundant albatross in the North Pacific. However, the entire population was nearly extirpated during the last century by feather hunters at Japanese breeding colonies. In addition, the breeding grounds of the remaining birds were threatened by volcanic eruptions in the 1930s; this species was believed to be extinct in 1949 until it was rediscovered in 1951 (USFWS 2008). The population is now increasing, and the most recent population estimate is 2406 (USFWS 2008). Current threats to the species include volcanic activity on Torishima, commercial fisheries, and pollutants (USFWS 2008).

Currently, nearly all short-tailed albatrosses breed on two islands off the coast of Japan: Torishima and Minami-kojima (USFWS 2008). Single nests have been found in recent years on other islands, including Kita-Kojima, Senkaku; Yomejima Island; and Midway Island, Hawaii (USFWS 2008). During the breeding season (December to May), the highest densities are found around Japan (BirdLife International 2017); parents forage primarily off the east coast of Honshu Island, where the warm Kuroshio and the cold Oyashio currents meet (USFWS 2008).

During the non-breeding season, short-tailed albatrosses roam much of the North Pacific Ocean; females spend more time offshore from Japan and Russia, whereas males and juveniles spend more time around the Aleutian Islands and Bering Sea (Suryan et al. 2007). Post-breeding dispersal occurs from April through August (USFWS 2008). After leaving the breeding areas, short-tailed albatrosses seem to spend the majority of time within the EEZs of Japan, Russia, and the U.S., primarily in the Aleutian Islands and Bering Sea (Suryan et al. 2007). Most of the short-tailed albatrosses sighted off the Pacific Coast of North America (south to California) are juveniles and sub-adults (USFWS 2008; O'Connor 2013). Satellite-tracked first and second year birds were found in Oregon waters most often during winter and spring, possibly in response to ice conditions in the Bering Sea (O'Connor 2013). They are considered a continental shelf-edge specialist (Piatt et al. 2006). One short-tailed albatross was taken as bycatch in the Astoria Fan survey area during the west coast groundfish fishery in 2002–2009 (Jannot et al. 2011). The short-tailed albatross could be encountered in very small numbers in the proposed project area.

(2) Western Snowy Plover

The western snowy plover is listed as a ***Threatened*** species under the ESA (USFWS 1993). It is listed as ***Least Concern*** on the IUCN Red List of Threatened Species because of its very large worldwide range (IUCN 2016). However, the Eurasian subspecies of snowy plover has recently been split from the North American population on the basis of calls, morphology, and genetic differences (Chesser et al. 2011). The North American breeding population is thought to be ~18,000 individuals (Page et al. 2009).

In North America, snowy plovers are distributed across the Great Plains, locally along the Gulf Coast, and down the west coasts of Washington, Oregon, and California. The Pacific coastal population of the western snowy plover is threatened by increasing development and disturbance in their breeding and wintering habitat along Pacific coast beaches (Page et al. 2009). This species is strictly coastal, and is not found offshore. The breeding population in Oregon was 337 in 2014 (Lauten et al. 2014); in Washington, it was 33 in 2012 (Pearson et al. 2013).

Breeding habitat includes sandy beaches and dune systems immediately inland from the active beach face as well as salt flats, mud flats, and gravel bars. These areas are above high tides and below heavily vegetated areas, and they have minimal disturbance from humans. Shoreline areas with little or no vegetation that are subject to intermittent inundation are important feeding areas (USFWS 2011). The western snowy plover would be unlikely to occur in the offshore waters of the proposed project area, although they could be sighted in the areas closer to shore.

(3) Marbled Murrelet

The marbled murrelet was listed as a ***Threatened*** species under the ESA in the southern part of its range (Washington, Oregon, and California) by the USFWS in 1992 (USFWS 1992). It is listed as ***Endangered*** on the IUCN Red List of Threatened Species (IUCN 2016). In January 2010, USFWS published a 12-month finding that a petition to remove the California, Oregon, and Washington population of the marbled murrelet from the Federal List of Endangered and Threatened Wildlife was not warranted (USFWS 2010). The population marbled murrelets in California, Oregon, and Washington has declined by nearly 30% from 23,700 individuals in 2000 to 16,700 individuals in 2010 (Miller et al. 2012). The primary reason for declining populations is the fragmentation and destruction of old-growth forest nesting habitat. Marbled murrelets are also threatened by gillnet fishing, nest predation, and oil spills. They are widespread along the Pacific Coast and generally found in nearshore waters, usually within 5 km of shore (Nelson 1997).

Critical marbled murrelet nesting habitat consists of forest stands containing large trees (greater than 81 cm diameter) with potential nest platforms (including large branches, deformities, mistletoe infestations) at 10 meters in height. High canopy cover is important for nesting murrelets. Feeding habitat for marbled murrelets is mostly within 2 km of shore (outside of the survey area) in waters up to 30 m deep (USFWS 2006). Although they have been observed more than 40 km from shore in water deeper than 200 m (Adams et al. 2014), the mean offshore distance over a three year tracking study was 1.4 km (Hébert and Golightly 2008). Marbled murrelet nesting activities in Washington and Oregon occur between late March and August and they remain in Washington and Oregon waters during the non-breeding season. The single egg is incubated by both adults who alternate incubation duties every 24 h. Upon arrival of the non-incubating individual at dawn, incubating individuals leave the nest to feed at sea and return to the nest the following morning. Marbled murrelets occur in open-ocean habitats after breeding. They feed on small schooling fish and invertebrates in bays and fiords and in the open ocean (Nelson 1997).

During surveys of the Oregon and Washington shelf in October 2011 and September 2012, no marbled murrelets were sighted (Adams et al. 2014). Similarly, predictive density distribution maps for southern Washington indicate that murrelets are unlikely to occur in deeper waters off the coast (Menza et al. 2016). On the California shelf, the highest densities were seen during fall (Adams et al. 2014). During 1989-1990 offshore and coastal counts of marbled murrelets off Oregon and Washington, 71 murrelets were seen during September 1990 but none were seen during September 1989; the September 1990 count was the highest during the surveys which were conducted during all seasons (Briggs et al. 1992). Marbled murrelets would be unlikely to occur in the offshore waters of the proposed project area, although they could be sighted in the areas closer to shore.

Fish

(1) ESA-listed Species

The term "species" under the ESA includes species, subspecies, and, for vertebrates only, DPSs or "evolutionarily significant units (ESUs)"; for Pacific salmon, ESUs are essentially equivalent to DPSs for the purpose of the ESA. ESA-listed species that could occur in the proposed project area off Washington and Oregon are the ESUs of chinook, chum, coho, and sockeye salmon and the DPSs of Pacific eulachon, steelhead, and green sturgeon listed in Table 7 (NMFS 2017). Listed critical habitat for salmon and steelhead is in freshwater, whereas listed critical habitat for green sturgeon includes freshwater and coastal bays, estuaries, and marine waters <100 m deep off California, Oregon, Washington, and Alaska (NMFS 2009). Listed critical habitat for the Pacific eulachon includes freshwater and estuarine waters for spawning. Nearshore and offshore foraging habitat are not considered critical habitat (NMFS 2011a).

(2) Essential Fish Habitat

Essential Fish Habitat (EFH) is identified for only those species managed under a federal Fishery Management Plan (FMP). In Washington and Oregon, there are four FMPs covering groundfish, coastal pelagic species, highly migratory species, and Pacific salmon. The entire western seaboard from the coast to the limits of the EEZ is EFH for one or more species for which EFH has been designated. The proposed project areas encompasses several EFHs.

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C.§1801-1882) established Regional Fishery Management Councils and mandated that FMPs be developed to manage exploited fish and invertebrate species responsibly in federal waters of the U.S. When Congress reauthorized the act in 1996 as the Sustainable Fisheries Act, several reforms and changes were made. One change was to charge NMFS with designating and conserving EFH for species managed under existing FMPs.

Groundfish EFH.—The Pacific Coast Groundfish FMP manages more than 90 species (160 species/life stage combinations). The FMP provides a description of groundfish EFH for each of the species and their life stages (PFMC 2016a). When the EFH are taken together, the EFH for Pacific Coast groundfish includes all waters and substrate from the mean higher high water level or the upriver extent of saltwater intrusion along the coasts of Washington, Oregon, and California to within water depths <3500 m and seamounts in depths >3500 m (PMFC 2016a). In addition to the EFH parameters mentioned above, there are several distinct EFH Conservation Areas within the proposed project area, including Astoria Canyon and Nehalem Bank/Shale Pile within the Astoria Fan survey area; Bandon High Spot and Deepwater off Coos Bay within the Southern Oregon survey area; and Daisy Bank/Nelson Island and Siletz Deepwater are located between the two survey sites; Heceta Bank is located just to the east of the proposed project area, and Newport Rockpile/Stonewall Bank is located outside of the project area to the east (USGS 2016; NOAA WCR 2017; OOI 2017b). The Astoria Canyon and Deepwater off Coos Bay EFH Conservation Areas overlap the proposed seismic track lines in the Astoria Fan and

TABLE 7. Fish "species" listed under the ESA that could occur in the proposed project area off Washington and Oregon.

Species	ESU or DPS	Status[1]	Critical Habitat
Pacific eulachon/smelt	Southern DPS	T	Freshwater/estuarine
Green sturgeon	Southern DPS	T	Marine/freshwater
Chinook salmon	Lower Columbia River	T	Freshwater
	Upper Columbia River spring-run	EN	Freshwater
	Snake River fall-run	T	—
	Snake River spring/summer-run	T	—
	Upper Willamette River	T	Freshwater
Chum salmon	Columbia River	T	Freshwater
Coho salmon	Lower Columbia River	T	Freshwater
	Oregon coast	T	Freshwater
	S. Oregon and N. California coasts	T	—
Sockeye salmon	Ozette Lake	T	Freshwater
	Snake River	EN	—
Steelhead trout	Lower Columbia River	T	Freshwater
	Middle Columbia River	T	Freshwater
	Upper Columbia River	EN	Freshwater
	Snake River Basin	T	Freshwater
	Upper Willamette River	T	Freshwater

[1] Status under the ESA: EN = Endangered; T = Threatened.

Southern Oregon survey areas, respectively (Fig. 14). These seven EFHs are closed to bottom trawl fishing gear (OOI 2017b).

Coastal pelagic species EFH.—The FMP for Pacific coast Coastal Pelagic Species (CPS) includes four finfish (Pacific sardine, Pacific [chub] mackerel, northern anchovy and jack mackerel), market squid and all euphausiids (krill) species that occur in the West Coast EEZ (PFMC 2016b). EFH for these species is defined both through geographic boundaries and by sea-surface temperature ranges. Because of similarities in their life histories and similarities in their habitat requirements, the four CPS finfish are treated as a single species complex for the purposes of EFH. Market squid are also treated in this same complex because they are similarly fished above spawning aggregations. The geographic boundary of EFH for CPS finfish and market squid is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C and 26°C. The southern extent of the EFH is the U.S.-Mexico boundary. The northern boundary of the range of CPS finfish is the position of the 10°C isotherm which varies both seasonally and annually (PFMC 2016b). EFH for krill (*Thysanoessa spinifera*) extends from the shoreline outwards to a depth of 1000 m, while EFH for *Euphausia pacifica* and other krill species in the area extends from the shoreline to ~2000-m depth in Washington, Oregon, and California (NOAA 2017b). The *E. pacifica*/other sp. and *T. spinifera* krill EFHs overlap with the central and eastern portions of the proposed Astoria Fan survey area, and with the eastern portion of the Southern Oregon survey area (Fig. 15).

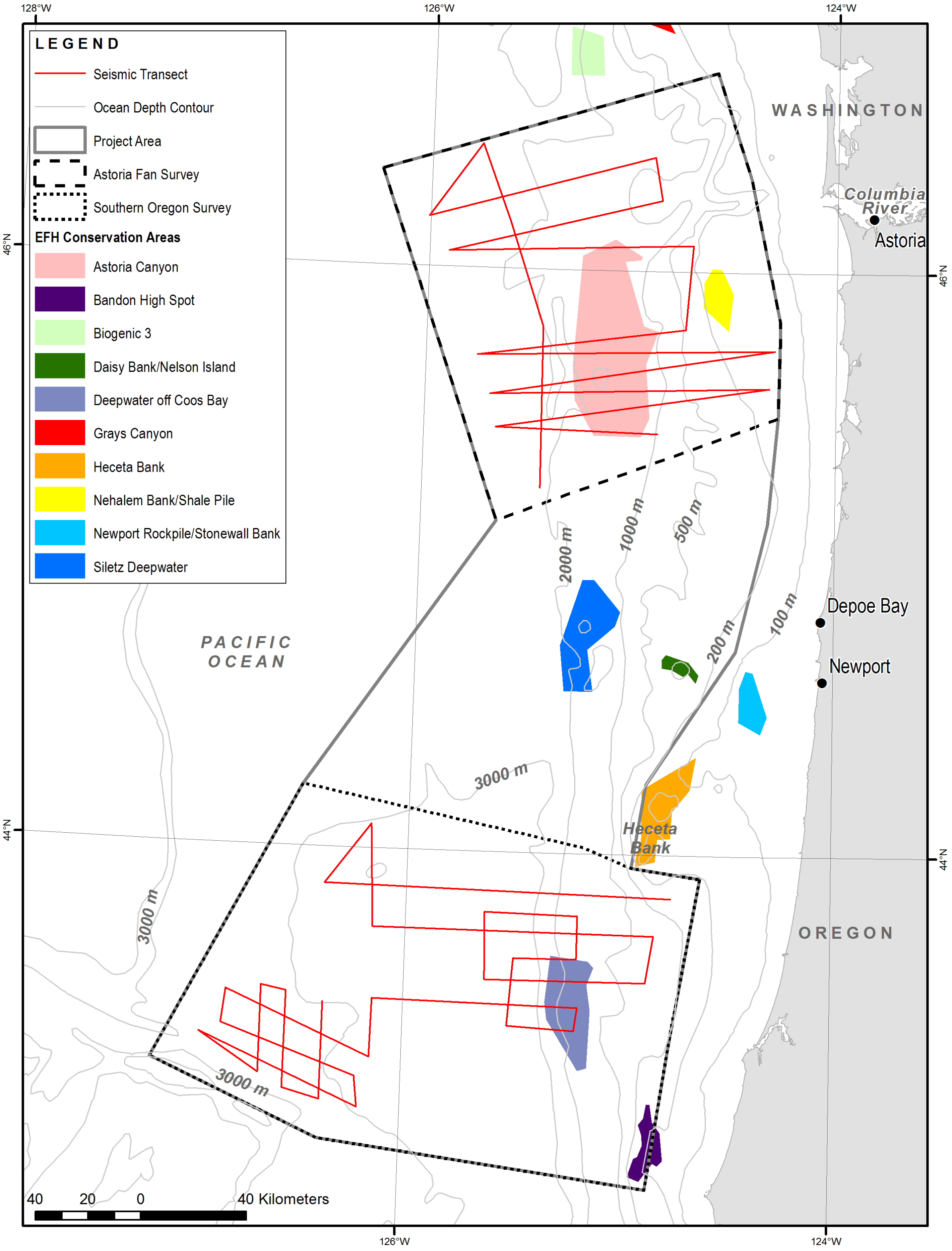


FIGURE 14. EFH for groundfish species in Washington and Oregon. Sources: USGS 2016; NOAA 2017b; NOAA WCR 2017; OOI 2017b.

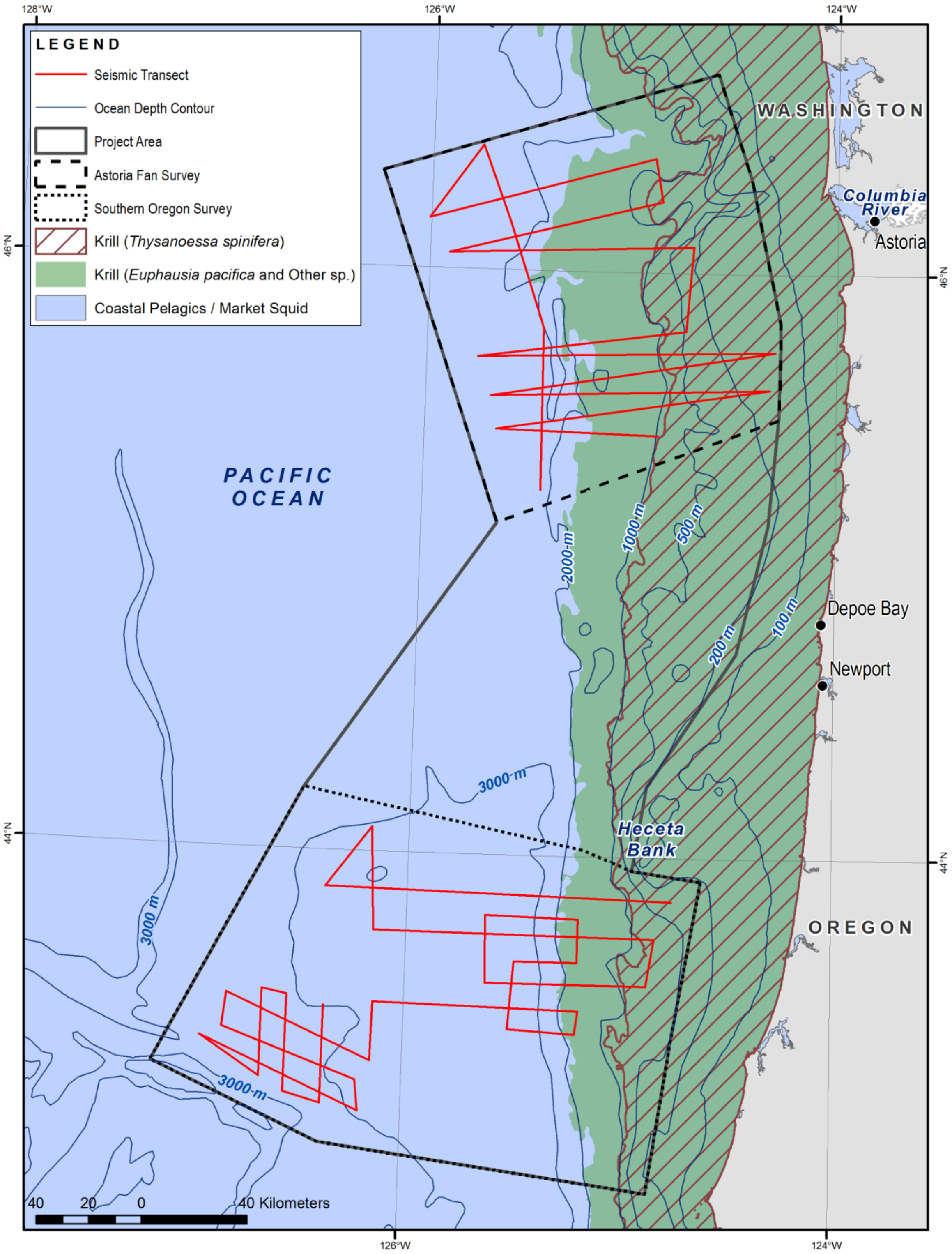


FIGURE 15. EFH for Coastal Pelagic species in Washington and Oregon. Sources: USGS 2016; NOAA 2017b; NOAA WCR 2017; OOI 2017b.

Pacific coast salmon EFH.—The FMP for Pacific coast salmon includes the coast-wide aggregate of natural and hatchery salmon species that is contacted by salmon fisheries in the EEZ off the coasts of Washington, Oregon, and California (PFMC 2016c). The PFMC manages the fisheries for coho, chinook, and pink (odd-numbered years) salmon and has defined EFH for these three species. Pacific coast salmon EFH includes marine areas within the EEZ, from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ, along with estuarine and all currently or historically occupied freshwater habitat within the internal waters of Washington, Oregon, Idaho, and California north of Point Conception (PFMC 2016c).

Highly migratory species EFH.—The FMP for the U.S. west coast fisheries for highly migratory species includes dorado/dolphinfish and important species of tunas (North Pacific albacore, yellowfin, bigeye, skipjack, and northern bluefin), billfish/swordfish (striped marlin and swordfish), and sharks (common thresher, shortfin mako/bonito and blue) which are harvested by West Coast fisheries (PFMC 2016d). EFH for each life stage of these species is described in the FMP (PFMC 2016d); collectively the highly migratory species EFH extends outwards from near shore (~10 m water depth) to the limit of the EEZ off of Washington, Oregon, and California (NOAA 2017b).

(3) Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPCs) are a subset of EFH that provide highly important ecological functions or are especially vulnerable to degradation. Rocky reefs are designated as HAPCS in the proposed Astoria Fan and Southern Oregon survey areas, and one area of interest HAPC is within the proposed project area between these two survey sites (Fig. 16; PFMC 2016a):

Rocky Reefs HAPC.—The rocky reefs HAPC includes waters, substrates, and other biogenic features associated with hard substrate (bedrock, boulders, cobble, gravel, etc.) to mean higher high water level. The HAPC occurs primarily in Oregon waters 200–2000 m deep. The rocky reefs HAPC in Washington are mostly scattered in <200 m depth, including in the northern portion of the Olympic Coast National Marine Sanctuary and northeastern portion of the Astoria Fan survey area. The majority of the Astoria Fan survey area and the eastern portion of the Southern Oregon survey area are located in the Rocky Reefs HAPC off Oregon (PFMC 2016a).

Daisy Bank/Nelson Island HAPC.—Daisy Bank area of interest HAPC is a highly unique geological feature that occurs in Federal waters due west of Newport, Oregon (44°38’N), and appears to play a unique and potentially rare ecological role for groundfish and large invertebrate sponge species. The bank supports more than 600,000 juvenile rockfish per km^2. Daisy Bank also appears to support more and larger lingcod and large sponges than other nearby banks (M. Hixon, pers. comm. 2004 *in* PFMC 2016a). The Daisy Bank/Nelson Island HAPC occurs within the proposed project area between the Astoria Fan and Southern Oregon survey sites.

Washington State waters HAPC.—The Washington State waters HAPC encompasses all waters and sea bottom in state waters shoreward from the 5.6 km boundary of the territorial sea shoreward to mean higher high water level. The HAPC encompasses a variety of habitats important to groundfish, including other HAPCs such as rocky reef habitat supporting juvenile rockfish (primarily north of 47.2°N). Sandy substrates within state waters (primarily south of 47.2°N) are important habitat for juvenile flatfish. A large proportion of this area is also contained within the Olympic Coast National Marine Sanctuary (PFMC 2016a). The Washington State waters HAPC is located ~20 km east of the proposed Astoria Fan survey area.

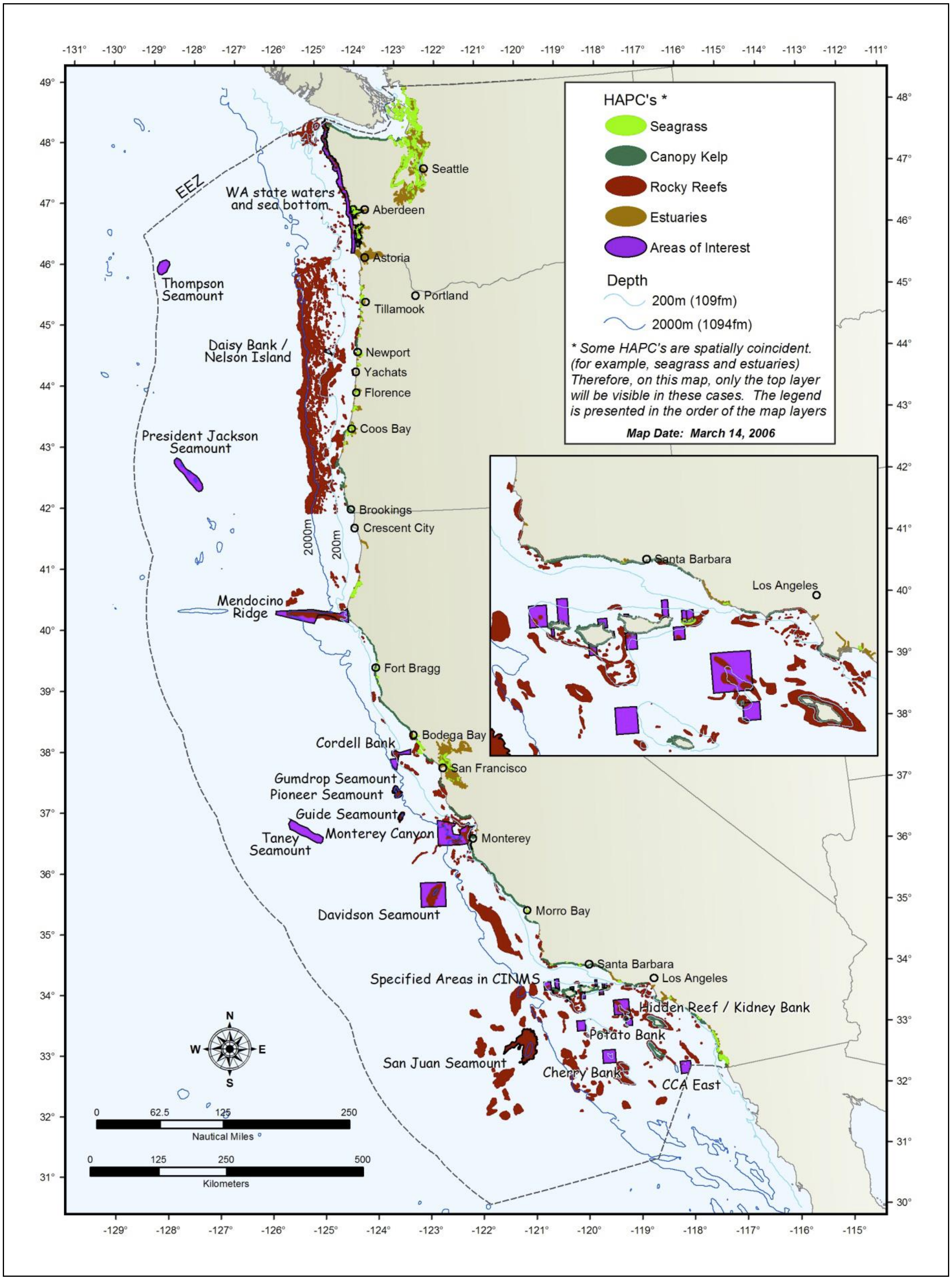


FIGURE 16. Groundfish HAPC in Washington, Oregon, and California. Source: PFMC (2016a).

Thomson and President Jackson Seamounts HAPC.—Seamounts have relatively high biodiversity and up to a third of species occurring on these features may be endemic (de Forges et al. 2000 *in* PFMC 2016a). Currents generated by seamounts retain rockfish larvae and zooplankton, a principal food source for rockfish (Genin et al. 1988, Mullineaux and Mills 1997, Haury et al. 2000, and Dower and Perry 2001 *in* PFMC 2016a). Deep-sea corals also occur on seamounts (Monterey Bay National Marine Sanctuary 2005 *in* PFMC 2016a). The northwestern extent of the proposed Astoria Fan survey area occurs ~180 km east of the Thomson Seamount area of interest HAPC. President Jackson Seamount area of interest HAPC is located ~90 km southwest of the proposed Southern Oregon survey area.

There are no HAPCs designated at this time for highly migratory species (PFMC 2016d).

(4) Critical Habitat

Critical habitat for the ESA-listed fish species that occurs near the proposed project area is listed in Table 7. Most of these are freshwater habitats which are located outside of the proposed project area. Critical habitat for the Southern DPS of North American green sturgeon occurs in marine waters near the proposed project area, but the survey was planned so it would not overlap with this habitat (see Fig. 1).

Critical habitat for green sturgeon includes freshwater and coastal bays, estuaries, and marine waters out to the ~109-m (60 fathom) contour off California, Oregon, Washington, and Alaska (NMFS 2009). The coastal portion of this critical habitat includes marine waters from Monterey Bay, California, north to Cape Flattery, Washington, to its U.S. boundary (NMFS 2009).

(5) Fisheries

The commercial Oregon and Washington fisheries include at least 134 species of fish, 24 species of crustaceans, 15 species of mollusks, and several other invertebrates (PFIN 2015; ODFW 2017a). The highest landings (in metric tons) are in July and August, followed by June and September in both states (NMFS 2015b). The most common gear type used in both states in 2015 was trawls (87% of the total catch in Washington; 52% of the total catch in Oregon). The next most common gear types in Washington were nets (15%), troll lines (12%) and pots and traps (11%), and in Oregon, troll lines (5%) and nets (4%) (NMFS 2015b). The total catch weight and value for commercial fisheries in Oregon in 2016 were 102,976 mt and $148.9 million, respectively (ODFW 2017a), and in Washington for 2015, 76,880 mt and $300.2 million, respectively (PFIN 2015).

Four commercial species accounted for 77% of the total landings value for Oregon during 2016, Pacific whiting (hake; 50%), pink shrimp (16%), Dungeness crab (7%) and northern anchovy (5%) (ODFW 2017a). The total landings values for each of these species in 2016 were $8.7 million, $25.1 million, $55.6 million, and $1.2 million, respectively (ODFW 2017a). For Washington, pink shrimp (25%), pacific whiting (19%), albacore tuna (10%), and Dungeness crab (9%) accounted for a combined 63% of the total landings value for Washington during 2015. The total landings values for each of these species in 2015 were $29.9 million, $2.6 million, $20 million, and $72.6 million, respectively (PFIN 2015).

Marine recreational fisheries on the U.S. west coast occur in both non-federal (shore to 5.6 km off the coast) and federal (5.6 km to the extent of the EEZ) waters, and include resident and non-resident anglers fishing from shore, private boats, and commercial passenger fishing vessels (NMFS 2016c). Species typically taken during recreational fisheries on the west coast include highly migratory species (albacore and other tunas, striped marlin, common thresher and shortfin mako sharks), salmon (Chinook, coho), steelhead, groundfish (rockfish, lingcod scorpionfish, greenling, flatfish and sharks), coastal pelagic species (Pacific sardine, northern anchovy, market squid, Pacific mackerel), various state-managed species (barracuda, bass, bonito, sturgeon, surfperches), and invertebrates (abalone, lobster, crab, clams, oysters) (NMFS 2013d). During 2013, 1.7 million anglers took 7.5 million saltwater fishing trips, supporting over $2.5 billion in sales (trip and durable goods-related) on the U.S. west coast (NMFS 2016c).

Recreational fisheries off Washington include marine salmon (Chinook, coho, chum, pink, sockeye and jacks), marine fish (bottomfish [e.g., rockfish, lingcod, sole, flounder], forage fish [e.g., herring, smelt], tunas and mackerels, and Pacific halibut), and shellfish (e.g., clams, oysters, shrimp, crab) (Kraig and Scalici 2017). The recreational fishing season varies by species and location, but overall run from May to October with peaks typically during mid-summer to early-fall (Kraig and Scalici 2017).

Recreational oceanic salmon fisheries off Oregon are open from March to October (location- and species-dependent); during 2016, there were 34,546 angler trips for this fishery (ODFW 2017b). Recreational groundfish taken off Oregon for which catch quotas are set include black rockfish, cabezon, canary rockfish, kelp, and rock greenlings, “minor nearshore rockfishes” (blue, China, copper grass and quillback), and yelloweye rockfish; these species are principally fished from late-spring to the fall, with peak catches typically during late-summer (ODFW 2016). Pacific halibut are also caught during both nearshore and offshore recreational fisheries off Oregon, with the season running from May to October, with peak catches during mid- to late-spring and late-summer/early-fall (ODFW 2017c).

IV. ENVIRONMENTAL CONSEQUENCES

Proposed Action

(1) Direct Effects on Marine Mammals and Sea Turtles and Their Significance

The material in this section includes a summary of the anticipated potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles given in the PEIS, and reference to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, and § 3.8.4.3, and Appendix E of the PEIS. Relevant background information on the hearing abilities of marine mammals and sea turtles can also be found in the PEIS.

This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic surveys scheduled to occur during September 2017, along with a description of the rationale for NSF’s estimates of the numbers of individuals exposed to receive sound levels ≥160 dB re 1 μPa_{rms}. Acoustic modeling for the proposed action was conducted by L-DEO, consistent with past EAs and determined to be acceptable by NMFS for use in the calculation of estimated Level B takes under the MMPA.

(a) Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al.

2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2015, 2016). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015.

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016). Although the possibility cannot be entirely excluded, it is unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter a survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

***Tolerance*.—**Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

***Masking*.—**Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2016; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Nieukirk et al. (2012) and Blackwell et al. (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (e.g., Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Sciacca et al. 2016). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. We are not aware of any information concerning masking of hearing in sea turtles.

Disturbance Reactions.—Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (NRC 2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean, 'in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations'.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013a). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016).

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m. More recent studies examining the behavioral responses of humpback whales to airguns have also been conducted off eastern Australia (Cato et al. 2011, 2012, 2013, 2016), although results are not yet available for all studies. Dunlop et al. (2015) reported that humpback whales responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3 (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Responses to ramp up and use of a 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c).

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis (Malme et al. 1985). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011), Atkinson et al. (2015), Houser et al. (2016), and Lyamin et al. (2016) also reported that sound could be a potential source of stress for marine mammals.

Bowhead whales show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 µPa; at SPLs <108 dB re 1 µPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $\mathrm{CSEL}_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 $\mu\mathrm{Pa}^2 \cdot \mathrm{s}$, decreased at $\mathrm{CSEL}_{10\text{-min}}$ >127 dB re 1 $\mu\mathrm{Pa}^2 \cdot \mathrm{s}$, and whales were nearly silent at $\mathrm{CSEL}_{10\text{-min}}$ >160 dB re 1 $\mu\mathrm{Pa}^2 \cdot \mathrm{s}$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) and in 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b). Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The 2001 seismic program, as well as a subsequent survey in 2010, involved a comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs of sound above about 163 dB re 1 $\mu\mathrm{Pa}_{\mathrm{rms}}$ (Johnson et al. 2007; Nowacek et al. 2012, 2013b). The lack of strong avoidance or other strong responses was presumably in part a result of the mitigation measures; effects probably would have been more significant without such intensive mitigation efforts. Gray whales in British Columbia exposed to seismic survey sound levels up to ~170 dB re 1 µPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year. In addition, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Toothed Whales

Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015; Monaco et al. 2016). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994 to 2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015).

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010), but foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009). Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994 to 2010 indicated that detection rates of beaked whales were significantly higher ($p<0.05$) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 µPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012c) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013a). The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans. NMFS is currently developing new guidance for predicting behavioural effects (Scholik-Schlomer 2015). As behavioural responses are not consistently associated with received levels, Gomez et al. (2016) recommended that a response/no response dichotomous approach be used when assessing behavioural reactions.

Pinnipeds

Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994 to 2010 showed that the detection rate for grey seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015). There were no significant differences in CPA distances of grey or harbor seals during seismic vs. non-seismic periods (Stone 2015). Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses; only mild behavioural responses were observed.

Sea Turtles

Several recent papers discuss the morphology of the turtle ear (e.g., Christensen-Dalsgaard et al. 2012; Willis et al. 2013) and the hearing ability of sea turtles (e.g., Martin et al. 2012; Piniak et al. 2012a,b; Lavender et al. 2014). The limited available data indicate that sea turtles will hear airgun sounds and sometimes exhibit localized avoidance (see PEIS, § 3.4.4.3). In additional, Nelms et al. (2016) suggest that sea turtles could be excluded from critical habitats during seismic surveys.

DeRuiter and Doukara (2012) observed that immediately following an airgun pulse, small numbers of basking loggerhead turtles (6 of 86 turtles observed) exhibited an apparent startle response (sudden raising of the head and splashing of flippers, occasionally accompanied by blowing bubbles from the beak and nostrils, followed by a short dive). Diving turtles (49 of 86 individuals) were observed at distances from the center of the airgun array ranging from 50 to 839 m. The estimated sound level at the median distance of 130 m was 191 dB re 1 μPa_{peak}. These observations were made during ~150 h of vessel-based monitoring from a seismic vessel operating an airgun array (13 airguns, 2440 in^3) off Algeria; there was no corresponding observation effort during periods when the airgun array was inactive (DeRuiter and Doukara 2012).

Based on available data, it is likely that sea turtles will exhibit behavioral changes and/or avoidance within an area of unknown size near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate would likely have the greatest impact; concentration areas are not known to occur within the proposed survey area. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of the year.

***Hearing Impairment and Other Physical Effects*.—**Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed by Southall et al. 2007; Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a, 2016; Ketten 2012; Supin et al. 2016).

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b;

Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 µPa^2 · s (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 µPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise.

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016)

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al. 2007). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012a, 2013b,c, 2014, 2015a) indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012a) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB (Kastelein et al. 2012a). Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 µPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa; no low-frequency TTS was observed.

Based on the best available information at the time, Southall et al. (2007) recommended a TTS threshold for exposure to single or multiple pulses of 183 dB re 1 $\mu Pa^2 \cdot s$ for all cetaceans and 173 dB re 1 $\mu Pa^2 \cdot s$ for pinnipeds in water. For the harbor porpoise, Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{\text{eq-fast}}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, according to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS. In addition, Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372*ff*; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

The new noise exposure criteria for marine mammals that were recently released by NMFS (2016a) account for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such airgun pulses, the thresholds use dual metrics of cumulative SEL (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including LF cetaceans (e.g., baleen whales), MF cetaceans (e.g., most delphinids), HF cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

Nowacek et al. (2013a) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale stranding along Ireland’s coast increased with seismic surveys operating offshore (McGeady et al. 2016). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding.

Since 1991, there have been 62 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2015c). In a hearing to examine the Bureau of Ocean Energy Management’s 2017-2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=110E5E8F-3A65-4BEC-9D25-5D843A0284D3), it was Dr. Knapp’s (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico.

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the deep water in the majority of the study area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Sea Turtles

There is substantial overlap in the frequencies that sea turtles detect versus the frequencies in airgun pulses. We are not aware of measurements of the absolute hearing thresholds of any sea turtle to waterborne sounds similar to airgun pulses. In the absence of relevant absolute threshold data, we cannot estimate how far away an airgun array might be audible. Moein et al. (1994) and Lenhardt (2002) reported TTS for loggerhead turtles exposed to many airgun pulses (see § 3.4.4 of the PEIS). This suggests that sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs (see Nelms et al. 2016). However, exposure duration during the proposed surveys would be much less than during the aforementioned studies. Also, recent monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound level diminishes rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

Although it is possible that exposure to airgun sounds could cause mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014), especially because sea turtles appear to be highly resistant to explosives (Ketten et al. 2005 *in* Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or >207 dB_{peak} for sounds from seismic airguns.

The PSOs stationed on the *Revelle* would watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

(b) Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed survey, but not during transits. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the anticipated potential effects (or lack thereof) of MBESs and SBPs on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel linking the operation of an MBES to a mass stranding of melon-headed whales (*Peponocephala electra*; Southall et al. 2013) off Madagascar. During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of an MBES. Leading scientific experts knowledgeable about MBES expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

Reference has also been made that two beaked whales stranded in the Gulf of California in 2002 were observed during a seismic survey in the region by the R/V *Ewing* (Malakoff 2002, Cox et al. 2006 *in* PEIS:3-136), which used a similar MBES system. As noted in the PEIS, however, "The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence" (Hogarth 2002, Yoder 2002 *in* PEIS:3-190).

Lurton (2016) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12-kHz), 240-dB source-level system like that used on the *Revelle*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioural response were 9 m and 70 m. For pinnipeds, "all ranges are multiplied by a factor of 4" (Lurton 2016:209).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including low-frequency active sonars (e.g., Miller et al. 2012; Sivle et al. 2012; Samarra and Miller 2016), mid-frequency active sonars (e.g., Tyack et al. 2011; Melcón et al. 2012; Miller et al. 2012, 2014; Sivle et al. 2012, 2015; DeRuiter et al. 2013a,b; Goldbogen et al. 2013; Antunes et al. 2014; Baird et al. 2014; Kastelein et al. 2012d, 2015a; Wensveen et al. 2015; Friedlaender et al. 2016; Isojunno et al. 2016; Samarra and Miller 2016), and high-frequency active sonars (Kastelein et al. 2015c,d). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

In the fall of 2006, an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment was carried out in the Gulf of Maine (Gong et al. 2014); the OAWRS emitted three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz (Risch et al. 2012). Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during OAWRS activities that were carried out ~200 km away; received levels in the sanctuary were 88–110 dB re 1 µPa. In contrast, Gong et al. (2014) reported no effect of the OAWRS signals on humpback whale vocalizations in the Gulf of Maine. Range to the source, ambient noise, and/or behavioral state may have differentially influenced the behavioral responses of humpbacks in the two areas (Risch et al. 2014).

Deng et al. (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by grey seals to echosounders with frequencies of 200 and 375 kHz. Short-finned pilot whales increased their heading variance in response to an EK60 echosounder with a resonant frequency of 38 kHz (Quick et al. 2016).

Despite the aforementioned information that has recently become available, this Final EA is in agreement with the assessment presented in § 3.4.7, 3.6.7, 3.7.7, and 3.8.7 of the PEIS that operation of MBESs and SBPs is not likely to impact marine mammals and is not expected to affect sea turtles, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal or sea turtle given the movement and speed of the vessel. Also, for sea turtles, the associated frequency ranges are above their known hearing range.

(c) Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals and/or sea turtles include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear.

Vessel noise from the *Revelle* could affect marine animals in the proposed survey areas. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbour porpoise (Dyndo et al. 2015). Increased levels of ship noise have been shown to affect foraging by porpoise (Teilmann et al. 2015).

Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Dunlop 2015; Erbe et al. 2015). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011, 2012, 2016a,b; Castellote et al. 2012; Melcón et al. 2012; Azzara et al. 2013; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Bittencourt et al. 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Tenessen and Parks 2016). Harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016). Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016).

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed survey area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald et al. 2013).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels (e.g., Anderwald et al. 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Pirotta et al. (2015) noted that the physical presence of vessels, not just ship noise, disturbed the foraging activity of bottlenose dolphins. Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

The PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals or sea turtles, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals or sea turtles (e.g., Redfern et al. 2013). Information on vessel strikes is reviewed in § 3.4.4.4, § 3.6.4.4, and § 3.8.4.4 of the PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels (McKenna et al. 2015). The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals or sea turtles exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. There has been no history of marine mammal vessel strikes with the R/V *Revelle,* the R/V *Langseth*, or its predecessor, R/V *Maurice Ewing*, over the last two decades.

Entanglement of sea turtles in seismic gear is also a concern (Nelms et al. 2016). There have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore from West Africa (Weir 2007), and in April 2011, a dead olive ridley turtle was found in a deflector foil of the seismic gear on the R/V *Langseth* during equipment recovery at the conclusion of a survey off Costa Rica, where sea turtles were numerous. Such incidents are not possible with the pair of GI guns that would be towed by the *Revelle*. Also, towing the hydrophone streamer or other equipment during the proposed survey is not expected to significantly interfere with sea turtle movements, including migration, because sea turtles are not expected to be abundant in the survey areas.

(2) Mitigation Measures

Several mitigation measures are built into the proposed seismic surveys as an integral part of the planned activities. These measures include the following: ramp ups; typically two, however a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers for 30 min before and during ramp ups during the day; and shut downs when mammals or turtles are detected in or about to enter designated EZ. These mitigation measures are described in § 2.4.4.1 of the

PEIS and summarized earlier in this document, in § II(3). Additional mitigation measures per the IHA and ITS would be followed, including monitoring a 200-m buffer zone and shut downs for non-traveling aggregations of large whales (i.e., baleen and/or sperm whales), large whale with a calf, and killer whales, and North Pacific right whales observed at any distance. Per the IHA and ITS, seismic operations would not need to cease for bowriding small delphinids. In addition, the acoustic source would be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated exclusion zones. The fact that the GI airguns, as a result of their design, direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure.

Previous and subsequent analysis of the potential impacts takes account of these planned mitigation measures. It would not be meaningful to analyze the effects of the planned activities without mitigation, as the mitigation (and associated monitoring) measures are a basic part of the activities, and would be implemented under the Proposed Action or Alternative Action.

(3) Potential Numbers of Marine Mammals Exposed to Various Received Sound Levels

All takes would be anticipated to be Level B "takes by harassment" as described in § I, involving temporary changes in behavior. As required by NMFS, Level A takes have been requested; given the very small exclusion zones and the proposed mitigation measures to be applied, injurious takes would not be expected. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious Level A "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to Level A and Level B sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the seismic surveys in the northeastern Pacific Ocean off the coasts of Oregon and Washington. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

(a) Basis for Estimating Exposure

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, i.e., the PTS thresholds (Level A), as animals are more likely to move away when received levels are higher. Likewise, they are less likely to approach within the PTS threshold radii than they are to approach within the considerably larger ≥160 dB (Level B) radius.

Extensive systematic aircraft- and ship-based surveys have been conducted for marine mammals in offshore waters of Oregon and Washington (e.g., Bonnell et al. 1992; Green et al. 1992, 1993; Barlow 1997, 2003; Barlow and Taylor 2001; Calambokidis and Barlow 2004; Forney 2007; Barlow and Forney 2007; Barlow 2010, 2016). The most comprehensive and recent density data available for cetacean species in slope and offshore waters of Oregon and Washington are from the 1991, 1993, 1996, 2001, 2005, 2008, and 2014 NMFS/SWFSC (Southwest Fisheries Science Centre) ship surveys as synthesized by Barlow (2016). The surveys were conducted up to ~556 km from shore from June or August to November or December.

Systematic, offshore, at-sea survey data for pinnipeds are more limited. The most comprehensive studies are reported by Bonnell et al. (1992) based on systematic aerial surveys conducted in 1989–1990. USN (2010) calculated density estimates for pinnipeds off Washington at different times of the year using information on breeding and migration, population estimates from shore counts, and areas used by the different species while at sea.

Oceanographic conditions, including occasional El Niño and La Niña events, influence the distribution and numbers of marine mammals present in the North Pacific Ocean, including waters off Oregon and Washington, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species (Forney and Barlow 1998; Buchanan et al. 2001; Ferrero et al. 2002; Philbrick et al. 2003; Escorza-Treviño 2009). Thus, cetacean densities used here were derived from the pooled results of the 1991–2014 surveys off Oregon and Washington and taken directly from the report (Barlow 2016) with the exception of the gray whale and harbor porpoise. (Abundance and density were not estimated for gray whales or harbor porpoises in the NMFS/SWFSC surveys because their inshore habitats were inadequately covered in those studies.) Gray whale density is based on the USN (2010) method and used the abundance of gray whales that remain between Oregon and BC in summer (updated to abundance calculated by Calambokidis et al. 2014) and the area out to 43 km from shore. Harbor porpoise densities based on aerial line-transect surveys during 2007–2012 for the Northern Oregon/Washington Coast stock were used (Forney et al. 2014).

Table 8 gives the densities for each species of cetacean reported off Oregon and Washington. The densities from NMFS/SWFSC vessel-based surveys have been corrected by the authors for both trackline detection probability and availability bias. Trackline detection probability bias is associated with diminishing sightability with increasing lateral distance from the trackline [$f(0)$]. Availability bias refers to the fact that there is less-than-100% probability of sighting an animal that is present along the survey trackline, and it is measured by $g(0)$.

Table 8 also includes mean density information for the five pinniped species that occur off Oregon and Washington. Four of the five species' densities were calculated using the methods in USN (2010) with updated population sizes based on Carretta et al. (2016a) and Muto et al. (2016), when appropriate. For the harbor seal, densities were calculated using the population estimate for the Oregon/Washington Coastal stock and the range for that stock given in Carretta et al. (2013).

There is some uncertainty about the representativeness of the estimated density data and the assumptions used in their calculations. Oceanographic conditions, including occasional El Niño and La Niña events, influence the distribution and numbers of marine mammals present in the North Pacific Ocean, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species. Thus, for some species, the densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys. However, the approach used here is based on the best available data. The calculated exposures that are based on these densities are best estimates for the proposed surveys for any time of the year and are based on data collected during the same time of the year (late summer to early fall) as the proposed surveys.

The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all cetaceans and pinnipeds. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Table 9 shows the density estimates calculated as described above and the estimates of the number of marine

TABLE 8. Densities of marine mammals off Oregon and Washington. Cetacean densities are from Barlow (2016) and are based on ship transect surveys conducted up to 556 km offshore in 1991, 1993, 1996, 2001, 2005, 2007, and 2014. Pinniped densities are from shore counts and calculations in USN (2010). Cetacean densities from Barlow (2016) are corrected for *f*(0) and *g*(0). Species listed as "Endangered" under the ESA are in italics.

Species	Density (#/1000 km^2)	Mean group size	Source
Mysticetes			
North Pacific right whale	*0*	–	–
Gray whale	2.6	–	USN (2010)[1]
Humpback whale	*2.1*	*2*	*Barlow (2016)*
Minke whale	1.3	1	Barlow (2016)
Sei whale	*0.4*	*2*	*Barlow (2016)*
Fin whale	*4.2*	*2*	*Barlow (2016)*
Blue whale	*0.3*	*1*	*Barlow (2016)*
Odontocetes			
Sperm whale	*0.9*	*6*	*Barlow (2016)*
Pygmy/dwarf sperm whale	1.6	1	Barlow (2016)
Cuvier’s beaked whale	2.8	2	Barlow (2016)
Baird's beaked whale	10.7	8	Barlow (2016)
Mesoplodont (unidentified) [2]	1.2	2	Barlow (2016)
Bottlenose dolphin	0	13	Barlow (2016)
Striped dolphin	7.7	109	Barlow (2016)
Short-beaked common dolphin	69.2	286	Barlow (2016)
Pacific white-sided dolphin	40.7	62	Barlow (2016)
Northern right-whale dolphin	46.4	63	Barlow (2016)
Risso’s dolphin	11.8	28	Barlow (2016)
False killer whale	0	5[3]	–
Killer whale	*0.9*	*8*	*Barlow (2016)*
Short-finned pilot whale	0.2	18	Barlow (2016)
Harbor porpoise	467.0	2	Forney et al. (2014)
Dall's porpoise	54.4	4	Barlow (2016)
Pinnipeds			
Northern fur seal	83.4	–	USN (2010)[4]
California sea lion	283.3	–	USN (2010)[5]
Steller sea lion	15.0	–	USN (2010)[6]
Harbor seal	292.3	–	See text
Northern elephant seal	83.1	–	USN (2010)[7]

Note: – mean group size not provided in source and species not included in Barlow (2016).

[1] Population size in USN (2010) was updated based on Calambokidis et al. (2014).

[2] Includes Blainville's, Stejneger's, and Hubb's beaked whales.

[3] Mean group size from Mobley et al. (2000).

[4] Population size in USN (2010) was updated based on Carretta et al. (2016a) and Muto et al. (2016).

[5] Population size in USN (2010) was updated based on Carretta et al. (2016a).

[6] Population size in USN (2010) was updated based on Muto et al. (2016).

[7] Population size in USN (2010) was updated based on Carretta et al. (2016a) with the number of adult males proportionally adjusted.

TABLE 9. Densities and estimates of the possible numbers of individual marine mammals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed seismic surveys in the northeastern Pacific in September 2017. The proposed sound source consists of a pair of 45-in^3 GI airguns with a total discharge volume of ~90 in^3. Species in italics are listed under the ESA as *endangered*.

Species	Estimated Density[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2]		Level A + Level B as % of Pop.[5]	Requested Take Authorization[6]
		Level A[3]	Level B[4]		
LF Cetaceans					
North Pacific right whale	*0*	*0*	*0*	*0%*	*0*
Gray whale	2.6	0	4	0.02%	212
Humpback whale	*2.1*	*0*	*3*	*0.01%*	*218*
Minke whale	1.3	0	2	0.02%	90
Sei whale	*0.4*	*0*	*1*	*0.01%*	*126*
Fin whale	*4.2*	*0*	*6*	*0.07%*	*85*
Blue whale	*0.3*	*0*	*1*	*0.09%*	*11*
MF Cetaceans					
Sperm whale	*0.9*	*0*	*2*	*0.01%*	*240*
Cuvier's beaked whale	2.8	0	4	0.12%	34
Baird's beaked whale	10.7	0	14	0.21%	66
Mesoplodont (unidentified) [7]	1.2	0	2	0.18%	11
Bottlenose dolphin	0	0	0	0%	19
Striped dolphin	7.7	0	10	0.03%	292
Short-beaked common dolphin	69.2	0	89	0.01%	**286**[8]
Pacific white-sided dolphin	40.7	0	52	0.20%	266
Northern right-whale dolphin	46.4	0	60	0.11%	546
Risso's dolphin	11.8	0	16	0.25%	63
False killer whale	0	0	0	N.A.	**5**
Killer whale[9]	*0.9*	*0*	*2*	*0.44%*	***8***[10]
Short-finned pilot whale	0.2	0	1	0.12%	**18**[11]
HF Cetaceans					
Pygmy/dwarf sperm whale	1.6	0	2	0.07%	41
Harbor porpoise	467.0	15	582	1.04%	597
Dall's porpoise	54.4	2	68	0.27%	258
Otariids					
Northern fur seal	83.4	0	107	0.02%	6626
California sea lion	283.3	0	362	0.12%	2968
Steller sea lion	15.0	0	20	0.03%	744
Phocids					
Harbor seal	292.3	3	371	1.51%	374
Northern elephant seal	83.1	1	106	0.06%	1790

[1] See text for density sources.

[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area on one selected day multiplied by the number of survey days (5), times 1.25 (see text).

[3] Level A takes if there were no mitigation measures. Ensonified areas are based on PTS thresholds, with Peak SPL values (for all hearing groups except LF cetaceans) based on distances with a high-pass filter applied, which were later corrected by NMFS by using distances without applying a high-pass filter.

[4] Level B takes, based on the 160-dB criterion (daily ensonified area = 204.2 km^2), excluding exposures to sound levels equivalent to PTS thresholds.

[5] Level A and B takes (used by NMFS as proxy for number of individuals exposed), expressed as % of population; N.A. = population size not available (see Table 6).

[6] Requested takes (Level A+Level B) increased to 1% of population or mean group size (in bold) from Barlow (2016).

[7] Includes Blainville's, Stejneger's, and/or Hubb's beaked whales (Barlow 2016). Given their expected occurrence in the study area (Table 5), all calculated Level B takes of *Mesoplodon* sp. are likely to be Stejneger's beaked whale. Nonetheless, take authorization is requested for 2 Blainville's, 2 Hubb's, and 7 Stejneger's beaked whales.

[8] Mean group size (0.03% of population instead of 1%), as common dolphins are unlikely to be encountered during the surveys.

[9] Includes resident, transient, and offshore stocks.

[10] Mean group size (1.8% of population).

[11] Mean group size (2.2% of population).

mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic surveys in the northeastern Pacific Ocean off the coasts of Oregon and Washington if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Table 9. Except for two species (right whale and short-beaked common dolphin), we have included a *Requested Take Authorization* for at least 1% of the population or for the mean group size, whichever is largest, as previous surveys in the area (see Cumulative Effects, below) have encountered higher numbers of individuals compared to expected densities for some species. Mean group sizes are from Barlow (2016) for waters off Oregon and Washington, except for the mean group size of false killer whale, which is from Hawaiian waters (Mobley et al. 2000). No takes of right whales are anticipated or requested.

It should be noted that the following estimates of exposures assume that the proposed surveys would be completed; in fact, the calculated takes ***have been increased by 25%*** (see below). Thus, the following estimates of the numbers of marine mammals potentially exposed to Level B sounds ≥160 dB re 1 μPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and §4.1.1.1 of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2013e). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013e).

(b) Potential Number of Marine Mammals Exposed *to ≥160 dB*

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions have been estimated using a method required by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day; the 200-km line(s) selected had a proportion of depth intervals (100–1000 m and >1000 m) with associated radii that was roughly similar to that of the entire survey. The area expected to be ensonified on that day was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by "drawing" the applicable 160-dB and PTS threshold buffers (see Tables 1 and 2) around each seismic line. The ensonified areas were then multiplied by the number of survey days (5 days) increased by 25%; this is equivalent to adding an additional 25% to the proposed line km for a total of ~1250 km. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the *Revelle* approaches.

Per NMFS requirement, estimates of the numbers of cetaceans and pinnipeds that could be exposed to seismic sounds with received levels equal to Level A thresholds for various hearing groups (see Tables 2 and 4), if there were no mitigation measures (shut downs when PSOs observed animals approaching or inside the EZs), are also given in Table 9. As noted earlier, Level A takes for various hearing groups, except LF cetaceans, are based on distances to the Peak SPL thresholds with a high-pass filter applied. However, NMFS subsequently concluded that it was more appropriate to use the distances (radii) to the thresholds without applying a high-pass filter; revised takes estimates are shown in Appendix A. Level A takes are likely overestimates because the predicted exclusion zones are extremely small, and mitigation measures would further reduce the chances of, if not eliminate, any such takes. Level A takes are considered highly unlikely. Because Level B takes shown in Table 9 are based on the 160-dB criterion minus the PTS thresholds, Level B takes were also corrected by NMFS (Appendix A).

Based on the original analysis, the estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 µPa$_{\text{rms}}$ in the survey area is 939 (Table 9). That total includes 15 cetaceans listed under the ESA: 6 fin whales, 3 humpbacks, 2 sperm whales, 2 killer whales, 1 sei whale, and 1 blue whale, representing 0.07%, 0.01, 0.01%, 0.44%, 0.01%, and 0.09% of their regional populations, respectively. In addition, 20 beaked whales could be exposed. Most (71%) of the cetaceans potentially exposed would be HF cetaceans, with estimates of 597 harbor porpoises and 70 Dall's porpoises exposed to ≥160 dB re 1 µPa$_{\text{rms}}$ (0.27–1.04% of the regional populations); however, the number of harbor porpoises is an overestimate, as most are expected to occur in nearshore waters, away from the majority of the proposed activities. For delphinids, all estimated takes are <0.5% of their regional populations. The estimate of the number of pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 µPa$_{\text{rms}}$ is 489 otariids and 481 phocids. Although the highest percentage of a population expected to be taken is for harbor seals (1.5% of the population), this number is an overestimate as this species is unlikely to occur in deeper waters of the proposed project area, where most seismic activities are planned.

(4) Conclusions for Marine Mammals and Sea Turtles

The proposed seismic project would involve towing a very small source, a pair of 45-in^3 GI airguns that introduce pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

(a) Cetaceans

In § 3.6.7, 3.7.7, and 3.8.7, the PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some cetaceans and pinnipeds in the BC QAA and S California DAA, that Level A effects were highly unlikely, and that operations were unlikely to adversely affect ESA-listed species. NMFS requires the calculation and request of potential Level A takes for the Proposed Action (following a different methodology than used in the PEIS and most previous analyses for NSF-funded seismic surveys). For three past NSF-funded seismic surveys, NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (NMFS 2015d, 2016d,e).

In this Final EA, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are very low percentages of the regional population sizes (Table 9). Based on experience working in the area and variability of the environmental conditions of the project area, we believe the calculated takes for many of the species may be too low. As a result, we have increased the requested takes to 1% of the regional population sizes, except in a few instances where noted otherwise.

The estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds. The reasons for that conclusion are outlined above. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on marine mammals would be anticipated from the proposed activities.

In decades of seismic surveys carried out by SIO and other vessels in the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The 160-dB zone, which is based on predicted sound levels, is thought to be conservative; thus, not all animals detected within this zone would be expected to have been exposed to actual sound levels >160 dB.

For the proposed survey, NMFS issued a Final Environmental Assessment and a FONSI (Appendix A). NMFS also issued an IHA on 22 September 2017 (Appendix B); therefore, the proposed activity meets the criteria that the proposed activity "must not cause serious physical injury or death of marine mammals, must have negligible impacts on the species and stocks, must "take" no more than small numbers of those species or stocks, and must not have an unmitigable adverse impact on the availability of the species or stocks for legitimate subsistence uses." In the Biological Opinion dated 22 September 2017 (Appendix C), NMFS determined that the level of incidental take was not likely to jeopardize the continued existence of any listed species or result in the destruction of or adverse modification to critical habitat. The issuance of the Final Environmental Assessment, FONSI, IHA, and Biological Opinion by NMFS on 22 September 2017 further verifies that significant impacts would not be expected from the proposed activity.

(b) Sea Turtles

In § 3.4.7, the PEIS concluded that with implementation of the proposed monitoring and mitigation measures, no significant impacts of airgun operations are likely to sea turtle populations in any of the analysis areas, and that any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. Only one species of sea turtle—the leatherback—is expected to be encountered in the proposed project area. Only foraging or migrating individuals would occur. Given the proposed activities, no significant impacts on sea turtles would be anticipated. In decades of seismic surveys carried out by SIO and other vessels in the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related turtle injuries or mortality.

Although NSF did not estimate, and has not historically estimated, take for sea turtles, the Biological Opinion and ITS noted that takes would be expected at exposures to levels 175 dB re 1 μPa_{rms}

and above, but the number of exposures could not be quantified because of a lack of information on turtle densities in the area (Appendix C). NSF and L-DEO would adhere to the requirements of the ITS and the IHA and associated take levels issued. In their September 2017 Final Environmental Assessment, FONSI, and Biological Opinion, NMFS determined that the level of incidental take was not likely to jeopardize the continued existence of any listed species or result in the destruction of or adverse modification to critical habitat**.** The Biological Opinion further verified that significant impacts would not be expected from the proposed activity.

(5) Direct Effects on Invertebrates, Fish, Fisheries, and EFH and Their Significance

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. Relevant new studies on the effects of sound on marine invertebrates, fish, and fisheries that have been published since the release of the PEIS are summarized below. Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2015; Carroll et al. 2016).

(a) Effects of Sound on Marine Invertebrates

Noise effects on marine invertebrates are varied, ranging from no overt reactions to behavioral/physiological responses, injuries, or mortalities (Aguilar de Soto 2016; Carroll et al. 2016). Fewtrell and McCauley (2012) exposed captive squid (*Sepioteuthis australis*) to pulses from a single airgun; the received sound levels ranged from 120 to 184 dB re 1 dB re 1 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses were seen at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$; the squid were seen to discharge ink or change their swimming pattern or vertical position in the water column. Solé et al. (2013) exposed four caged cephalopod species to low-frequency (50–400 Hz) sinusoidal wave sweeps (with a 1-s sweep period for 2 h) with received levels of 157 ± 5 dB re 1 µPa, and peak levels up to 175 dB re 1 µPa. Besides exhibiting startle responses, all four species examined received damage to the statocyst, which is the organ responsible for equilibrium and movement. The animals showed stressed behavior, decreased activity, and loss of muscle tone.

When New Zealand scallop (*Pecten novaezelandiae*) larvae were exposed to recorded seismic pulses, significant developmental delays were reported, and 46% of the larvae exhibited body abnormalities; it was suggested that the malformations could be attributable to cumulative exposure (Aguilar de Soto et al. 2013). Their experiment used larvae enclosed in 60-mL flasks suspended in a 2-m diameter by 1.3-m water depth tank and exposed to a playback of seismic sound at a distance of 5–10 cm. Day et al. (2016) exposed egg-bearing female spiny lobsters (*Jasus edwardsi*) to three different air gun configurations in the field: 45 in^3, 150 in^3 (low pressure), and 150 in^3 (high pressure), each with corresponding maximum peak-to-peak source levels of 209, 210, and 212 dB re 1 µPa; and maximum cumulative SEL source levels of 192, 193, and 199 dB re 1 $\mu Pa^2 \cdot s$. Embryonic development of spiny lobster was assessed through the number, morphology, energy content, and competency of hatched larvae. It was determined that none of these variables were significantly different for the exposed larvae when compared to the control larvae. Other studies conducted in the field have shown no effects on Dungeness crab larvae or snow crab embryos to seismic sounds (Pearson et al. 1994; DFO 2004).

Celi et al. (2013) exposed captive red swamp crayfish (*Procambarus clarkia*) to linear sweeps with a frequency range of 0.1–25 kHz and a peak amplitude of 148 dB re 1 μPa_{rms} at 12 kHz for 30 min. They found that the noise exposure caused changes in the haemato-immunological parameters (indicating stress) and reduced agonistic behaviors. Wale et al. (2013a,b) showed increased oxygen consumption and effects on feeding and righting behaviour of shore crabs when exposed to ship sound playbacks.

Payne et al. (2015) undertook two pilot studies which (i) examined the effects of a seismic air gun recording in the laboratory on lobster (*Homerus americanus*) mortality, gross pathology, histopathology, serum biochemistry, and feeding; and (ii) examined prolonged or delayed effects of seismic air gun pulses in the laboratory on lobster mortality, gross pathology, histopathology, and serum biochemistry. For experiment (i), lobsters were exposed to peak-to-peak and root-mean-squared received sound levels of 180 dB re 1 µPa and 171 dB re 1 μPa_{rms} respectively. Overall there was no mortality, loss of appendages, or other signs of gross pathology observed in exposed lobster. No differences were observed in haemolymph, feeding, ovary histopathology, or glycogen accumulation in the hepatopancreas. The only observed differences were greater degrees of tubular vacuolation and tubular dilation in the hepatopancreas of the exposed lobsters. For experiment (ii), lobsters were exposed to 20 air gun shots per day for five successive days in a laboratory setting. The peak-to-peak and root-mean-squared received sound levels ranged from ~176 to 200 dB re 1 µPa and 148 to 172 dB re 1 μPa_{rms} respectively. The lobsters were returned to their aquaria and examined after six months. No differences in mortality, gross pathology, loss of appendages, hepatopancreas/ovary histopathology or glycogen accumulation in the hepatopancreas were observed between exposed and control lobsters. The only observed difference was a slight statistically significant difference for calcium-protein concentration in the haemolymph, with lobsters in the exposed group having a lower concentration than the control group.

Leite et al. (2016) reported observing a dead giant squid (*Architeuthis dux*) while undertaking marine mammal observation work aboard a seismic vessel conducting a seismic survey in offshore Brazil. The seismic vessel was operating 48-airgun array with a total volume of 5085 in^3. As no further information on the squid could be obtained, it is unknown whether the airgun sounds played a factor in the death of the squid.

(b) Effects of Sound on Fish

Potential impacts of exposure to airgun sound on marine fishes have been reviewed by Popper (2009), Popper and Hastings (2009a,b), and Fay and Popper (2012); they include pathological, physiological, and behavioral effects. Radford et al. (2014) suggested that masking of key environmental sounds or social signals could also be a potential negative effect from sound. Popper et al. (2014) presented guidelines for seismic sound level thresholds related to potential effects on fish. The effect types discussed include mortality, mortal injury, recoverable injury, temporary threshold shift, masking, and behavioral effects. Seismic sound level thresholds were discussed in relation to fish without swim bladders, fish with swim bladders, and fish eggs and larvae.

Bui et al. (2013) examined the behavioral responses of Atlantic salmon (*Salmo salar* L.) to light, sound, and surface disturbance events. They reported that the fish showed short-term avoidance responses to the three stimuli. Salmon that were exposed to 12 Hz sounds and/or surface disturbances increased their swimming speeds.

Peña et al. (2013) used an omnidirectional fisheries sonar to determine the effects of a 3-D seismic survey off Vesterålen, northern Norway, on feeding herring (*Clupea harengus*). They reported that herring schools did not react to the seismic survey; no significant changes were detected in swimming speed, swim direction, or school size when the drifting seismic vessel approached the fish from a distance of 27 km to 2 km over a 6-h period. Peña et al. (2013) attributed the lack of response to strong motivation for feeding, the slow approach of the seismic vessel, and an increased tolerance to airgun sounds.

Miller and Cripps (2013) used underwater visual census to examine the effect of a seismic survey on a shallow-water coral reef fish community in Australia. The census took place at six sites on the reef before and after the survey. When the census data collected during the seismic program were combined with historical data, the analyses showed that the seismic survey had no significant effect on the overall abundance or species richness of reef fish. This was in part attributed to the design of the seismic survey (e.g., ≥400 m buffer zone around reef), which reduced the impacts of seismic sounds on the fish communities by exposing them to relatively low SELs (<187 dB re 1 μPa^2 · s). Fewtrell and McCauley (2012) exposed pink snapper (*Pagrus auratus*) and trevally (*Pseudocaranx dentex*) to pulses from a single airgun; the received sound levels ranged from 120 to 184 dB re 1 dB re 1 μPa^2 · s SEL. Increases in alarm responses were seen in the fish at SELs >147–151 dB re 1 μPa^2 · s; the fish swam faster and formed more cohesive groups in response to the airgun sounds.

Hastings and Miksis-Olds (2012) measured the hearing sensitivity of caged reef fish following exposure to a seismic survey in Australia. When the auditory evoked potentials (AEP) were examined for fish that had been in cages as close as 45 m from the pass of the seismic vessel and at water depth of 5 m, there was no evidence of TTS in any of the fish examined, even though the cumulative SELs had reached 190 dB re 1 μPa^2 · s.

Popper et al. (2016) conducted a study that examined the effects of exposure to seismic airgun sound on caged pallid sturgeon (*Scaphirhynchus albus*) and paddlefish (*Polyodon spathula*); the maximum received peak SPL in this study was 224 dB re 1 μPa. Results of the study indicated no mortality, either during or seven days after exposure, and no statistical differences in effects on body tissues between exposed and control fish.

Andrews et al. (2014) conducted functional genomic studies on the inner ear of Atlantic salmon (*Salmo salar*) that had been exposed to seismic airgun sound. The airguns had a maximum SPL of ~145 dB re 1 μPa^2/Hz and the fish were exposed to 50 discharges per trial. The results provided evidence that fish exposed to seismic sound either increased or decreased their expressions of different genes, demonstrating that seismic sound can affect fish on a genetic level.

Sierra-Flores (2015) examined sound as a short-term stressor in Atlantic cod (*Gadus morhua*) using cortisol as a biomarker. An underwater loudspeaker emitted SPLs ranging from 104 to 110 dB re 1 μPa$_{rms}$. Plasma cortisol levels of fish increased rapidly with noise exposure, returning to baseline levels 20-40 min post-exposure. A second experiment examined the effects of long-term noise exposure on Atlantic cod spawning performance. Tanks were stocked with male and female cod and exposed daily to six noise events, each lasting one hour. The noise exposure had a total SPL of 133 dB re 1 μPa. Cod eggs were collected daily and measured for egg quality parameters as well as egg cortisol content. Total egg volume, floating fraction, egg diameter and egg weight did not appear to be negatively affected by noise exposure. However fertilization rate and viable egg productivity were reduced by 40% and 50%, respectively, compared with the control group Mean egg cortisol content was found to be 34% greater in the exposed group as compared to the control group. Elevated cortisol levels inhibit reproductive physiology for males and can result in a greater frequency of larval deformities for spawning females.

(c) Effects of Sound on Fisheries

Handegard et al. (2013) examined different exposure metrics to explain the disturbance of seismic surveys on fish. They applied metrics to two experiments in Norwegian waters, during which fish distribution and fisheries were affected by airguns. Even though the disturbance for one experiment was greater, the other appeared to have the stronger SEL, based on a relatively complex propagation model.

Handegard et al. (2013) recommended that simple sound propagation models should be avoided and that the use of sound energy metrics like SEL to interpret disturbance effects should be done with caution. In this case, the simplest model (exposures per area) best explained the disturbance effect.

Hovem et al. (2012) used a model to predict the effects of airgun sounds on fish populations. Modeled SELs were compared with empirical data and were then compared with startle response levels for cod. This work suggested that in the future, particular acoustic-biological models could be useful in designing and planning seismic surveys to minimize disturbance to fishing. Their preliminary analyses indicated that seismic surveys should occur at a distance of 5–10 km from fishing areas, in order to minimize potential effects on fishing.

In their introduction, Løkkeborg et al. (2012) described three studies in the 1990s that showed effects on fisheries. Results of a study off Norway in 2009 indicated that fishes reacted to airgun sound based on observed changes in catch rates during seismic shooting; gillnet catches increased during the seismic shooting, likely a result of increased movement of exposed fish, whereas longline catches decreased overall (Løkkeborg et al. 2012).

Streever et al. (2016) completed a Before-After/Control-Impact (BACI) study in the nearshore waters of Prudhoe Bay, Alaska in 2014 which compared fish catch rates during times with and without seismic activity. The air gun arrays used in the geophysical survey had sound pressure levels of 237 dB re $1\mu Pa_{0\text{-}p}$, 243 dB re $1\mu Pa_{p\text{-}p}$, and 218 dB re $1\mu Pa_{rms}$. Received SPL_{max} ranged from 107 to 144 dB re 1 µPa, and received SEL_{cum} ranged from 111 to 141 dB re $1\mu Pa^2$-s for air gun pulses measured by sound recorders at four fyke net locations. They determined that fyke nets closest to air gun activities showed decreases in catch per unit effort (CPUE) while nets further away from the air gun source showed increases in CPUE.

Paxton et al. (2017) examined the effects of seismic sounds on the distribution and behavior of fish on a temperate reef during a seismic survey conducted in the Atlantic Ocean on the inner continental shelf of North Carolina. Hydrophones were set up near the seismic vessel path to measure SPLs, and a video camera was set up to observe fish abundances and behaviors. Received SPLs were estimated at ~202 to 230 dB re 1 µPa. Overall abundance of fish was lower when undergoing seismic activity as opposed to days when no seismic occurred. Only one fish was observed to exhibit a startle response to the airgun shots. The authors claim that although the study was based on limited data, it contributes evidence that normal fish use of reef ecosystems is reduced when they are impacted by seismic sounds.

(d) Conclusions for Invertebrates, Fish, and Fisheries

This newly available information does not affect the outcome of the effects assessment as presented in the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations. The PEIS also concluded that seismic surveys could cause temporary, localized reduced fish catch to some species, but that effects on commercial and recreation fisheries would not be significant.

Interactions between the proposed survey and fishing operations in the proposed survey areas are expected to be limited. Two possible conflicts in general are the *Revelle*'s streamer entangling with fishing gear and the temporary displacement of fishers from the proposed survey areas. Fishing activities could occur within the proposed survey areas; however, a safe distance would need to be kept from the *Revelle* and the towed seismic equipment. In this instance, the towed seismic equipment is relatively short, so this distance would be relatively small. Conflicts would be avoided through communication with the fishing community during the survey.

Given the proposed activity, no significant impacts on marine invertebrates, marine fish, and their fisheries would be expected. In decades of seismic surveys carried out by SIO and other vessels in the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality. NSF consulted with NMFS regarding EFH; NMFS concluded the EFH consultation noting that while the proposed action would result in some level of adverse effects on EFH, the proposed action would not result in long-term significant adverse effects to EFH in the action area (Appendix D). The issuance of the Final Environmental Assessment, FONSI, IHA, Biological Opinion and letter regarding EFH by NMFS in September 2017 further verifies that significant impacts would not be expected from the proposed activity.

(6) Direct Effects on Seabirds and Their Significance

The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) has recently been investigated, and the peak hearing sensitivity was found to be between 1500 and 3000 Hz (Crowell 2016). Great cormorants were also found to respond to underwater sounds and may have special adaptations for hearing underwater (Hansen et al. 2016; Johansen et al. 2016). Effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the PEIS. The PEIS concluded that there could be transitory disturbance, but that there would be no significant impacts of NSF-funded marine seismic research on seabirds or their populations. Given the proposed activities and the mitigation measures, no significant impacts on seabirds would be anticipated. In decades of seismic surveys carried out by SIO and other vessels in the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related seabird injuries or mortality. Furthermore, NSF received concurrence from USFWS on 18 September 2017 that the proposed activity “may affect” but “is not likely to adversely affect” species under their jurisdiction (Appendix E).

(7) Indirect Effects on Marine Mammals, Sea Turtles, Seabirds, Fish, and Their Significance

The proposed seismic operations would not result in any permanent impact on habitats used by marine mammals, sea turtles, seabirds, or fish, or to the food sources they use. The main impact issue associated with the proposed activities would be temporarily elevated anthropogenic sound levels and the associated direct effects on marine mammals, sea turtles, seabirds, and fish as discussed above.

During the proposed seismic surveys, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates, if any, would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed surveys would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned.

(8) Cumulative Effects

The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research. However, the PEIS also stated that, “A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the area of the proposed seismic surveys that may result in cumulative impacts to environmental resources.” Here we focus on activities that could impact animals specifically in the proposed survey area (academic and industry research activities, vessel traffic, tourism, and fisheries).

(a) Past and future research activities in the area

During September 2007 and July 2009, SIO conducted low-energy seismic surveys for ~6–7 days off the coast of Oregon. During July 2008, University of Texas Institute for Geophysics conducted a low-energy seismic survey for ~6 days off the coast of Oregon. In June–August 2004 and August–October 2005, the riserless drilling vessel *JOIDES Resolution* conducted coring off Oregon. Seismic surveys using a 36-airgun array were conducted off the coast of Oregon and Washington by the *Langseth* during June–July 2012. Other research activities may have been conducted in the past or may be conducted in the study area in the future; however, we are not aware of any research activities that are planned to occur in the proposed project area during September 2017.

(b) Navy operations in the area

In the summer of 2012, the U.S. Navy conducted a test sponsored by the Naval Sea Systems Command, who is responsible for the research, development, and construction of Navy systems. They tested a towed array with an active acoustic source and a passive receiver. The primary test took place during both a north and south ship transit between San Diego, CA, and Puget Sound in the Pacific Northwest, when the ship was >12 n.mi. (~22 km) from the coast of the U.S. Other navy activities may have been or may be conducted in this region in the future as this area is part of the U.S. Navy's Northwest Training and Testing Area; however, we are not aware of any specific activities that are planned to occur in the proposed survey area during September 2017.

(c) Vessel traffic

Several major ports are located on the northwestern coast of the U.S., including Portland, and major shipping lanes originate there. Vessel traffic in the proposed survey area will consist mainly of commercial fishing and cargo vessels. Based on the data available through the Automate Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard (USCG), 15–49 cargo vessels travelled through the proposed survey areas during the month of September 2012 (USCG 2016). Live vessel traffic information is available from MarineTraffic (2017), including vessel names, types, flags, positions, and destinations. Various types of vessels were in the general vicinity of the proposed survey areas when MarineTraffic (2017) was accessed on 28 February 2017, including cargo vessels (9), tankers (1), tugs (3), and fishing vessels (1). The total transit time by the *Revelle* (8 days) would be minimal relative to the number of other vessels operating in the proposed survey area during September 2017. Thus, the combination of SIO's operations with the existing shipping operations is expected to produce only a negligible increase in overall ship disturbance effects on marine mammals.

(d) Tourism

Various companies offer whale and dolphin watching off the coast of Oregon and Washington. Whale watching can occur in this area year-round (Oregon Coast Visitors Association 2017). The main focus of the whale watch industry is the southward gray whale migration from mid-December through January and their northbound migration from March to June (Oregon Coast Visitors Association 2017). However, some whales are resident off Oregon in the summer and can be seen there from June through November (Oregon Coast Visitors Association 2017). There are at least 11 whale watching boat charters along the coast of Oregon, including at Newport and Depoe Bay; whale watching flights are also carried out by at least six companies (Oregon Coast Visitors Association 2017). Whale watching also takes place in Washington State, but most of the excursions occur near the San Juan Islands and inshore of the proposed project area.

SIO's operations would not be located in areas used for whale-watching activities and would be short in duration (~8 days), whereas whale watching is ongoing. The combination of the proposed surveys with the existing tourism operations would be expected to produce only a negligible increase in overall disturbance effects on marine mammals.

(e) Fisheries

The commercial Oregon and Washington fisheries are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles involve direct removal of prey items, sound produced during fishing activities, potential entanglement (Reeves et al. 2003), and the direct and indirect removal of prey items.

Marine mammals.—According to Lewison et al. (2014), the northwest coast of the U.S. has relatively high bycatch rates for marine mammals. Between 1990 and 1996, an average of 456 cetaceans and 160 pinnipeds were killed or seriously injured per year in the California/Oregon driftnet fishery. As a result of regulatory action to reduce cetacean bycatch in 1997, bycatch was reduced to a yearly average of 105 cetaceans (8 odontocete species and fin, minke, and gray whales) and 77 pinnipeds (California sea lion and northern elephant seal) during the 1997–2006 period (Moore et al. 2009). In 2009, based on observed bycatch, the estimated total bycatch in the California/Oregon large-mesh drift gillnet fishery for thresher sharks and swordfish was 7 short-beaked common dolphins, 15 Pacific white-sided dolphins, and 37 California sea lions (Carretta and Enriquez 2010).

Before 2000, high bycatch of harbor porpoises, southern sea otters, and pinnipeds (California sea lion, harbor seals, and elephant seals) occurred in the set gillnet fishery for California halibut. The bycatch likely led to the decline of the harbor porpoise. Restrictions applied between 2000 and 2002 effectively closed most of the fishery (Moore et al. 2009).

Three fisheries had marine mammal takes in the non-Pacific hake groundfish fisheries from 2002 to 2005 (NMFS 2008b). An estimated 250 marine mammals were killed in the limited-entry bottom trawl fishery; bycatch estimates included 227.6 California sea lions, 11.5 Steller sea lions, 7.5 Pacific white-sided dolphins, and 3.1 harbor porpoises (NMFS 2008b). Bycatch in the limited-entry sablefish fishery was estimated at 29 California sea lions. Eight California sea lions were also killed in the non-sablefish endorsed fishery during the same period (NMFS 2008b). A number of pinnipeds were also caught in the west coast Pacific hake fishery; estimated bycatch for 2002–2006 included 2.5 harbor seals, 8.3 Steller sea lions, 6.9 California sea lions, and 3.4 elephant seals (NMFS 2008b). During 2007–2009, bycatch totals for the U.S. west coast groundfish fishery included 19 California sea lions, 12 Steller sea lions, 12 northern elephant seals, 5 harbor seals, 1 Risso's dolphin, 1 bottlenose dolphin, and 1 sperm whale (Jannot et al. 2011). The extent of bycatch is unknown in some fisheries that receive little or no observer coverage. In 2005, ~87 short-beaked common dolphins were killed in squid purse seines; an estimated 5196 other marine mammals were caught but released alive across all other observed California purse seine fisheries (Carretta and Enriquez 2006). In 2005, the bycatch for the Northwest Region (including Oregon) for the sablefish-endorsed fixed gear, groundfish bottom trawl, and mid-water hake trawl fisheries was estimated at 37 animals, including 33.7 California sea lions, 2.4 Steller sea lions, and 1.2 harbor seals (NMFS 2011b). From 2010–2014, Carretta et al. (2016b) reported 85 large whales and 116 small cetaceans entangled in fishing gear for the U.S. west coast; there were 180 cases of pinniped injuries and mortalities in the hook and line fishery.

Sea turtles.—According to Lewison et al. (2014), the northwest coast of the U.S. has relatively low bycatch rates for sea turtles. Finkbeiner et al. (2011) reported that between 1990 and 2007, the annual mean bycatch for sea turtles in the California/Oregon driftnet fishery was 30 individuals before regulations came into effect, and <10 after regulations were put in place. Moore et al. (2009) reported that an average of 14 leatherbacks were killed annually in the California/Oregon drift gillnet fishery before regulations were implemented to reduce bycatch in 1997 and 2001. There was no bycatch reported for 2005 (NMFS 2011b). One sea turtle (a leatherback in 2008) was killed or injured in the west coast groundfish fishery in 2002–2009 off California (Jannot et al. 2011). Carretta and Enriquez (2010) reported one leatherback caught and released alive in 2009.

Seabirds.—According to Lewison et al. (2014), the northwest coast of the U.S. has relatively low bycatch rates for seabirds. Net fisheries for salmon in Puget Sound have killed thousands of birds annually, mostly murres and auklets (Moore et al. 2009). Annual seabird bycatch in the set net fishery for California halibut during 1990–2001 ranged from 308 to 3259; most bycatch consisted of common murres, loons, grebes, and cormorants (Moore et al. 2009). Closure of the central California fishery in depths <110 m in 2002 reduced bycatch to an estimated 61 seabirds in 2003 (Moore et al. 2009). The estimated take of seabirds in the non-Pacific hake fisheries during 2002–2005 totaled 575, half of which were common murres. Other species caught included Leach’s storm petrel, Brandt’s cormorant, black-footed albatross, western gull, and brown pelican (NMFS 2008b). Jannot et al. (2011) reported takes of 11 seabird species in the west coast groundfish fishery during 2002–2009, including marbled murrelets and short-tailed albatross; in 2009, northern fulmars made up most of the bycatch. The estimated take of seabirds in the Pacific hake fisheries during the same period was 50 birds, including seven black-footed albatrosses, five common murres, 23 northern fulmars, two sooty shearwaters, and 13 unidentified seabirds (NMFS 2008b). In 2005, the bycatch for the Northwest Region (including Oregon) was estimated at 106 birds for the west coast groundfish limited entry non-trawl, groundfish bottom trawl, and mid-water hake trawl fisheries, including 58.8 black-footed albatross, 35.6 brown pelicans, 3.8 gulls, 2 sooty shearwaters, 2 northern fulmars, 2 common murres, and 2 unidentified seabirds (NMFS 2011b).

Conclusions.—There may be some localized avoidance or attraction by marine mammals of fishing vessels near the proposed project area. SIO’s operations in the proposed project would be limited (cruise duration of ~8 days), and the combination of SIO’s operations with the existing fishing operations would be expected to produce only a negligible increase in overall disturbance effects on marine mammals, sea turtles, seabirds, and fish. Proposed survey operations should not impede fishing operations, and the *Revelle* would avoid fishing vessels when towing seismic equipment. Operation of the *Revelle*, therefore, would not be expected to significantly impact recreational or commercial fishing operations in the area.

(e) Summary of Cumulative Impacts to Marine Mammals, Sea Turtles, Seabirds, and Fish

Impacts of SIO’s proposed seismic survey are expected to be no more than a very minor (and short-term) increment when viewed in light of other human activities within the proposed survey area. Unlike some other ongoing and routine activities in the area (e.g., commercial fishing), SIO’s activities are not expected to result in injuries or deaths of marine mammals and sea turtles. Although the airgun sounds from the seismic survey will have higher source levels than do the sounds from most other human activities in the area except perhaps naval sonar, airgun operations during the surveys would last only ~5 days, in contrast to those from many other sources that have lower peak pressures but occur continuously over extended periods. Thus, the combination of SIO’s operations with the existing shipping and fishing activities would be expected to produce only a negligible increase in overall disturbance effects on marine mammals and turtles.

(9) Unavoidable Impacts

Unavoidable impacts to the species of marine mammals and turtles occurring in the proposed survey area would be limited to short-term, localized changes in behavior of individuals. For cetaceans, some of the changes in behavior may be sufficient to fall within the MMPA definition of "Level B Harassment" (behavioral disturbance; no serious injury or mortality). TTS, if it occurs, would be limited to a few individuals, is a temporary phenomenon that does not involve injury, and is unlikely to have long term consequences for the few individuals involved. No long-term or significant impacts would be expected on any of these individual marine mammals or turtles, or on the populations to which they belong. Effects on recruitment or survival would be expected to be (at most) negligible.

(10) Public Input and Coordination with Other Agencies and Processes

This Final EA was prepared by LGL on behalf of SIO, NSF, TAMU, OSU, and Rutgers. Potential impacts to marine mammals, endangered species, and critical habitat have also been assessed in the document; therefore, it was used to support the ESA Section 7 consultation process with NMFS and USFWS and the IHA process with NMFS.

(a) Endangered Species Act (ESA)

The Draft EA was used during the ESA Section 7 consultation process with NMFS and USFWS. On 11 May 2017, NSF submitted a letter of concurrence request to USFWS that the proposed activity may affect but was not likely to adversely affect the ***endangered*** short-tailed albatross, and the ***threatened*** marbled murrelet and western snowy plover, in the unlikely event the species was observed near survey operations. On 18 September 2017, USFWS provided a letter of concurrence (Appendix E) that the proposed activity "may affect" but was not likely to "adversely affect" these species under their jurisdiction. Mitigation measures for this species would include power downs/shut downs for diving or foraging ESA-listed seabirds within the exclusion zone.

On 20 March 2017, NSF submitted a formal ESA Section 7 consultation request, including the Draft EA, to NMFS for the proposed activity. On 22 September 2017, NMFS issued a Biological Opinion and ITS for the proposed activity and the consultation was concluded (Appendix C). NMFS concluded in the Biological Opinion that the proposed survey was not likely to jeopardize the continued existence of endangered species and would have no effect on their critical habitat. SIO, NSF, TAMU, OSU, and Rutgers would adhere to the monitoring and mitigation requirements identified in the ITS.

(b) Marine Mammal Protection Act (MMPA)

The Draft EA was also used as supporting documentation for an IHA application submitted on 22 March 2017 by SIO on behalf of itself, NSF, TAMU, OSU, and Rutgers, to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals during the proposed seismic survey. On 17 August 2017, NMFS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period. NMFS received public comments, which were summarized in their EA and will be made available on their website at http://www.nmfs.noaa.gov/pr/permits/incidental/research.htm#SIORevelle2017. NSF reviewed and considered the comments submitted during the IHA process. NMFS prepared a separate Environmental Assessment (Appendix A) for its federal action of issuing an IHA; NMFS' Environmental Assessment is incorporated by reference in this Final EA as appropriate and where indicated. NMFS issued an IHA on 22 September 2017 (Appendix B) for the proposed activity. SIO, NSF, TAMU, OSU, and Rutgers will adhere to the IHA requirements.

(c) Magnuson-Stevens Fishery Conservation and Management Act - Essential Fish Habitat (EFH)

Although NSF anticipated no significant impacts to EFH and HAPC, as the proposed activities may affect EFH and HAPC, in accordance with the Magnuson-Stevens Fishery Conservation and Management Act, NSF requested consultation with NMFS on 11 May 2017. In a letter dated 11 August, 2017, NMFS concluded that the Proposed Action would result in some level of adverse effects on EFH, but that much of the research available to date on the effects of seismic survey methods and how to minimize and mitigate those effects have been focused on marine mammals and not fish and benthic invertebrates (Appendix D). Therefore, NMFS offered the following single EFH conservation recommendation pursuant to section 305(b) of the MSA, "Additional research and monitoring should be undertaken to gain a better understanding of the potential effects these seismic surveys may have on EFH, federally managed species, their prey and other NMFS trust resources. This research should be a component of future NSF funded seismic survey activities. This will aid in the development of site and project specific EFH conservation recommendations for future projects as appropriate." In a letter dated 12 September 2017, NSF accepted the EFH conservation recommendation, agreeing to consider for future activities additional research and monitoring measures that could be undertaken to gain a better understanding of the potential effects seismic surveys may have on EFH, federally managed species, their prey and other NMFS trust resources (Appendix D).

(d) Coastal Zone Management Act (CZMA)

On 8 May 2017, NSF submitted Negative Determinations pursuant to Part 930 Subpart C of the CZMA to the states of Oregon and Washington (Appendix F). On 8 May 2017, the Oregon Coastal Management Program concurred with the Negative Determination (Appendix F). No response or request for an extension from Washington state was received by NSF; per CZMA Subpart C 930.35(c), since no response was received within 60 days, state concurrence was presumed.

Alternative Action: Another Time

An alternative to issuing the IHA for the period requested, and to conducting the Project then, is to issue the IHA for another time, and to conduct the project at that alternative time. The proposed dates for the cruise (~1 week in September) are the dates when the personnel and equipment essential to meet the overall project objectives are available.

Marine mammals and sea turtles are expected to be found throughout the proposed survey area and throughout the time period during which the project would occur. Except for some baleen whales, most marine mammal species are probably year-round residents in the survey area, so altering the timing of the proposed project likely would result in no net benefits for any species (see § III, above).

No Action Alternative

An alternative to conducting the proposed activities is the "No Action" alternative, i.e., do not issue an IHA and do not conduct the operations. If the research were not conducted, the "No Action" alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed activities; however, valuable data about the marine environment would be lost. Chief scientist training for seismic surveys would not occur and information to address questions about earthquake hazards and paleoclimate records in basins off the Oregon continental margin would not be gained. The No Action Alternative would not meet the purpose and need for the proposed activities.

V. LIST OF PREPARERS

LGL Ltd., environmental research associates

Patrick Abgrall, Ph.D., King City, ON*
William E. Cross, M.Sc., King City, ON
Meike Holst, M.Sc., Sidney, BC*
Andrew Davis, B.Sc., St. John's, NL
Mark Fitzgerald, B.Sc., King City, ON
William R. Koski, M.Sc., King City, ON
Andrew Murphy, M.Sc., St. John's, NL
Sarah Penney-Belbin, M.Sc., St. John's, NL*
W. John Richardson, Ph.D., King City, ON

Lamont-Doherty Earth Observatory

Anne Bécel, Ph.D., Palisades, NY
Sean Higgins, Ph.D., Palisades, NY

Scripps Institution of Oceanography

Lee Ellett, AAS, La Jolla, CA

National Science Foundation

Holly E. Smith, M.A., Arlington, VA

* Principal preparers of this specific document. Others listed above contributed to a lesser extent, or contributed substantially to previous related documents from which material has been excerpted.

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LIST OF APPENDICES

APPENDIX A:
NMFS ENVIRONMENTAL ASSESSMENT AND FONSI

PROPOSED ACTION: Issuance of an Incidental Harassment Authorization to the Scripps Institution of Oceanography to Take Marine Mammals by Harassment Incidental to a Low-Energy Geophysical Survey in the Northeastern Pacific Ocean, Fall 2017

TYPE OF STATEMENT: Environmental Assessment

LEAD AGENCY:
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

RESPONSIBLE OFFICIAL:
Donna S. Wieting,
Director, Office of Protected Resources,
National Marine Fisheries Service

FOR FURTHER INFORMATION:
Jordan Carduner
National Marine Fisheries Service
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway
Silver Spring, MD 20910
301-427-8401

LOCATION: Northeastern Pacific Ocean

ABSTRACT:

This Environmental Assessment analyzes the environmental impacts of the National Marine Fisheries Service, Office of Protected Resources proposal to issue an Incidental Harassment Authorization to the Scripps Institution of Oceanography, for takes of small numbers of marine mammals by Level A and Level B harassment incidental to a Low-Energy Geophysical Survey in the Northeastern Pacific Ocean, Fall 2017

DATE: September 2017

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List of Acronyms and Abbreviations

µPa	microPascal
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
dB	decibel
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
FONSI	Finding of No Significant Impact
FR	Federal Register
IHA	Incidental Harassment Authorization
Km	kilometer
m	meter
MMPA	Marine Mammal Protection Act
MSFCMA	Magnuson-Stevens Fishery Conservation Management Act
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OPR	Office of Protected Resources
OMB	Office of Management and Budget
PAM	Passive Acoustic Monitoring
PSAO	Protected Species Acoustic Observer
PSO	Protected Species Observer
rms	root-mean-square
SIO	Scripps Institution of Oceanography
USFWS	US Fish and Wildlife Service

Chapter 1 Introduction and Purpose and Need

1.1. Background

The Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1631 et seq.) prohibits the incidental taking of marine mammals. The incidental take of a marine mammal falls under three categories: mortality, serious injury or harassment (i.e., injury and behavioral effects). Harassment[1] is any act of pursuit, torment or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment) or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns (Level B harassment). Disruption of behavioral patterns includes, but is not limited to, migration, breathing, nursing, breeding, feeding or sheltering. However, there are exceptions to the prohibition on take in Sections 101(a)(5)(A) and (D) of the MMPA that gives the National Marine Fisheries Service (NMFS) the authority to authorize the incidental but not intentional take of small numbers of marine mammals by harassment, provided certain determinations are made and statutory and regulatory procedures are met. Refer to Chapter 2 for details regarding this exception and NMFS incidental harassment authorization (IHA) criteria.

NMFS also promulgated regulations to implement the provisions of the MMPA governing the taking and importing of marine mammals, 50 Code of Federal Regulations (CFR) Part 216 and produced Office of Management and Budget (OMB)-approved application instructions (OMB Number 0648-0151) that prescribe the procedures necessary to apply for permits. All applicants must comply with these regulations and application instructions in addition to the provisions of the MMPA.

1.1.1. Applicant's Incidental Take Authorization Request

Scripps Institution of Oceanography(SIO) requested an Incidental Take Authorization (ITA) for take of marine mammals, by harassment, incidental to a low-energy marine geophysical survey in the northeastern Pacific Ocean over the course of five days in September 2017. This survey will take place offshore Oregon and Washington, occurring specifically off the Oregon continental margin out to 127.5°W and between ~43 and 46.5°N in water depths ranging from ~130 m–2600 m. Two potential survey areas off the Oregon continental margin have been proposed (See Figure 1). One potential survey area, referred to by SIO as the Astoria Fan area, is located off northern Oregon off the mouth of the Columbia River and near the Astoria Canyon; the other potential survey area, referred to as the southern Oregon area, is located off the southern Oregon margin. Both the proposed Astoria Fan and Southern Oregon survey areas are located at least 23 km from the west coast of the U.S. In either case, the survey area that is chosen will only involve one source vessel, the R/V *Roger Revelle*.

SIO's proposed low-energy seismic survey will comprise of an Early Career Seismic Chief Scientist Training Cruise which aims to train scientists on how to effectively plan seismic surveys, acquire data, and manage activities at sea. In addition, the survey would provide critical data to understand the sediment and crustal structure within the Cascadia continental margin. SIO's IHA application, available online at *www.nmfs.noaa.gov/pr/permits/incidental/research*, presents more detailed information on the proposed project.

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[1] As defined in the MMPA for non-military readiness activities (Section 3 (18)(A))

The airgun array that would be deployed on the R/V *Roger Revelle* consists of 2 airguns with a total volume of ~90 in^3 as an energy source. The receiving system would consist of an 800 m streamer containing hydrophones along predetermined lines. As the airgun array is towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the onboard processing system. The OBSs would record the returning acoustic signals internally for later analysis.

The total line km for the Southern Oregon survey is 1013 km, ~5% of which are in intermediate water (100–1000 m), with the remainder in water deeper than 1000 m. The total length for the Astoria Fan survey is 1057 km, with ~23% of line km in intermediate water and the remainder in water >1000 m. No effort during either survey would occur in shallow water <100 m deep.

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the entire survey. The ocean floor would be mapped with the Kongsberg EM 122 multibeam echosounder (MBES) and a Knudsen Chirp 3260 sub-bottom profiler (SBP).

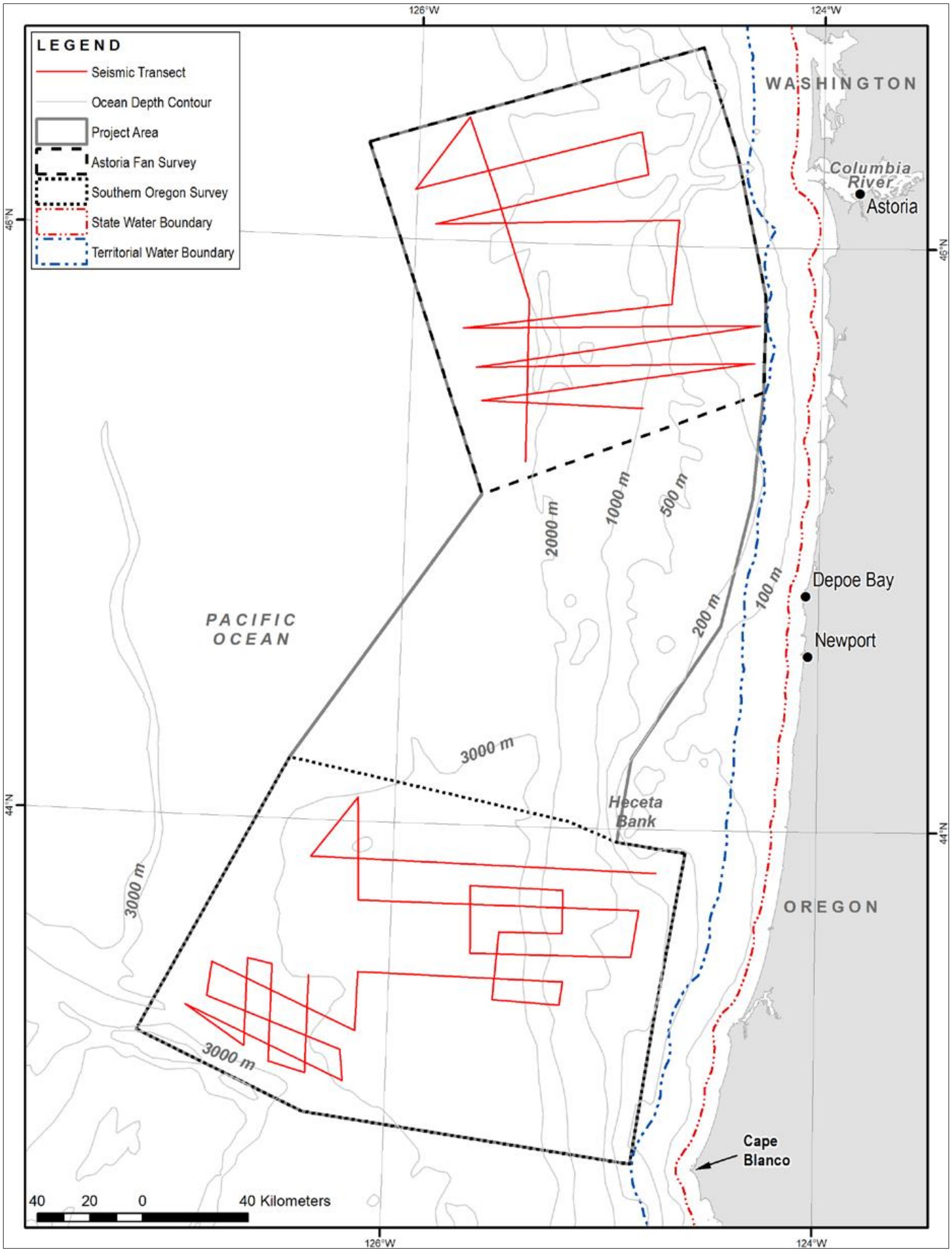

Figure 1: Planned potential track lines for low-energy seismic survey proposed by Scripps Institution of Oceanography conducted aboard the R/V *Revelle.*

1.1.2. Marine Mammals in the Proposed Action Area

There are 27 marine mammal species with confirmed or potential occurrence in the area of the proposed seismic survey in the northeastern Pacific Ocean, including five cetacean species that are listed under the U.S. Endangered Species Act (ESA) as endangered or threatened: fin, sei, blue, sperm, and humpback whale (Mexico DPS). These 27 marine mammal species are listed below:

- Gray Whale*(Eschrichtius robustus)*
- Sperm whale (*Physeter macrocephalus*)
- Humpback whale (*Megaptera novaeangliae*)
- Minke whale (*Balaenoptera acutorostrata*)
- Sei whale (*Balaenoptera borealis*)
- Fin whale (*Balaenoptera physalus*)
- Blue whale (*Balaenoptera musculus*)
- Pygmy sperm whale (*Kogia breviceps*)
- Cuvier's beaked whale (*Ziphius cavirostris*)
- Baird's beaked whale (*Berardius bairdii*)
- Mesoplodont beaked whales
- Striped dolphin (*Stenella coeruleoalba*)
- Risso's dolphin (*Grampus griseus*)
- Northern right whale dolphin (*Lissodelphis borealis*)
- Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
- Short-beaked common dolphin (*Delphinus delphis*)
- Bottlenose dolphin (*Tursiops truncatus*)
- Harbor porpoise *(Phocoena phocoena)*
- Dall's porpoise(*Phocoena dalli)*
- False killer whale (*Pseudorca crassidens*)
- Killer whale (*Orcinus orca*)
- Short-finned pilot whale (*Globicephala macrorhynchus*)
- California sea lion (*Zalophus californianus*)
- Steller sea lion (*Eumetopias jubatus*)
- Harbor seal (*Phoca vitulina*)
- Northern elephant seal (*Mirounga angustirostris*)
- Northern fur seal (*Callorhinus ursinus*)

1.2. Purpose and Need

1.2.1. Description of Proposed Action

NMFS proposes to issue an IHA to SIO pursuant to Section 101(a)(5)(D) of the MMPA and 50 CFR Part 216. The IHA would be valid from September 22, 2017 through September 21, 2018 and would authorize takes of marine mammals, by Level A harassment and Level B harassment, incidental to the proposed seismic survey being conducted by SIO from the R/V *Revelle*. NMFS's proposed action is a direct outcome of SIO requesting an IHA to take marine mammals incidental to a marine seismic survey.

1.2.2. Purpose

The purpose of NMFS's proposed action is to authorize take of marine mammals incidental to SIO's marine seismic survey. Acoustic stimuli from use of air guns during the marine seismic survey has the potential to result in marine mammals in and near the survey area to be injured and behaviorally disturbed and thus the activity warrants an IHA from NMFS.

The IHA, if issued, would provide an exemption to SIO from the take prohibitions contained in the MMPA. To authorize the incidental take of small numbers of marine mammals, NMFS will evaluate the best available scientific information to determine whether the take would have a negligible impact on marine mammals or stocks and whether the activity would have an unmitigable impact on the availability of affected marine mammal species for subsistence use. NMFS cannot issue this IHA if it would result in more than a negligible impact on marine mammals or stocks or would result in an unmitigable impact on subsistence uses. In addition, NMFS must prescribe the permissible methods of taking and other means of effecting the least practicable impact on the species or stocks of marine mammals and their habitat, paying particular attention to rookeries, mating grounds, and other areas of similar significance. If appropriate, we must prescribe means of effecting the least practicable impact on the availability of the species or stocks of marine mammals for subsistence uses. IHAs must also include requirements or conditions pertaining to monitoring and reporting, in large part to better understand the effects of such taking on the species.

1.2.3. Need

U.S. citizens seeking to obtain authorization for the incidental take of marine mammals under NMFS's jurisdiction must submit such a request (in the form of an application). On March 20, 2017, SIO submitted an application demonstrating the need and potential eligibility for an IHA under the MMPA. Therefore, NMFS has a corresponding duty to determine whether and how to authorize take of marine mammals incidental to the activities described in SIO's application. NMFS's responsibilities under section 101(a)(5)(D) of the MMPA and its implementing regulations establish and frame the need for NMFS proposed action.

1.3. The Environmental Review Process

In accordance with the Council on Environmental Quality (CEQ) Regulations and agency policies for implementing the National Environmental Policy Act (NEPA), NMFS, to the fullest extent possible, integrates the requirements of NEPA with other regulatory processes required by law or by agency practice so that all procedures run concurrently, rather than consecutively. This includes coordination within National Oceanic Atmospheric Administration (NOAA), (e.g., the Office of the National Marine Sanctuaries) and with other regulatory agencies (*e.g.*, the U.S. Fish and Wildlife Service), as appropriate, during NEPA reviews prior to implementation of a proposed action to ensure that requirements are met. Regarding the issuance of IHAs, we rely substantially on the public process required by the MMPA for preparing proposed IHAs to develop and evaluate relevant environmental information and provide a meaningful opportunity for public participation when we prepare corresponding NEPA documents. We fully consider public comments received in response to the publication of proposed IHAs during the corresponding NEPA review process.

1.3.1. The National Environmental Policy Act

NEPA requires federal agencies to examine the environmental impacts of their proposed actions within the United States and its territories. A NEPA analysis is a public document that provides an assessment of the potential effects a major federal action may have on the human environment, which includes the natural and physical environment. Major federal actions include activities that federal agencies fully or partially fund, regulate, conduct or approve. NMFS issuance of IHAs allows for the taking of marine mammals albeit consistent with provisions under the MMPA and incidental to the applicant's activities and is considered a major federal action. Therefore, NMFS analyzes the environmental effects associated with authorizing incidental takes of protected species and prepares the appropriate NEPA documentation.

1.3.2. Scoping and Public Involvement

The NEPA process is intended to enable NMFS to make decisions based on an understanding of the environmental consequences and take actions to protect, restore, and enhance the environment. An integral part of the NEPA process is public involvement. Early public involvement facilitates the development of an environmental assessment (EA) and informs the scope of issues to be addressed in the EA. Although agency procedures do not require public involvement prior to finalizing an EA, NMFS determined the publication of the proposed IHA and EA was the appropriate step to involve the public to understand the public concerns for the proposed action, identify significant issues related to the proposed action and obtain the necessary information to complete an analysis.

The public was given the opportunity to submit comments during a 30-day comment period that begins the date that the notice of the proposed IHA is published in the *Federal Register* (82 FR 39276, August 17, 2017). The notice included a detailed description of the proposed action resulting from the MMPA incidental take authorization process; consideration of environmental issues and impacts of relevance related to the proposed issuance of the IHA; and potential mitigation and monitoring measures to avoid and minimize potential adverse impacts to marine mammals and their habitat. The *Federal Register* notice of the proposed IHA, the draft EA and the corresponding public comment period are instrumental in providing the public with information on relevant environmental issues and offering the public a meaningful opportunity to provide comments for our consideration in both the MMPA and NEPA decision-making processes.

During the 30-day public comment period following the publishing of the proposed IHA in the *Federal Register* (82 FR 39276, August 17, 2017), NMFS received a comment letter from the Marine Mammal Commission (Commission) as well as one comment from a member of the general public. The Commission expressed concerns regarding SIO's method to estimate Level A and Level B harassment zones and numbers of incidental takes; rounding of estimated takes; and the extent to which monitoring requirements result in accurate reporting of the types of taking and the numbers of animals taken by the proposed activity. The comment received from a private citizen expressed concern that the project would result in the deaths of marine mammals. NMFS has posted the comments online at: *http://www.nmfs.noaa.gov/pr/permits/incidental*. A more detailed summary of the comments, and NMFS' responses to those comments, will be included in the *Federal Register* notice for the issued IHA, if NMFS determines the IHA should be issued.

1.4. Other Environmental Laws or Consultations

NMFS must comply with all applicable federal environmental laws, regulations, and Executive Orders (EO) necessary to implement a proposed action. NMFS evaluation of and compliance with environmental laws, regulations and EOs is based on the nature and location of the applicants proposed activities and NMFS proposed action. Therefore, this section only summarizes environmental laws and consultations applicable to NMFS' issuance of an IHA to SIO. There are no other environmental laws, regulations, EOs, consultations, federal permits or licenses applicable NMFS' issuance of an IHA to SIO.

1.4.1. The Endangered Species Act

The ESA established protection over and conservation of threatened and endangered species (T&E) and the ecosystems upon which they depend. An endangered species is a species in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The USFWS and NMFS jointly administer the ESA and are responsible for the listing of species (designating a species as either threatened or endangered) and designating geographic areas as critical habitat for T&E species. The ESA generally prohibits the "take" of an ESA-listed species unless an exception or exemption applies. The term "take" as defined in section 3 of the ESA means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat of such species. When a federal agency's action may affect a listed species, that agency is required to consult with NMFS and/or the USFWS under procedures set out in 50 CFR Part 402. NMFS and USFWS can also be action agencies under section 7. Informal consultation is sufficient for species the action agency determines are not likely to be adversely affected if NMFS or USFWS concurs with the action agency's findings, including any additional measures mutually agreed upon as necessary and sufficient to avoid adverse impacts to listed species and/or designated critical habitat.

NMFS' issuance of an IHA is a federal action that is also subject to the requirements of section 7 of the ESA. As a result, we are required to ensure that the issuance of an IHA to SIO is not likely to jeopardize the continued existence of any T&E species or result in the destruction or adverse modification of designated critical habitat for these species. There are five marine mammal species under NMFS's jurisdiction listed as endangered or threatened under the ESA with confirmed or possible occurrence in the proposed project area including the humpback, sei, fin, blue and sperm whale. The NMFS OPR Interagency Cooperation Division initiated consultation with the NMFS OPR Permits and Conservation Division on the proposed issuance of the IHA to SIO, pursuant to section 7 of the ESA, on July 31, 2017. The NMFS OPR Interagency Cooperation Division issued a Biological Opinion on September 21, 2017 which determined the action would not jeopardize the continued existence of any marine mammal species and would not destroy or adversely modify critical habitat.

1.4.2. Magnuson-Stevens Fishery Conservation and Management Act

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), Federal agencies are required to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency which may adversely affect essential fish habitat (EFH) identified under the MSFCMA.

There is no designated EFH within the action area for this proposed project. In accordance with the EFH requirements of the MSFCMA, we notified the NMFS Northwest Regional Office about this activity, and EFH consultation was not considered necessary for issuance of this IHA. Authorizing the take of marine mammals through the issuance of this IHA is unlikely to affect the ability of the water column or substrate to provide necessary spawning, feeding, breeding or growth to maturity functions for managed fish. Likewise, authorizing the take of marine mammals is not likely to directly or indirectly reduce the quantity or quality of EFH by affecting the physical, biological or chemical parameters of EFH. Marine mammals have not been identified as a prey component of EFH for managed fish species, so authorizing the incidental take of marine mammals probably will not reduce the quantity and/or quality of EFH.

1.5. Document Scope

This draft EA was prepared in accordance with NEPA (42 USC 4321, et seq.) and CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508). The analysis in this draft EA addresses potential impacts to the human environment and natural resources, specifically marine mammals and their habitat, resulting from NMFS' proposed action to authorize incidental take associated with the proposed seismic survey by SIO. We analyze direct, indirect, and cumulative impacts related to authorizing incidental take of marine mammals under the MMPA. The scope of our analysis is limited to the decision for which we are responsible (i.e. whether or not to issue the IHA). This draft EA is intended to provide focused information on the primary issues and impacts of environmental concern, which is our issuance of the IHA authorizing the take of marine mammals incidental to SIO's seismic survey activities, and the mitigation and monitoring measures to minimize the effects of that take. For these reasons, this EA does not provide a detailed evaluation of the effects to the elements of the human environment listed in Table 1 below. In summary, the analysis herein supports our preliminary determinations that the issuance of an IHA would not result in any significant direct, indirect or cumulative impacts. Based on our MMPA analysis, harassment from the seismic survey activities involving the use of airguns may have short-term, limited impacts on individual marine mammals, but impacts resulting from the activity are not expected to adversely affect the marine mammal species or stocks through effects on annual rates of recruitment or survival

1.5.1. Best Available Data and Information

In accordance with NEPA and the Administrative Procedure Act of 1946 (5 U.S.C. §§ 551–559), NMFS used the best available data and information accepted by the appropriate regulatory and scientific communities to compile and assess the environmental baseline and impacts evaluated in this document. Literature searches of journals, books, periodicals or technical reports and prior analyses were conducted to support the analysis of potential impacts to marine mammals associated with acoustic sources and for the identification and evaluation of mitigation measures.

In addition, NMFS previously prepared Environmental Assessments (EAs) analyzing the environmental impacts associated with the authorization of marine seismic surveys involving the use of airgun arrays which resulted in Findings of No Significant Impacts (FONSIs). Each of these EAs demonstrate the issuance of an IHA does not affect other aspects of the human environment because the action only affects the marine mammals that are the subject of the IHA. These EAs also demonstrate the issuance of IHAs for these types of activities (i.e., marine seismic surveys involving use of airgun arrays) do not individually or cumulatively have a significant effect on the human environment and resulted in negligible impacts to marine mammals under the MMPA (NMFS 2013a, NMFS 2013b, NMFS 2014). While the activities evaluated in these EAs took place in various regions of the Atlantic Ocean, it is reasonable to expect that the findings would be similar for SIO's proposed activity in the Pacific Ocean. NOTE: All sources identified in this EA,including those listed in Chapter 6, were evaluated for credibility of the source, quality of the information, and relevance of the content to ensure use of the best available information

Table 1. Components of the human environment not affected by our issuance of an IHA

Biological	Physical	Socioeconomic / Cultural

Amphibians	Air Quality	Commercial Fishing
Humans	Geography	Military Activities
Non-Indigenous Species	Land Use	Oil and Gas Activities
Seabirds	Oceanography	Recreational Fishing
	State Marine Protected Areas	Shipping and Boating
	Federal Marine Protected Areas	National Historic Preservation Sites
	National Estuarine Research Reserves	National Trails and Nationwide Inventory of Rivers
	National Marine Sanctuaries	Low Income Populations
	Park Land	Minority Populations
	Prime Farmlands	Indigenous Cultural Resources
	Wetlands	Public Health and Safety
	Wild and Scenic Rivers	Historic and Cultural Resources
	Ecologically Critical Areas	

Chapter 2 Alternatives

2.1. Introduction

As described in Chapter 1, NMFS's Proposed Action is to issue an IHA to authorize the take of small numbers of marine mammals incidental to SIO's proposed seismic survey activity. NMFS' Proposed Action is triggered by SIO's request for an IHA per the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 *et seq.*). In accordance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) Regulations, NMFS is required to consider alternatives to a Proposed Action. This includes the no action and other reasonable course of action associated with authorizing incidental take of protected species. This evaluation of alternatives under NEPA assists NMFS with ensuring that any unnecessary impacts are avoided through an assessment of alternative ways to achieve the purpose and need for our Proposed Action that may result in less environmental harm. To warrant detailed evaluation under NEPA, an alternative must be reasonable along with meeting the stated purpose and need for the proposed action. For the purposes of this draft EA, an alternative will only meet the purpose and need if it satisfies the requirements under section 101(a)(5)(D) of the MMPA. Therefore, NMFS applied the following screening criteria to the alternatives to identify which alternatives to carry forward for analysis. Accordingly, an alternative must meet the criteria described below to be considered "reasonable".

The MMPA requires NMFS to prescribe the means of effecting the least practicable impact on the species or stocks of marine mammals and their habitat. In order to do so, NMFS must consider SIOs proposed mitigation measures, as well as other potential measures, and assess how such measures could minimize impacts on the affected species or stocks and their habitat. Our evaluation of potential measures includes consideration of the following factors in relation to one another: (1) the manner in which, and the degree to which, we expect the successful implementation of the measure to minimize adverse impacts to marine mammals; (2) the proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and (3) the practicability of the measure for applicant implementation. Any additional mitigation measure proposed by us beyond what the applicant proposes should be able to or have a reasonable likelihood of accomplishing or contributing to the accomplishment of one or more of the following goals:

- Avoidance or minimization of marine mammal injury, serious injury, or death, wherever possible;
- A reduction in the numbers of marine mammals taken (total number or number at biologically important time or location);
- A reduction in the number of times the activity takes individual marine mammals (total number or number at biologically important time or location);
- A reduction in the intensity of the anticipated takes (either total number or number at biologically important time or location);
- Avoidance or minimization of adverse effects to marine mammal habitat, paying special attention to the food base; activities that block or limit passage to or from biologically important areas; permanent destruction of habitat; or temporary destruction/disturbance of habitat during a biologically important time; and
- For monitoring directly related to mitigation, an increase in the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation.

Alternative 1 includes a suite of mitigation measures intended to minimize potentially adverse interactions with marine mammals.

2.2. Description of Applicants Proposed Activities

SIO proposes to conduct an Early Career Seismic Chief Scientist Training Cruise involving low-energy seismic surveys in the northeastern Pacific off the coasts of Oregon and Washington. The proposed survey plans to use conventional seismic methodology to image the Cascadia continental margin., an active continental margin off the west coast of the United States. Two potential survey sites off the Oregon continental margin have been proposed. One survey option (Astoria Fan) is located off northern Oregon off the mouth of the Columbia River and near the Astoria Canyon; the other (southern Oregon) is located off the southern Oregon margin. Only one of the two potential survey sites (Astoria Fan or southern Oregon) will be surveyed.

To achieve the program's goals, Principal Investigators aboard the ship intend to collect low-energy, high-resolution multi-channel seismic profiles off the coasts of Oregon and Washington. In addition, a number of early career researchers and students would participate in the survey activities. The scientists on board would be responsible for modifying the survey to fit the allocated cruise length while meeting the project objectives, including choosing which survey or what portion of each survey to conduct.

The survey would involve one source vessel, the R/V *Revelle*. The *Revelle* would deploy 2 GI airguns, with a total volume of ~90 in^3. The airguns would be configured 2 meters apart from one another and seismic pulses would be emitted at intervals of ~8–10 s (20–25 m). The generator chamber of each GI gun, the one responsible for introducing the sound pulse into the ocean, is 45 in3. The larger (105 in^3) injector chamber injects air into the previously generated bubble to maintain its shape, and does not introduce more sound into the water. The two 45-in^3 GI guns would be towed 21 m behind the Revelle, 2 m apart side by side, at a depth of 3 m. Since the dimension of the source is small (2 airguns separated by 2 m), the array can be considered as a point source. As the airguns are towed along the survey lines, the towed hydrophone array in the 800-m streamer would receive the reflected signals and transfer the data to the on-board processing system.

Table 2: GI Airgun Specifications

Energy Source	Two GI guns of 45 in^3
Source output (downward)	0-peak is 3.4 bar-m (230.6 dB re 1 μPa·m); peak-peak is 6.2 bar-m (235.8 dB re 1 μPa·m)
Towing depth of energy source	3 m
Air discharge volume	~90 in^3
Dominant frequency components	0–188 Hz
Gun positions used	Two inline airguns 2 m apart
Gun volumes at each position (in^3)	45, 45

The total line km for the Southern Oregon survey is 1013 km, ~5% of which are in intermediate water (100–1000 meters), with the remainder in water deeper than 1000 meters. The total length for the Astoria Fan survey is 1057 km, with ~23% of line km in intermediate water and the remainder in water >1000 m. No effort during either survey would occur in shallow water <100 m deep. The total track distance to be surveyed is estimated to be no greater than ~1057 km which is the line km of the longest potential survey.

The *Revelle* has a length of 83 m, a beam of 16.0 m, and a maximum draft of 5.2 m. The ship is powered by two 3000-hp Propulsion General Electric motors and a 1180-hp azimuthing jet bow thruster. An operation speed of ~8.3–9.3 km/h (~4.5–5 kt) would be used during seismic acquisition. When not towing seismic survey gear, the *Revelle* cruises at 22.2–23.1 km/h (12–12.5 kt) and has a maximum speed of 27.8 km/h (15 kt). It has a normal operating range of ~27,780 km. The *Revelle* would also serve as the platform from which vessel-based protected species observers (PSO) would watch for marine mammals before and during airgun operations.

Table 3: Specifications for the R/V *Roger Revelle*

Operator:	Scripps Institution of Oceanography of the University of California
Date Built:	1996
Gross Tonnage	3,180
Compressors for Air Guns	Price Air Compressors, 300 cfm at 1750 psi
Accommodation Capacity	22 crew plus 37 scientists

2.2.1. Specified Time and Specified Area

The proposed survey would take place during September 2017 off the Oregon continental margin out to 127.5° W and between ~43 and 46.5° N (Fig. 1). Water depths in the survey area are ~130–2600 m. The *Revelle* would likely depart from Newport, OR, on or about September 22, 2017 and would return to Newport on or about September 29, 2017. Some deviation in timing could result from unforeseen events such as weather, logistical issues, or mechanical issues with the research vessel and/or equipment. Seismic operations would take up to 5 days, and the transit to and from Newport would take ~2 days.

2.3. Alternative 1 – Issuance of an Authorization with Mitigation Measures

The Proposed Action constitutes Alternative 1 and is the Preferred Alternative. Under this alternative, NMFS would issue an IHA to SIO allowing the incidental take, by Level A harassment and Level B harassment, of 27 species of marine mammals subject to the mandatory mitigation and monitoring measures and reporting requirements set forth in the proposed IHA, if issued. This Alternative includes mandatory requirements for SIO to achieve the MMPA standard of effecting the least practicable impact on each species or stock of marine mammal and their habitat, paying particular attention to rookeries, mating grounds, and other areas of similar significance.

2.3.1. Proposed Mitigation and Monitoring Measures

As described in Section 1.2.2, NMFS must prescribe the means of effecting the least practicable impact on the species or stocks of marine mammals and their habitat. In order to do so, we must consider SIO’s proposed mitigation measures, as well as other potential measures, and assess how such measures could benefit the affected species or stocks and their habitat. Our evaluation of potential measures includes consideration of the following factors in relation to one another: (1) the manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned) the likelihood of effective implementation (probability implemented as planned). And (2) the practicability of the measure(s) for applicant implementation, which may consider such things as cost, impact on operations, and, in the case of a military readiness activity, personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

To reduce the potential for disturbance associated with the activities, SIO has proposed to implement several mitigation and monitoring measures. SIO would employ the following mitigation measures:

1. Visual Monitoring. Monitoring would be conducted by three dedicated, trained, NMFS-approved PSOs. The PSOs would have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO observations would take place during daytime airgun operations and nighttime start ups (if applicable) of the airguns. Airgun operations would be suspended when marine mammals are observed within, or about to enter, the EZ (described further below). PSOs would also watch for marine mammals near the seismic vessel for at least 30 minutes prior to the planned start of airgun operations. In addition, observations would be made during daytime periods when the *Revelle* is underway without seismic operations, such as during transits. During the majority of seismic operations, two PSOs would monitor for marine mammals around the seismic vessel. A minimum of one PSO must be on duty at all times when the array is active. PSOs would work in shifts of 4 hour duration or less.
2. Establishment of an Exclusion Zone (EZ). An exclusion zone is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce the potential for certain outcomes, *e.g.*, auditory injury, disruption of critical behaviors. The PSOs would establish a minimum exclusion zone with a 100 m radius. The 100 m EZ would be based on radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on a course to enter this zone, the acoustic source would be shut down (see Shut Down Procedures below). PSOs would also establish and monitor a 200 m buffer zone. During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) would be communicated to the operator to prepare for potential shutdown of the acoustic source.
3. Use of shutdown procedures. If a marine mammal is detected outside the EZ but appears likely to enter the EZ, and if the vessel's speed and/or course cannot be changed to avoid having the animal enter the EZ, the airguns would be shut down before the animal is within the EZ. Likewise, if a marine mammal is already within the EZ when first detected, the airguns would be shut down immediately. Following a shutdown, airgun activity would not resume until the marine mammal has cleared the 100 m EZ. The animal would be considered to have cleared the 100 m EZ if the following conditions have been met:
    - it is visually observed to have departed the 100 m EZ, or
    - it has not been seen within the 100 m EZ for 15 min in the case of small odontocetes, or

- it has not been seen within the 100 m EZ for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales.

Additionally, shutdown of the acoustic source would also be required upon observation of any of the following, at any distance from the vessel:

- a killer whale;
- a large whale (*i.e.*, sperm whale or any baleen whale) with a calf; or
- an aggregation of large whales of any species (*i.e.*, sperm whale or any baleen whale) that does not appear to be traveling (*e.g.*, feeding, socializing, etc.).

4. Use of ramp-up procedures. Ramp-up of an acoustic source is intended to provide a gradual increase in sound levels following a shutdown, enabling animals to move away from the source if the signal is sufficiently aversive prior to its reaching full intensity. Ramp-up would be required after the array is shut down for any reason. Ramp-up would begin with the activation of one 45 in^3 airgun, with the second 45 in^3 airgun activated after 5 minutes. During ramp up, PSOs would monitor the EZ, and if marine mammals were observed within or approaching the 100 m EZ, a shutdown would be implemented as though the full array were operational. If airguns have been shut down due to detection of a marine mammal within or approaching the 100 m EZ, ramp-up would not be initiated until all marine mammals have cleared the EZ (as described above) during the day or night. Thirty minutes of pre-clearance observation are required prior to ramp-up for any shutdown of longer than 30 minutes (*i.e.*, if the array were shut down during transit from one line to another). If a marine mammal were observed within or approaching the 100 m EZ during this pre-clearance period, ramp-up would not be initiated until all marine mammals have cleared the EZ.

5. Use of speed or course alteration. If a marine mammal is detected outside the EZ, based on its position and the relative motion, is likely to enter the EZ, the vessel's speed and/or direct course could be changed. This would be done if operationally practicable while minimizing the effect on the planned science objectives. The activities and movements of the marine mammal (relative to the seismic vessel) would then be closely monitored to determine whether the animal is approaching the EZ. If the animal appears likely to enter the EZ, a shutdown of the seismic source would cocur.

2.3.2 Proposed Reporting Measures

SIO is required to submit a draft monitoring report to the NMFS Office of Protected Resources within 90 days after the conclusion of the activities. A final report shall be prepared and submitted within 30 days following resolution of any comments on the draft report from NMFS. The final report will include:

The following information would be recorded for each sighting and would be documented in the monitoring report submitted to NMFS:

- 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.);

- Behavioral pace;
- Time, location, heading, speed, activity of the vessel;
- Sea state;
- Visibility; and
- Sun glare

All observations, speed or course alterations, and shut downs would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures would allow initial summaries of data to be prepared during and shortly after the field program, and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations would provide

1. The basis for real-time mitigation (GI airgun shut down).
2. Information needed to estimate the number of marine mammals potentially taken by harassment.
3. Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted.
4. Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity.
5. Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

2.4. Alternative 2 – No Action

For NMFS, denial of MMPA authorizations constitutes the NMFS No Action Alternative, which is consistent with our statutory obligation under the MMPA to grant or deny permit applications and to prescribe mitigation, monitoring and reporting with any authorizations. Under the No Action Alternative, there are two potential outcome scenarios. One is that the planned marine seismic survey, including deployment of the airgun array, would occur in the absence of an MMPA authorization. In this case, (1) SIO would be in violation of the MMPA if takes occur, (2) mitigation, monitoring and reporting measures would not be prescribed by NMFS, and 3) mitigation measures might not be performed voluntarily by the applicant. Another potential outcome scenario is SIO could choose not to proceed with their marine seismic survey.

By prescribing measures to protect and minimize impacts on marine mammals species or stocks from incidental take through the authorization program, we can potentially lessen the impacts of these activities on the marine environment. While NMFS does not authorize the anchor retrieval operations, NMFS does authorize the unintentional, incidental unintentional take of marine mammals (under its jurisdiction) in connection with these activities and prescribes, where applicable, the methods of taking and other means of effecting the least practicable impact on the species and stocks and their habitats. Although the No Action Alternative would not meet the purpose and need to allow incidental takes of marine mammals under certain conditions, the CEQ's regulations require consideration and analysis of a No Action Alternative for the purposes of presenting a comparative analysis to the action alternatives.

2.5. Alternatives Considered but Eliminated from Further Consideration

NMFS considered whether other alternatives could meet the purpose and need and support SIO's proposed project. An alternative that would allow for the issuance of an IHA with no required mitigation or monitoring measures was considered but eliminated from consideration, as it would not be in compliance with the MMPA and, therefore, would not meet the purpose and need. For that reason, this alternative is not analyzed further in this document.

Chapter 3 Affected Environment

NMFS reviewed all possible environmental, cultural, historical, social, and economic resources based on the geographic location associated with NMFS's proposed action, alternatives, and SIO's request for an IHA. Based on this review, this section describes the affected environment and existing (baseline) conditions for select resource categories. As explained in Chapter 1, certain resource categories not affected by NMFS's proposed action and alternatives were not carried forward for further consideration or evaluation in this EA (See Table 1 in Section 1.5.1). Chapter 4 provides an analysis and description of environmental impacts associated with the affected environment.

3.1. Physical Environment

The Pacific Ocean covers approximately 165.2 million square kilometers (63.8 million square mi) and extends approximately 15,500 km (9,600 mi) from the Bering Sea in the Arctic to the northern extent of the circumpolar Southern Ocean at 60 S. The survey study area would occur in the approximate area 43-46.5°N and 127.5°W in the northeastern Pacific Ocean (LGL 2017). The proposed survey activity will not take place within or near a national marine sanctuary or marine monuments, wildlife refuge, National Park or other conservation area.

3.1.1. Ambient Sound

The need to understand the marine acoustic environment is critical when assessing the effects of anthropogenic noise on marine wildlife. Sounds generated by seismic surveys within the marine environment can affect its inhabitants' behavior (e.g., deflection from loud sounds) or ability to effectively live in the marine environment (e.g., masking of sounds that could otherwise be heard).

Ambient sound levels are the result of numerous natural and anthropogenic sounds that can propagate over large distances and vary greatly on a seasonal and spatial scale. These ambient sounds occupy all frequencies and contributions in ocean soundscape from a few hundred Hz to 200 kHz (NRC, 2003). The main sources of underwater ambient sound are typically associated with:

- Wind and wave action
- Precipitation
- Vessel activities
- Biological sounds (e.g. fish, snapping shrimp)

The contribution of these sources to background sound levels differs with their spectral components and local propagation characteristics (e.g., water depth, temperature, salinity, and ocean bottom conditions). In deep water, low-frequency ambient sound from 1-10 Hz mainly comprises turbulent pressure fluctuations from surface waves and the motion of water at the air-water interfaces. At these infrasonic frequencies, sound levels depend only slightly on wind speed. Between 20-300 Hz, distant anthropogenic sound (ship transiting, etc.) dominates wind-related sounds. Above 300 Hz, the ambient sound level depends on weather conditions, with wind- and wave-related effects mostly dominating sounds. Biological sounds arise from a variety of sources (e.g., marine mammals, fish, and shellfish) and range from approximately 12 Hz to over 100 kHz. The relative strength of biological sounds varies greatly; depending on the situation, biological sound can be nearly absent to dominant over narrow or even broad frequency ranges (Richardson et al. 1995).

3.2. Biological Environment

The primary component of the biological environment that would be impacted by the proposed issuance of an IHA would be marine mammals, which would be directly impacted by the authorization of incidental take.

3.2.1. Marine Mammal Habitat

We present information on marine mammal habitat and the potential impacts to marine mammal habitat in our Federal Register notice of the proposed IHA (82 FR 39276, August 17, 2017). Also, SIO presented more detailed information on the physical and oceanographic aspects of the central Pacific Ocean environment in the IHA application (LGL, 2017). In summary, there are no rookeries or major haulout sites nearby or ocean bottom structure of significant biological importance to marine mammals that may be present in the marine waters in the vicinity of the project area. No ESA-listed designated critical habitat exists in the area of the proposed activities. Marine mammals in the survey area use pelagic, open ocean waters, but may have differing habitat preferences based on their life history functions (LGL, 2017).

3.2.2. Marine Mammals

Of the 27 cetacean species that may occur within or near the survey area in the central Pacific Ocean, four are listed under the ESA as endangered or threatened: fin, sei, blue, sperm and humpback whales (Mexico DPS). The rest of this section deals with species distribution in the proposed survey area offshore Oregon and Washington. Information on the occurrence near the proposed survey area, habitat, population size, and conservation status for each of the cetacean species is presented in Table 4.

The spatial occurrence of the North Pacific right whale and dwarf sperm whale are such the proposed survey is not expected encounter the species. The North Pacific right whale is one of the most endangered species of whale in the world (Carretta *et al.* 2017). Only 82 sightings of right whales in the entire eastern North Pacific were reported from 1962 to 1999, with the majority of these occurring in the Bering Sea and adjacent areas of the Aleutian Islands (Brownell *et al.* 2001). Most sightings in the past 20 years have occurred in the southeastern Bering Sea, with a few in the Gulf of Alaska (Wade *et al.* 2011). Despite many miles of systematic aerial and ship-based surveys for marine mammals off the coasts of Washington, Oregon and California over several years, only seven documented sightings of right whales were made from 1990 to 2000 (Waite *et al.* 2003). Because of the small population size and the fact that North Pacific right whales spend the summer feeding in high latitudes, the likelihood that the proposed survey would encounter a North Pacific right whale right whale is discountable. Along the U.S. west coast, no at-sea sightings of dwarf sperm whales have ever been reported despite numerous vessel surveys of this region (Barlow 1995; Barlow and Gerrodette 1996; Barlow and Forney 2007; Forney 2007; Barlow 2010, Barlow 2016). Therefore, based on the best available information, the likelihood of the survey encountering a dwarf sperm whale is discountable. Thus, the North Pacific right whale and dwarf sperm whale are not discussed further in this document.

Table 4. Marine mammals that could occur in or near the proposed survey area in the northeastern Pacific Ocean.

Species	Stock	ESA/MMPA status; Strategic (Y/N)[1]	Stock abundance[2] (CV, Nmin, most recent abundance survey)[3]	PBR[4]	Relative Occurrence in Project Area
Order Cetartiodactyla – Cetacea – Superfamily Mysticeti (baleen whales)					
Family: Balaenopteridae					
Gray whale[5] (*Eschrichtius robustus*)	Eastern North Pacific	-/-; N	20,990 (0.05; 20,125; 2011)	3.1	Common in nearshore areas, rare elsewhere
Humpback whale[6] (*Megaptera novaeangliae*)	California/Oregon/Washington	E/T / D; N	1,918 (0.03; 1,876; 2014)	11	Common in nearshore areas, rare elsewhere
Minke whale (*Balaenoptera acutorostrata)*	California/Oregon/Washington	-/-; N	636 (0.72; 369; 2014)	3.5	Rare
Sei whale (*Balaenoptera borealis)*	Eastern N Pacific	E/D; Y	519 (0.4; 374; 2014)	0.75	Rare
Fin whale (*Balaenoptera physalus*	California/Oregon/Washington	E/D; Y	9,029 (0.12; 8,127; 2014)	81	Common
Blue whale (*Balaenoptera musculus)*	Eastern N Pacific	E/D; Y	1,647 (0.07; 1,551; 2011)	2.3	Rare
Order Cetartiodactyla – Cetacea – Superfamily Odontoceti (toothed whales, dolphins, and porpoises)					
Family: Physeteridae					
Sperm whale (*Physeter macrocephalus*)	California/Oregon/Washington	E/D; Y	2,106 (0.58; 1,332; 2014)	2.7	Common
Order Cetartiodactyla – Cetacea – Superfamily Odontoceti (toothed whales, dolphins, and porpoises)					
Family: Kogiidae					
Pygmy sperm whale (*Kogia breviceps*)	California/Oregon/Washington	-/-; N	4,111 (1.12; 1,924; 2014)	19	Rare
Order Cetartiodactyla – Cetacea – Superfamily Odontoceti (toothed whales, dolphins, and porpoises)					
Family delphinidae					
	West coast transient	-/-; N	243 (n/a; 243 ;2009)	2.4	Rare
	Eastern North Pacific offshore	-/-; N	240 (0.49; 162; 2014)	1.6	Rare
False killer whale[7] (*Pseudorca crassidens*)	Hawaii Pelagic	-/-; N	1,540 (0.66; 928; 2010)	9.3	Rare
Short-finned pilot whale (*Globicephala macrorhynchus*)	California/Oregon/ Washington	-/-; N	836 (0.79; 466; 2014)	4.5	Rare
	Northern Oregon/ Washington Coast	-/-; N	21,487 (0.44; 15,123; 2011)	151	Abundant
	Northern California / Southern Oregon	-/-; N	35,769 (0.52; 23,749; 2011)	475	Abundant
Dall's porpoise (*Phocoena dalli)*	California/Oregon/ Washington	-/-; N	25,750 (0.45; 17,954; 2014)	172	Abundant

Bottlenose dolphin (*Tursiops truncatus*)	California/Oregon/Washington Offshore	-/-; N	1,924 (0.54; 1,255; 2014)	11	Rare
Striped dolphin (*Stenella coeruleoala*)	California/Oregon/Washington	-/-; N	29,211 (0.2; 24,782; 2014)	238	Rare
Risso's dolphin (*Grampus griseus*)	California/Oregon/Washington	-/-; N	6,336 (0.32; 4,817; 2014)	46	Common
Short-beaked common dolphin (*Delphinus delphis*)	California/Oregon/Washington	-; N	969,861 (0.17; 839,325; 2014)	8,393	Common
Pacific white-sided dolphin (Lagenorhynchus obliquidens)	California/Oregon/Washington	-; N	26,814 (0.28; 21,195; 2014)	191	Abundant
Northern right whale dolphin (*Lissodelphis borealis*)	California/Oregon/Washington	-; N	26,556 (0.44; 18,608; 2014)	179	Common
Order Cetartiodactyla – Cetacea – Superfamily Odontoceti (toothed whales, dolphins, and porpoises)					
Family:Ziphiidae					
Cuvier's beaked whale (*Ziphius cavirostris*)	California/Oregon/Washington	-/-; N	6,590 (0.55; 4,481; 2008)	45	Common
Baird's beaked whale *(Berardius bairdii)*	California/Oregon/Washington	-; N	847 (0.81; 466; 2008)	4.7	Common
Mesoplodont beaked whales[8]	California/Oregon/Washington	-/-; N	694 (0.65; 389; 2008)	3.9	Rare
Order Carnivora – Superfamily Pinnipedia					
Family Otariidae (eared seals and sea lions)					
California sea lion (*Zalophus californianus*)	U.S.	-; N	296,750 (n/a; 153,337; 2011)	9,200	Rare
Steller sea lion (*Eumetopias jubatus*)	Eastern U.S.	-; N	41,638 (n/a; 41,638; 2015)	2,498	Common in nearshore areas, rare elsewhere
Family Phocidae (earless seals)					
Harbor seal [9] (*Phoca vitulina*)	Oregon/Washington Coast	-; N	24,732 (unk; unk; n/a)	Unknown	Common in nearshore areas, rare elsewhere
Northern elephant seal (*Mirounga angustirostris*)	California breeding	-; N	179,000 (n/a; 81,368; 2010)	4,882	Common in nearshore areas, rare elsewhere
Northern fur seal (*Callorhinus ursinus*)	California	-; N	14,050 (n/a; 7,524; 2013)	451	Common in nearshore areas, rare elsewhere

[1] Endangered Species Act (ESA) status: Endangered (E), Threatened (T)/MMPA status: Depleted (D). A dash (-) indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic stock is one for which the level of direct human-caused mortality exceeds PBR (see footnote 3) or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

[2] Abundance estimates from Carretta *et al.* (2017) unless otherwise noted.

[3] CV is coefficient of variation; N_{min} is the minimum estimate of stock abundance. In some cases, CV is not applicable. For certain stocks, abundance estimates are actual counts of animals and there is no associated CV. The most recent abundance survey that is reflected in the abundance estimate is presented; there may be more recent surveys that have not yet been incorporated into the estimate.

[4] Potential biological removal (PBR), defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population size (OSP).

[5] Values for gray whale and North Pacific right whale are from Muto *et al.* 2016.

[6] Humpback whales in the survey area could originate from either the ESA threatened Mexico DPS or from the ESA endangered Central America DPS.

[7] NMFS does not have a defined stock for false killer whales off the West Coast of the U.S. as they are considered uncommon visitors to the area; any false killer whales observed off the West Coast of the U.S. would likely be part of the eastern North Pacific population. Of the stocks defined by NMFS, the Hawaii Pelagic stock is the most likely to include individuals in the eastern North Pacific population.

[8] Includes the following species: Blainville's beaked whale (*M. densirostris*), Perrin's beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubbs' beaked whale (*M. carlhubbsi*).

[9] The most recent abundance estimate is from 1999. This is the best available information, but because this abundance estimate is >8 years old, there is no current estimate of abundance available for this stock.

3.2.2.1 ESA-Listed Species

Sei Whale

The sei whale occurs in all ocean basins (Horwood 2009) but appears to prefer mid-latitude temperate waters (Jefferson *et al.* 2008). It undertakes seasonal migrations to feed in subpolar latitudes during summer and returns to lower latitudes during winter to calve (Horwood 2009). The sei whale is pelagic and generally not found in coastal waters (Harwood and Wilson 2001). It occurs in deeper waters characteristic of the continental shelf edge region (Hain *et al.* 1985) and in other regions of steep bathymetric relief such as seamounts and canyons (Kenney and Winn 1987; Gregr and Trites 2001).

Sei whales are rare in the waters off California, Oregon, and Washington (Brueggeman et al. 1990; Green et al. 1992; Barlow 1994, 1997). Only nine confirmed sightings were reported for California, Oregon, and Washington during extensive surveys from 1991–2008, including two within or near the westernmost portion of the Southern Oregon survey area (Green et al. 1992, 1993; Hill and Barlow 1992; Carretta and Forney 1993; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999; Barlow 2003; Forney 2007; Barlow 2010; Carretta et al. 2016a). Two sightings of four individuals were made from the *Langseth* seismic vessel off Washington/Oregon during June–July 2012 (RPS 2012), including within the proposed project area. Sei whales are listed as endangered under the ESA, and the Eastern North Pacific stock of sei whales is considered a depleted and strategic stock under the MMPA.

Fin Whale

The fin whale is widely distributed in all the world's oceans (Gambell 1985), although it is most abundant in temperate and cold waters (Aguilar 2009). Nonetheless, its overall range and distribution are not well known (Jefferson et al. 2008). The fin whale most commonly occurs offshore, but can also be found in coastal areas (Aguilar 2009). Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in summer (Aguilar 2009). However, recent evidence suggests that some animals may remain at high latitudes in winter or low latitudes in summer (Edwards et al. 2015).

The fin whale is known to use the shelf edge as a migration route (Evans 1987). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily, or because the contours are areas of high biological productivity. However, fin whale movements have been reported to be complex, and not all populations follow this simple pattern (Jefferson et al. 2008). Stafford et al. (2009) noted that sea-surface temperature is a good predictor variable for fin whale call detections in the North Pacific.

North Pacific fin whales summer from the Chukchi Sea to California and winters from California southwards (Gambell 1985). In the U.S., three stocks are recognized in the North Pacific: California/Oregon/Washington, Hawaii, and Northeast Pacific (Carretta et al. 2015). Information about the seasonal distribution of fin whales in the North Pacific has been obtained from the detection of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2007, 2009). Fin whale calls are recorded in the North Pacific year-round (e.g., Moore et al. 2006; Stafford et al. 2007, 2009). In the central North Pacific, call rates peak during fall and winter (Moore et al. 1998, 2006; Watkins et al. 2000a,b).

The North Pacific population summers from the Chukchi Sea to California and winters from California southwards (Gambell 1985). 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; Edwards et al. 2015). Vocalizations from fin whales have also been detected year-round off northern California, Oregon, and Washington (Moore et al. 1998, 2006; Watkins et al. 2000a; Stafford et al. 2007, 2009). Fin whales are listed as endangered under the ESA, and the California/Oregon/Washington stock of fin whales is considered depleted and strategic under the MMPA.

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). Blue whale migration is less well defined than for some other rorquals, and their movements tend to be more closely linked to areas of high primary productivity, and hence prey, to meet their high energetic demands (Branch *et al.* 2007). Generally, blue whales are seasonal migrants between high latitudes in the summer, where they feed, and low latitudes in the winter, where they mate and give birth (Lockyer and Brown 1981). Some individuals may stay in low or high latitudes throughout the year (Reilly and Thayer 1990; Watkins *et al.* 2000). North Pacific blue whales were once thought to belong to as many as five separate populations (Reeves *et al.* 1998), but acoustic evidence suggests only two populations, in the eastern and western North Pacific, respectively (Stafford *et al.* 2001, Stafford 2003, McDonald *et al.* 2006, Monnahan *et al.* 2014). Only the Eastern North Pacific stock of blue whale occurs in the proposed survey area.

Blue whale densities along the U.S. west coast including Oregon are believed to be highest in shelf waters, with lower densities in deeper offshore areas (Becker et al. 2012; Calambokidis et al. 2015). Based on the absolute dynamic topography of the region, blue whales could occur in relatively high densities off Oregon during July–December (Pardo et al. 2015).

Five blue whale sightings were reported in the proposed project area off Oregon/Washington during 1991–2008; one sighting occurred within the nearshore portion of the proposed Astoria Fan survey area, and four sightings occurred nearshore, east of the Southern Oregon survey area (Carretta et al. 2017). Hazen et al. (2016) examined blue whale tag data from 182 individuals along the western United States during 1993–2008; multiple tag data tracks were within the proposed project area, particularly between August and November. Blue whales are listed as endangered under the ESA, and the Eastern North Pacific stock of blue whales is considered a depleted and strategic stock under the MMPA.

Sperm Whale

Sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea in summer, but the majority are thought to be south of 40°N in winter (Rice 1974, 1989; Gosho *et al*. 1984; Miyashita *et al*. 1995). They are generally distributed over large areas that have high secondary productivity and steep underwater topography, in waters at least 1000 m deep (Jaquet and Whitehead 1996; Whitehead 2009).

Sperm whales are seen off Washington and Oregon in every season except winter (Green et al. 1992). Estimates of sperm whale abundance in California, Oregon, and Washington waters out to 300 nautical miles ranged between 2,000 and 3,000 animals for the 1991-2008 time series (Moore and Barlow 2014). At least five sightings during these surveys were within or adjacent to the Southern Oregon survey area, and one sighting was within the Astoria Fan survey area (Carretta et al. 2017). Sperm whales are listed as endangered under the ESA, and the California/Oregon/Washington stock is considered depleted and strategic under the MMPA.

Humpback Whale

Humpback whales are found worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres (Muto *et al.*, 2015). These wintering grounds are used for mating, giving birth, and nursing new calves. Humpback whales migrate nearly 3,000 mi (4,830 km) from their winter breeding grounds to their summer foraging grounds in Alaska. The humpback whale is the most common species of large cetacean reported off the coasts of Oregon and Washington from May to November (Green *et al.* 1992; Calambokidis *et al.* 2008).

There are five stocks of humpback whales, one of which occurs along the U.S. west coast: The California/Oregon/Washington Stock, which includes animals that appear to be part of two separate feeding groups, a California and Oregon feeding group and a northern Washington and southern British Columbia feeding group (Calambokidis *et al.* 2008, Barlow *et al.* 2011). Very few photographic matches between these feeding groups have been documented (Calambokidis *et al.* 2008). Humpbacks from both groups have been photographically matched to breeding areas off Central America, mainland Mexico, and Baja California, but whales from the northern Washington and southern British Columbia feeding group also winter near the Hawaiian Islands and the Revillagigedo Islands off Mexico (Barlow *et al.* 2011).

Humpback whales were listed as endangered under the Endangered Species Conservation Act (ESCA) in June 1970. In 1973, the ESA replaced the ESCA, and humpbacks continued to be listed as endangered. NMFS recently evaluated the status of the species, and on September 8, 2016, NMFS divided the species into 14 distinct population segments (DPS), removed the current species-level listing, and in its place listed four DPSs as endangered and one DPS as threatened (81 FR 62259; September 8, 2016). The remaining nine DPSs were not listed. The Mexico DPS and the Central America DPS are the only DPSs that are expected to occur in the survey area. The Mexico DPS is listed as threatened and the Central America DPS is listed as endangered under the ESA (81 FR 62259; September 8, 2016). The California/Oregon/Washington stock is considered a depleted and strategic stock under the MMPA.

3.2.2.2 Non-ESA Listed Species

Minke Whale

The minke whale has a cosmopolitan distribution ranging from the tropics and subtropics to the ice edge in both hemispheres (Jefferson *et al*. 2008). The California/Oregon/Washington stock of minke whale is the only stock that occurs in the proposed survey area. Minke whale sightings have been made off Oregon and Washington in shelf and deeper waters (Green et al. 1992; Adams et al. 2014; Carretta et al. 2017). A single minke whale was observed off the outer Washington coast (~47ºN) during small boat surveys from August 2004 through September 2008, 14 km from shore with a bottom depth of 38 m (Oleson et al. 2009). One sighting was made near the Astoria Fan survey area at the 200-m isopleth off the mouth of the Columbia River in July 2012 (Adams et al. 2014). Minke whales strandings have been reported in all seasons in Washington; most strandings (52 percent) occurred in spring (Norman et al. 2004). The minke whale is not listed as threatened or endangered under the ESA, and the California/Oregon/Washington stock is not listed as depleted or strategic under the MMPA.

Gray Whale

Gray whales occur along the eastern and western margins of the North Pacific. During summer and fall, most whales in the Eastern North Pacific stock feed in the Chukchi, Beaufort and northwestern Bering Seas, with the exception of a relatively small number of whales (approximately 200) that summer and feed along the Pacific coast between Kodiak Island, Alaska and northern California (Carretta *et al.* 2017). Three primary wintering lagoons in Baja California, Mexico are utilized, and some females are known to make repeated returns to specific lagoons (Jones 1990).

According to predictive density distribution maps, low densities of gray whales could be encountered throughout the Astoria Fan and Southern Oregon survey areas (Menza *et al.* 2016). During aerial surveys over the shelf and slope off Oregon and Washington, gray whales were seen during the months of January, June–July, and September; one sighting was made within the Astoria Fan survey area in water >200 m during June 2011 (Adams *et al.* 2014). The proposed surveys would occur during the summer feeding season for gray whales in the Washington/Oregon region. Thus, gray whales could be encountered in the eastern portion of the proposed project area where the water is shallower. The Eastern North Pacific gray whale is not listed as threatened or endangered under the ESA nor is it classified as a depleted or strategic stock under the MMPA.

Pygmy Sperm Whales

Pygmy sperm whales are distributed throughout deep waters and along the continental slopes of the North Pacific and other ocean basins (Ross 1984; Caldwell and Caldwell 1989). Along the U.S. west coast, sightings of this species and of animals identified only as Kogia sp. have been rare (Figure 1). However, this probably reflects their pelagic distribution, small body size and cryptic behavior, rather than a measure of rarity. Barlow (2010) used data collected in 1991–2008 to estimate an abundance of 229 *Kogia* sp. off Oregon and Washington. However, no *Kogia* sp. were sighted during surveys off Oregon and Washington in 2014 (Barlow 2016). While uncommon, pygmy whales could be encountered within the proposed project area. Pygmy sperm whales are not listed as endangered or threatened under the ESA, and the California to Washington stock is not considered strategic or designated as depleted under the MMPA.

Killer whale

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters (Heyning and Dahlheim 1988), killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast, in British Columbia and Washington inland waterways, and along the outer coasts of Washington, Oregon and California (Carretta *et al*. 2017). Based on aspects of morphology, ecology, genetics and behavior killer whale stocks off the west coast of the United States are classified as either resident, transient or offshore (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992, Hoelzel et al. 1998). The offshore stocks apparently do not mix with the transient and resident killer whale stocks found in these regions (Ford et al. 1994, Black et al. 1997).

Eight killer whale stocks are recognized within the Pacific U.S. Exclusive Economic Zone. Of these, two stocks occur in the proposed project area: the West Coast Transient stock which occurs from Alaska through California, and the Eastern North Pacific Offshore stock which occurs from Southeast Alaska through California. Killer whales are not listed as endangered or threatened under the ESA (with the exception of the endangered Southern Resident DPS which does not occur in the survey area), and the West Coast Transient stock and Eastern North Pacific Offshore stock are not designated as depleted or strategic under the MMPA.

False killer whale

False killer whales are found worldwide in tropical and warm-temperate waters (Stacey et al. 1994). In the North Pacific, this species occurs throughout the waters of southern Japan, Hawaii, and the eastern tropical Pacific. The species generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow water (Jefferson *et al.* 2008; Baird 2009). False killer whales are typically only observed off the U.S. west coast during warm-water periods. Several sightings were made off California during 2014-2016 when waters were unusually warm (pers. comm. K. Forney, NMFS Southwest Fisheries Science Center, to J. Carduner, NMFS, July 27, 2017). False killer whales observed in the survey area would be expected to originate from the eastern North Pacific population that is primarily found south of United States waters. NMFS does not have a defined stock for false killer whales off the west coast of the United States as they are considered uncommon visitors to the area; any false killer whales observed off the West Coast of the United States would likely be part of the broader eastern North Pacific population. Of the stocks defined by NMFS, the Hawaii Pelagic stock is the most likely to include individuals in the eastern North Pacific population. False killer whales are not listed as endangered or threatened under the ESA (with the exception of the endangered Main Hawaiian Islands insular DPS which does not occur in the survey area), and the Hawaii pelagic stock is not designated as depleted or strategic under the MMPA.

Short-finned pilot whale

Short-finned pilot whales are found in all oceans, primarily in tropical and warm-temperate waters (Carretta *et al.*, 2016). The species prefers deeper waters, ranging from 324 m to 4,400 m, with most sightings between 500 m and 3,000 m (Baird 2016). The California/Oregon/Washington Stock of short-finned pilot whales are largely confined to the California Current and eastern tropical Pacific. After a strong El Niño event in 1982-83, short-finned pilot whales virtually disappeared from this region, and despite increased survey effort along the entire U.S. west coast, sightings and fishery takes are rare and have primarily occurred during warm-water years (Julian and Beeson 1998, Carretta et al. 2004, Barlow 2016). No short-finned pilot whales were seen during surveys off Oregon and Washington in 1989–1990, 1992, 1996, and 2001 (Barlow 2003). A few sightings were made off California during surveys in 1991–2008 (Barlow 2010). Carretta et al. (2017) reported two sightings off Oregon during 1991–2008, both near the southern portion of the Astoria Fan survey area. Short-finned pilot whales are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Harbor porpoise

In the eastern North Pacific Ocean, harbor porpoise are found in coastal and inland waters from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise are known to occur year-round in the inland transboundary waters of Washington and British Columbia, Canada (Osborne et al. 1988) and along the Oregon/Washington coast (Barlow 1988, Barlow et al. 1988, Green et al. 1992). Based on recent genetic evidence (Chivers *et al.* 2002, 2007) there are three separate stocks of North Pacific harbor porpoise that occur in Oregon/Washington waters: a Northern California/Southern Oregon stock (Point Arena, CA, to Lincoln City, OR), a Northern Oregon/Washington Coast stock (Lincoln City, OR, to Cape Flattery, WA), and the Washington Inland Waters stock (in waters east of Cape Flattery). Only the Northern California/Southern Oregon stock and Northern Oregon/Washington Coast stock occur in the proposed survey area.

Harbor porpoises inhabit coastal Oregon and Washington waters year-round, although there appear to be distinct seasonal changes in abundance there (Barlow 1988; Green et al. 1992). Green et al. (1992) reported that encounter rates were high during fall and winter, intermediate during spring, and low during summer. Encounter rates were highest along the Oregon/Washington coast in the area from Cape Blanco (~43°N), east of the proposed Southern Oregon survey area, to California, from fall through spring. During summer, the reported encounter rates decreased notably from inner shelf to offshore waters. Nearly 100 sightings were reported within or east of the proposed project area during aerial surveys in 2007–2012 (Forney et al. 2014). Two sightings of nine individuals were made from the *Langseth* seismic vessel off the southern coast of Washington during July 2012 (RPS 2012); all sightings occurred nearshore and to the east of the Astoria Fan survey area. The harbor porpoise is not listed as endangered or threatened under the ESA and the Northern California/Southern Oregon stock and Northern Oregon/Washington Coast stock are not considered depleted or strategic stocks under the MMPA.

Dall’s porpoise

The Dall’s porpoise is distributed throughout temperate to subantarctic waters of the North Pacific and adjacent seas (Jefferson et al. 2015). Off the U.S. west coast, they are generally found along shelf, slope and offshore waters (Morejohn 1979). Dall’s porpoise is likely the most abundant small cetacean in the North Pacific Ocean, and its abundance changes seasonally, likely in relation to water temperature (Becker 2007). Becker et al. (2014) projected high densities off southern Oregon throughout the year, with moderate densities to the north. According to predictive density distribution maps, the highest densities off southern Washington and Oregon occur along the 500 m isobath (Menza et al. 2016). Dall’s porpoise was the most abundant species sighted off Oregon/Washington during 1996, 2001, 2005, and 2008 shipboard surveys up to ~550 km from shore (Barlow 2003, 2010) with numerous other sightings within and near the Astoria Fan and Southern Oregon survey areas during the summer and fall (Becker et al. 2014; Carretta et al. 2016a). Dall’s porpoise is not listed as threatened or endangered under the ESA and the California/Oregon/Washington stock is not classified as a depleted or strategic stock under the MMPA.

Bottlenose dolphin

Bottlenose dolphins are widely distributed throughout the world in tropical and warm-temperate waters (Perrin *et al*. 2009). Generally, there are two distinct bottlenose dolphin ecotypes: one mainly found in coastal waters and one mainly found in oceanic waters (Duffield *et al*. 1983; Hoelzel *et al*. 1998; Walker *et al*. 1999). As well as inhabiting different areas, these ecotypes differ in their diving abilities (Klatsky 2004) and prey types (Mead and Potter 1995). Bottlenose dolphins occur frequently off the coast of California, and sightings have been made as far north as 41º N, but few records exist offshore Oregon and Washington (Carretta et al. 2017). Adams et al. (2014) made one sighting in Washington, to the north of the Astoria Fan survey area, during September 2012. Bottlenose dolphins are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington pelagic stock is not considered a depleted or strategic stock under the MMPA.

Striped dolphin

Striped dolphins are found in tropical to warm-temperate waters throughout the world (Carretta *et al.*, 2016). However, in the eastern North Pacific, its distribution extends as far north as Washington (Jefferson et al. 2015). Striped dolphins are a deep water species, preferring depths greater than 3,500 m (Baird 2016), but have been observed approaching shore where there is deep water close to the coast (Jefferson *et al*. 2008). The abundance of striped dolphins off the U.S. west coast appears to be variable among years and could be affected by oceanographic conditions (Carretta et al. 2016a).

Striped dolphins regularly occur off California (Becker et al. 2012), where they are seen 185–556 km from the coast (Carretta et al. 2017), though very few sightings have been made off Oregon (Barlow 2016), and no sightings have been reported for Washington. However, strandings have occurred along the coasts of Oregon and Washington (Carretta et al. 2017). During surveys off the U.S. west coast in 2014, striped dolphins were seen as far north as 44º N. Striped dolphins are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Short-beaked common dolphin

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Perrin 2009). Short-beaked common dolphins are the most abundant cetacean off California, and are widely distributed between the coast and at least 300 nautical miles from shore. It ranges as far south as 40° S in the Pacific Ocean, is common in coastal waters 200–300 m deep, and is also associated with prominent underwater topography, such as sea mounts (Evans 1994).

Few sightings of short-beaked common dolphins have been made off Oregon, and no sightings exist for Washington waters (Carretta et al. 2017). During surveys in 1991–2008, one sighting was made within the Astoria Fan survey area, and several records exist southwest of the Southern Oregon survey area (Carretta et al. 2017). During surveys off the west coast in 2014, sightings were made as far north as 44° N (Barlow 2014). Short-beaked common dolphins are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Pacific white-sided dolphin

Pacific white-sided dolphins are endemic to temperate waters of the North Pacific Ocean, and common both on the high seas and along the continental margins (Brownell et al. 1999). In the eastern North Pacific Ocean, including waters off Oregon, the Pacific white-sided dolphin is one of the most common cetacean species, occurring primarily in shelf and slope waters (Green et al. 1993; Barlow 2003, 2010). It is known to occur close to shore in certain regions, including seasonally off southern California (Brownell et al. 1999).

Based on year-round aerial surveys off Oregon/Washington, the Pacific white-sided dolphin was the most abundant cetacean species (Green et al. 1992, 1993). Adams et al. (2014) also reported numerous offshore sightings off Oregon during summer, fall, and winter surveys in 2011 and 2012, including in the Southern Oregon survey area during September. Pacific white-sided dolphins are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Northern right whale dolphin

Northern right-whale dolphins are endemic to temperate waters of the North Pacific Ocean. Off the U.S. west coast, they have been seen primarily in shelf and slope waters, with seasonal movements into the Southern California Bight (Leatherwood and Walker 1979; Dohl et al. 1980; 1983). Becker et al. (2014) predicted relatively high densities off southern Oregon, and moderate densities off northern Oregon and Washington. Barlow (2003, 2010) also found that the northern right whale dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996, 2001, 2005, and 2008 shipboard surveys. Several sightings were within and near the Astoria Fan and Southern Oregon survey areas during the summer and fall during surveys off California, Oregon and Washington (Forney 2007; Barlow 2010; Becker et al. 2012; Carretta et al. 2017). Northern right-whale dolphins are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Risso's dolphin

Risso's dolphins are found in tropical to warm-temperate waters (Carretta *et al.*, 2016). The species occurs from coastal to deep water but is most often found in depths greater than 3,000 m with the highest sighting rate in depths greater than 4,500 m (Baird 2016). It primarily occurs between 60ºN and 60ºS where surface water temperatures are at least 10ºC (Kruse *et al*. 1999). The distribution and abundance of Risso's dolphin is highly variable from California to Washington, presumably in response to changing oceanographic conditions on both annual and seasonal time scales (Forney and Barlow 1998; Buchanan et al. 2001). The highest densities were predicted along the coasts of Washington, Oregon, and central and southern California (Becker et al. 2012). Off Oregon and Washington, Risso's dolphins are most abundant over continental slope and shelf waters during spring and summer, less so during fall, and rare during winter (Green et al. 1992, 1993). Risso's dolphins were sighted off Oregon, including near the Astoria Fan and Southern Oregon survey areas, in June and October 2011 (Adams et al. 2014). Risso's dolphins are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Cuvier's beaked whale

Cuvier's beaked whale is the most widespread of the beaked whales occurring in almost all temperate, subtropical, and tropical waters and even some sub-polar and polar waters (MacLeod *et al*. 2006). It is found in deep water over and near the continental slope (Jefferson *et al*. 2008). Cuvier's beaked whale abundance for waters off Oregon and Washington in 2014 was estimated at 432 (Barlow 2016). One Cuvier's beaked whale sighting was made west of the proposed Southern Oregon survey area during the 1991–2008 surveys (Carretta et al. 2017). One sighting of three individuals was recorded in June 2006 during surveys off Washington during August 2004 through September 2008, north of the Astoria Fan survey area (Oleson et al. 2009). Cuvier's beaked whales are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Baird's beaked whale

Baird's beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean (Balcomb 1989, Macleod et al. 2006). It is sometimes seen close to shore where deep water approaches the coast, but its primary habitat is over or near the continental slope and oceanic seamounts (Jefferson et al. 2015). Along the U.S. west coast, Baird's beaked whales have been sighted primarily along the continental slope (Green et al. 1992; Becker et al. 2012; Carretta et al. 2016a) from late spring to early fall (Green et al. 1992). During 1991–2008 surveys, several sightings were reported to the south and west of the Southern Oregon survey area, to the west of the Astoria Fan survey area, and within the eastern portion of the Astoria Fan survey area (Carretta et al. 2017). Predicted density modeling showed higher densities in slope waters off northern Oregon, near the Astoria Fan survey area, compared with southern Oregon (Becker et al. 2012). Baird's beaked whales are not listed as endangered or threatened under the ESA, and the California/Oregon/Washington stock is not considered a depleted or strategic stock under the MMPA.

Mesoplodont beaked whales

Mesoplodont beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean. The six species known to occur in this region are: Blainville's beaked whale (*M. densirostris*), Perrin's beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubbs' beaked whale (*M. carlhubbsi*) (Mead 1989, Henshaw et al. 1997, Dalebout et al. 2002, MacLeod et al. 2006). Based on bycatch and stranding records in this region, it appears that Hubb's beaked whale is most commonly encountered (Carretta et al. 2008, Moore and Barlow 2013). Insufficient sighting records exist off the U.S. west coast to determine any possible spatial or seasonal patterns in the distribution of mesoplodont beaked whales. Until methods of distinguishing these six species at-sea are developed, the management unit must be defined to include all *Mesoplodon* stocks in this region. Although mesoplodont beaked whales have been sighted along the U.S. west coast on several line transect surveys utilizing both aerial and shipboard platforms, the rarity of sightings has historically precluded reliable population estimates. Mesoplodont beaked are not listed as endangered or threatened under the ESA, and the California, Oregon and Washington stock is not considered a depleted or strategic stock under the MMPA.

California sea lion

The primary range of the California sea lion includes the coastal areas and offshore islands of the eastern North Pacific Ocean from British Columbia, Canada, to central Mexico, including the

Gulf of California (Jefferson *et al.* 2015). However, its distribution is expanding (Jefferson *et al.* 2015), and its secondary range extends into the Gulf of Alaska where it is occasionally recorded (Maniscalco *et al.* 2004) and southern Mexico (Gallo-Reynoso and Solórzano-Velasco 1991). California sea lion breeding areas are on islands located in southern California, in western Baja California (Mexico), and the Gulf of California. During the breeding season, most California sea lions inhabit southern California and Mexico. In California and Baja California, births occur on land from mid-May to late June.

California sea lions are coastal animals that often haul out on shore throughout the year. Off Oregon and Washington, peak numbers occur during the fall. During aerial surveys off the coasts of Oregon and Washington during 1989–1990, California sea lions were sighted at sea during the fall and winter, but no sightings were made during June–August (Bonnell et al. 1992). Numbers off Oregon decrease during winter, as animals travel further north (Mate 1975 *in* Bonnell et al. 1992). California sea lions are not listed as threatened or endangered under the Endangered Species Act, and the U.S. stock is not considered a depleted or strategic stock under the MMPA.

Steller sea lion

Steller sea lions range along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984), with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands. They typically inhabit waters from the coast to the outer continental shelf and slope throughout their range and are not considered migratory, although foraging animals can travel long distances (Loughlin *et al.* 2003; Raum-Suryan *et al.* 2002).

During surveys off the coasts of Oregon and Washington, Bonnell *et al.* (1992) noted that 89 percent of sea lions occurred over the shelf at a mean distance of 21 km from the coast and near or in waters <200 m deep; the farthest sighting occurred ~40 km from shore, and the deepest sighting location was 1,611 m deep. Sightings were made along the 200 m depth contour within and near the proposed Astoria Fan and Southern Oregon survey sites throughout the year (Bonnell et al. 1992). The Eastern DPS of Steller sea lions is not listed as endangered or threatened under the ESA and the Eastern U.S. stock is not considered a depleted or strategic stock under the MMPA.

Harbor seal

Harbor seals inhabit coastal and estuarine waters off Baja California, north along the western coasts of the continental United States, British Columbia, and Southeast Alaska, west through the Gulf of Alaska and Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. They haul out on rocks, reefs, beaches, and drifting glacial ice and feed in marine, estuarine, and occasionally fresh waters. Harbor seals generally are non-migratory, with local movements associated with tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981).

Jeffries et al. (2000) documented several harbor seal rookeries and haulouts along the Washington coastline; it is the only pinniped species that breeds in Washington. During surveys off the Oregon and Washington coasts, 88 percent of at-sea harbor seals occurred over shelf waters <200 m deep, with a few sightings near the 2000 m contour, and only one sighting over deeper water (Bonnell et al. 1992). Most (68 percent) at-sea sightings were recorded in September and November (Bonnell et al. 1992). Harbor seals are not listed as endangered or threatened under the ESA and the Oregon/Washington coast stock is not considered a depleted or strategic stock under the MMPA.

Northern elephant seal

Northern elephant seals gather at breeding areas, located primarily on offshore islands of Baja California and California, from approximately December to March before dispersing for feeding. Males feed near the eastern Aleutian Islands and in the Gulf of Alaska, while females feed at sea south of 45° N (Stewart and Huber, 1993; Le Boeuf *et al*., 1993). Although movement and genetic exchange continues between rookeries, most elephant seals return to their natal rookeries when they start breeding (Huber *et al*., 1991). The California breeding population is now demographically isolated from the Baja California population and is considered to be a separate stock. Only the California breeding population is expected to occur in the proposed survey area. Off Washington, most elephant seal sightings at sea were during June, July, and September; off Oregon, sightings were recorded from November through May (Bonnell et al. 1992). Several seals were seen off Oregon during summer, fall, and winter surveys in 2011 and 2012, including one near the Southern Oregon survey area during October 2011 (Adams et al. 2014). Northern elephant seals are not listed as threatened or endangered under the ESA and the California breeding population is not considered a depleted or strategic stock under the MMPA.

Northern fur seal

Northern fur seals occur from southern California north to the Bering Sea and west to the Okhotsk Sea and Honshu Island, Japan. Two stocks of northern fur seals are recognized in U.S. waters: an eastern Pacific stock and a California stock (formerly referred to as the San Miguel Island stock). Only the California stock is expected to occur in the proposed survey area. Due to differing requirements during the annual reproductive season, adult males and females typically occur ashore at different, though overlapping, times. Adult males occur ashore and defend reproductive territories during a 3-month period from June through August while adult females are found ashore for as long as 6 months (June-November). The northern fur seals spends ~90 percent of its time at sea, typically in areas of upwelling along the continental slopes and over seamounts (Gentry 1981). The remainder of its life is spent on or near rookery islands or haulouts.

Bonnell et al. (1992) noted the presence of northern fur seals year-round off Oregon/Washington, with the greatest numbers (87 percent) occurring in January–May. Northern fur seals were seen as far out from the coast as 185 km, and numbers increased with distance from land; they were 5–6 times more abundant in offshore waters than over the shelf or slope (Bonnell et al. 1992). The highest densities were seen in the Columbia River plume (~46°N) and in deep offshore waters (>2000 m) off central and southern Oregon (Bonnell et al. 1992). The waters off Washington are a known foraging area for adult females, and concentrations of fur seals were also reported to occur near Cape Blanco, Oregon, at ~42.8° N (Pelland *et al.* 2014). Northern fur seals are not listed as threatened or endangered under the ESA listed and the California stock is not considered a depleted or strategic stock under the MMPA.

3.3. Socioeconomic Environment

3.3.1. Subsistence

There are no subsistence harvests for marine mammals in this area of the northeastern Pacific Ocean. Therefore, we anticipate no impacts to the subsistence harvest of marine mammals in the region.

Chapter 4 Environmental Consequences

The National Marine Fisheries Service (NMFS) reviewed all possible direct, indirect, cumulative, short-term, long-term impacts to protected species and their environment, associated with NMFS proposed action and alternatives. Based on this review, this section describes the potential environmental consequences for the affected resources described in Chapter 3.

4.1. Effects of Alternative 1 – Issuance of an IHA with Mitigation Measures

Under the Preferred Alternative, we would propose to issue an IHA to SIO allowing the take, by Level A and Level B harassment, of 27 species of marine mammals incidental to the proposed seismic survey, subject to the mandatory mitigation and monitoring measures and reporting requirements set forth in the Authorization, if issued. We would incorporate the mitigation and monitoring measures and reporting described earlier in this EA into a final Authorization.

4.1.1. Impacts to Marine Mammal Habitat

The proposed action (i.e., the issuance of an IHA for the take of marine mammals) would not result in any permanent impacts to marine mammals' habitat and would have only minimal, short-term effects on prey species. The proposed survey would not result in substantial damage to ocean and coastal habitats that constitute marine mammal habitats as airgun sounds do not result in physical impacts to habitat features, including substrates and/or water quality, and no anchoring of the vessel will occur during the survey as the survey is planned in water depths where anchoring is not practicable. The primary potential impacts to marine mammal habitat associated with elevated sound levels produced by the seismic airguns would have a limited effect on prey species.

The overall response of fishes and squids from seismic surveys is to exhibit responses including no reaction or habituation (Peña, Handegard, & Ona, 2013) to startle responses and/or avoidance (Fewtrell & McCauley, 2012) and vertical and horizontal movements away from the sound source. McCauley et al. (2017) reported that experimental exposure to a 150 in^3 airgun pulse decreased zooplankton abundance when compared with controls, and caused a two- to threefold increase in dead adult and larval zooplankton. Impacts to marine mammal prey are expected to be limited due to the relatively small temporal and spatial overlap between the proposed survey and any areas used by marine mammal prey species. The proposed survey would occur over a relatively short time period (5 days) and would occur over a very small area relative to the area available as marine mammal habitat in the northeastern Pacific Ocean. The proposed survey area is not known as a significant feeding area for any marine mammals and any impacts to marine mammal prey would be insignificant due to the limited spatial and temporal impact of the proposed survey. We expect that the seismic survey would have no more than a temporary and minimal adverse effect on any fish or invertebrate species. Although there is a small potential for injury to fish or marine life in close proximity to the vessel, we expect that the impacts of the seismic survey on fish and other marine life specifically related to acoustic activities would be temporary in nature, negligible, and would not result in substantial impact to these species' role in the ecosystem.

4.1.2. Impacts to Marine Mammals

We expect that SIO's seismic survey has the potential to take marine mammals by harassment, as defined by the MMPA. Acoustic stimuli generated by the airgun array may affect marine mammals in one or more of the following ways: behavioral disturbance, tolerance, masking of natural sounds, and temporary or permanent hearing impairment, or non-auditory physical effects (Richardson, Greene, Malme, & Thomson, 1995).

Our Federal Register notice of proposed Authorization (82 FR 39276, August 17, 2017) and SIO's application (LGL, 2017) provide detailed descriptions of these potential effects of seismic surveys on marine mammals. Potentinal effects are outlined below.

The effects of noise on marine mammals are highly variable, ranging from minor and negligible to potentially significant, depending on the intensity of the source, the distances between the animal and the source, and the overlap of the source frequency with the animals' audible frequency. Nevertheless, monitoring and mitigation measures required by NMFS for SIO's proposed activities would effectively reduce any significant adverse effects of these sound sources on marine mammals. The following descriptions summarize acoustic effects resulting from the use of airguns:

Behavioral Disturbance: The studies discussed in the *Federal Register* notice for the proposed Authorization (82 FR 39276, August 17, 2017) note that there is variability in the behavioral responses of marine mammals to noise exposure. It is important to consider context in predicting and observing the level and type of behavioral response to anthropogenic signals (Ellison, Southall, Clark, & Frankel, 2012).

Marine mammals may react to sound when exposed to anthropogenic noise. These behavioral reactions are often shown as: changing durations of surfacing and dives number of blows per surfacing; changing direction and/or speed; reduced/increased vocal activities; changing or cessation of certain behavioral activities (such as socializing or feeding); visible startle response or aggressive behavior (such as tail/fluke slapping or jaw clapping); avoidance of areas where noise sources are located; and/or flight responses (e.g., pinnipeds flushing into water from haulouts or rookeries). The onset of behavioral disturbance from anthropogenic noise depends on both external factors (characteristics of noise sources and their paths) and the receiving animals (hearing, motivation, experience, demography) and is also difficult to predict (Richardson et al., 1995; Southall et al., 2007).

Studies have shown that underwater sounds from seismic activities are often readily detectable by marine mammals in the water at distances of many kilometers (Castellote, Clark, & Lammers, 2012; Castellote & Llorens 2016). Many studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response when exposed to seismic activities (e.g., Akamatsu, Hatakeyama, & Takatsu, 1993; Harris, Miller, & Richardson, 2001; Madsen & Møhl, 2000; Malme, Miles, Clark, Tyack, & Bird, 1983, 1984; Richardson, Würsig, & Greene Jr., 1986; Weir, 2008). Other studies have shown that marine mammals continue important behaviors in the presence of seismic pulses (e.g., Dunn & Hernandez, 2009; Greene Jr., Altman, & Richardson, 1999; Holst & Beland, 2010; Holst & Smultea, 2008; Holst, Smultea, Koski, & Haley, 2005; Nieukirk, Stafford, Mellinger, Dziak, & Fox, 2004; Richardson et al., 1986; Smultea, Holst, Koski, & Stoltz, 2004).

In a passive acoustic research program that mapped the soundscape in the North Atlantic Ocean, Clark and Gagnon (2006) reported that some fin whales in the northeast Pacific Ocean stopped singing for an extended period starting soon after the onset of a seismic survey in the area. The authors could not determine whether or not the whales left the area ensonified by the survey, but the evidence suggests that most, if not all, of the singers remained in the area. When the survey stopped temporarily, the whales resumed singing within a few hours and the number of singers increased with time. Also, one whale continued to sing while the seismic survey was actively operating (Figure 4, Clark & Gagnon, 2006). The authors concluded that there is not enough scientific knowledge to adequately evaluate whether or not these effects on singing or mating behaviors are significant or would alter survivorship or reproductive success.

MacLeod et al. (2006) discussed the possible displacement of fin and sei whales related to distribution patterns of the species during a large-scale, offshore seismic survey along the west coast of Scotland in 1998. The authors hypothesized about the relationship between the whale's absence and the concurrent seismic activity, but could not rule out other contributing factors (Macleod et al., 2006; Parsons et al., 2009). We would expect that marine mammals may briefly respond to underwater sound produced by SIO's seismic survey by slightly changing their behavior or relocating a short distance. Based on the best available information, we expect short-term disturbance reactions that are confined to relatively small distances and durations (D. R. Thompson, Sjoberg, Bryant, Lovell, & Bjorge, 1998; P. M. Thompson et al., 2013), with no long-term effects on recruitment or survival of marine mammals.

McDonald et al. (1995) tracked blue whales relative to a seismic survey with a 1,600 in3 airgun array. One whale started its call sequence within 15 km (9.3 mi) from the source, then followed a pursuit track that decreased its distance to the vessel where it stopped calling at a range of 10 km (6.2 mi) (estimated received level at 143 dB re: 1 μPa (peak-to-peak)). After that point, the ship increased its distance from the whale which continued a new call sequence after approximately one hour and 10 km (6.2 mi) from the ship. The authors reported that the whale had taken a track paralleling the ship during the cessation phase but observed the whale moving diagonally away from the ship after approximately 30 minutes continuing to vocalize. Because the whale may have approached the ship intentionally or perhaps was unaffected by the airguns, the authors concluded that there was insufficient data to infer conclusions from their study related to blue whale responses (McDonald et al., 1995).

McCauley et al. (2000; 1998) studied the responses of migrating humpback whales off western Australia to a full-scale seismic survey with a 16-airgun array (2,678 in3) and to a single, 20-in3 airgun. Both studies point to a contextual variability in the behavioral responses of marine mammals to sound exposure. The mean received level for initial avoidance of an approaching airgun was 140 dB re: 1 μPa for humpback whale pods containing females. In contrast, some individual humpback whales, mainly males, approached within distances of 100 to 400 m (328 to 1,312 ft), where sound levels were 179 dB re: 1 μPa (McCauley et al., 2000). The authors hypothesized that the males gravitated towards the single operating air gun possibly due to its similarity to the sound produced by humpback whales breaching. Despite the evidence that some humpback whales exhibited localized avoidance reactions at received levels below 160 dB re: 1 μPa, the authors found no evidence of any gross changes in migration routes, such as inshore/offshore displacement during seismic operations (McCauley et al., 2000; McCauley et al., 1998).

DeRuiter et al. (2013) recently observed that beaked whales (considered a particularly sensitive species) exposed to playbacks (i.e., simulated) of U.S. Navy tactical mid-frequency active sonar from 89 to 127 dB re: 1 μPa at close distances responded notably by altering their dive patterns. In contrast, individuals showed no behavioral responses when exposed to similar received levels from actual U.S. Navy tactical mid-frequency active sonar operated at much further distances (DeRuiter et al., 2013). As noted earlier, one must consider the importance of context (e.g., the distance of a sound source from the animal) in predicting behavioral responses.

Tolerance: With repeated exposure to sound, many marine mammals may habituate to the sound at least partially (Richardson & Wursig, 1997). Bain and Williams (2006) examined the effects of a large airgun array (maximum total discharge volume of 1,100 in3) on six species in shallow waters off British Columbia and Washington: harbor seal, California sea lion (Zalophus californianus), Steller sea lion (Eumetopias jubatus), gray whale (Eschrichtius robustus), Dall's porpoise (Phocoenoides dalli), and the harbor porpoise. Harbor porpoises showed reactions at received levels less than 145 dB re: 1 µPa at a distance of greater than 70 km (43 miles) from the seismic source (Bain & Williams, 2006). However, the tendency for greater responsiveness by harbor porpoise is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson et al., 1995; Southall et al., 2007). In contrast, the authors reported that gray whales seemed to tolerate exposures to sound up to approximately 170 dB re: 1 µPa (Bain & Williams, 2006) and Dall's porpoises occupied and tolerated areas receiving exposures of 170–180 dB re: 1 µPa (Bain & Williams, 2006; Parsons et al., 2009). The authors observed several gray whales that moved away from the airguns toward deeper water where sound levels were higher due to propagation effects resulting in higher noise exposures (Bain & Williams, 2006). However, it is unclear whether their movements reflected a response to the sounds (Bain & Williams, 2006). Thus, the authors surmised that the lack of gray whale responses to higher received sound levels were ambiguous at best because one expects the species to be the most sensitive to the low-frequency sound emanating from the airguns (Bain & Williams, 2006).

Pirotta et al. (2014) observed short-term responses of harbor porpoises to a 2-D seismic survey in an enclosed bay in northeast Scotland which did not result in broad-scale displacement. The harbor porpoises that remained in the enclosed bay area reduced their buzzing activity by 15% during the seismic survey (Pirotta et al., 2014). Thus, animals exposed to anthropogenic disturbance may make trade-offs between perceived risks and the cost of leaving disturbed areas (Pirotta et al., 2014). However, unlike the semi-enclosed environment described in the Scottish study area, SIO's seismic study occurs in the open ocean. Because SIO would conduct the survey in an open ocean area, we do not anticipate that the seismic survey would entrap marine mammals between the sound source and the shore as marine mammals can temporarily leave the survey area during the operation of the airgun(s) to avoid acoustic harassment.

Masking: Studies have shown that marine mammals are able to compensate for masking by adjusting their acoustic behavior such as shifting call frequencies and increasing call volume and vocalization rates. For example, blue whales increase call rates when exposed to seismic survey noise in the St. Lawrence Estuary (Di Iorio & Clark, 2010). North Atlantic right whales exposed to high shipping noise increased call frequency (Parks, Clark, & Tyack, 2007), while some humpback whales respond to low-frequency active sonar playbacks by increasing song length (Miller, Biassoni, Samuels, & Tyack, 2000).

Risch et al. (2012) documented reductions in humpback whale vocalizations in the Stellwagen Bank National Marine Sanctuary concurrent with transmissions of the Ocean Acoustic Waveguide Remote Sensing (OAWRS) low-frequency fish sensor system at distances of 200 km from the source. The recorded OAWRS produced series of frequency modulated pulses and the signal received levels ranged from 88 to 110 dB re: 1 µPa (Risch et al., 2012). The authors hypothesized that individuals did not leave the area but instead ceased singing and noted that the duration and frequency range of the OAWRS signals (a novel sound to the whales) were similar to those of natural humpback whale song components used during mating (Risch et al., 2012). Thus, the novelty of the sound to humpback whales in the study area provided a compelling contextual probability for the observed effects (Risch et al., 2012). However, the authors did not state or imply that these changes had long-term effects on individual animals or populations (Risch et al., 2012).

We expect that masking effects of seismic pulses would be limited in the case of smaller odontocetes given the intermittent nature of seismic pulses in addition to the fact that sounds important to them are predominantly at much higher frequencies than are the dominant components of airgun sounds.

Hearing Impairment: Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience hearing threshold shift (Akamatsu et al.), which is the loss of hearing sensitivity at certain frequency ranges (Finneran, Carder, Schlundt, & Ridgway, 2005; Finneran & Schlundt, 2013; Finneran et al., 2000; Kastak & Schusterman, 1998; Kastak, Schusterman, Southall, & Reichmuth, 1999; C. E. Schlundt, J. J. Finneran, B. K. Branstetter, J. S. Trickey, & Jenkins, 2013; C. R. Schlundt, Finneran, Carder, & Ridgway, 2000).

Lucke et al. (2009) found a threshold shift (Akamatsu et al.) of a harbor porpoise after exposing it to airgun noise with a received sound pressure level (SPL) at 200.2 dB (peak –to-peak) re: 1 µPa, which corresponds to a sound exposure level of 164.5 dB re: 1 µPa2 s after integrating exposure. NMFS currently uses the root-mean-square (rms) of received SPL at 180 dB and 190 dB re: 1 µPa as the threshold above which permanent threshold shift (PTS) could occur for cetaceans and pinnipeds, respectively. Because the airgun noise is a broadband impulse, one cannot directly determine the equivalent of rms SPL from the reported peak-to-peak SPLs. However, applying a conservative conversion factor of 16 dB for broadband signals from seismic surveys (McCauley et al., 2000) to correct for the difference between peak-to-peak levels reported in Lucke et al. (2009) and rms SPLs, the rms SPL for TTS would be approximately 184 dB re: 1 µPa, and the received levels associated with PTS (Level A harassment) would be higher. This is still above our current 180 dB rms re: 1 µPa threshold for injury. However, we recognize that TTS of harbor porpoises is lower than other cetacean species empirically tested (Finneran & Schlundt, 2010; Finneran, Schlundt, Carder, & Ridgway, 2002; Kastelein & Jennings, 2012).

Studies by Kujawa and Liberman (2009) and Lin et al. (2011) found that despite completely reversible threshold shifts that leave cochlear sensory cells intact, large threshold shifts could cause synaptic level changes and delayed cochlear nerve degeneration in mice and guinea pigs, respectively. We note that the high level of TTS that led to the synaptic changes shown in these studies is in the range of the high degree of TTS that Southall et al. (2007) used to calculate PTS levels. It is unknown whether smaller levels of TTS would lead to similar changes. We, however, acknowledge the complexity of noise exposure on the nervous system, and will re-examine this issue as more data become available.

A study on bottlenose dolphins (C. E. Schlundt et al., 2013) measured hearing thresholds at multiple frequencies to determine the amount of TTS induced before and after exposure to a sequence of impulses produced by a seismic air gun. The air gun volume and operating pressure varied from 40-150 in3 and 1000-2000 psi, respectively. After three years and 180 sessions, the authors observed no significant TTS at any test frequency, for any combinations of airgun volume, pressure, or proximity to the dolphin during behavioral tests (C. E. Schlundt et al., 2013). Schlundt et al. (2013) suggest that the potential for airguns to cause hearing loss in dolphins is lower than previously predicted, perhaps as a result of the low-frequency content of air gun impulses compared to the high-frequency hearing ability of dolphins.

The avoidance behaviors observed in Thompson et al.'s (1998) study supports our expectation that individual marine mammals would largely avoid exposure at higher levels. Also, it is unlikely that animals would encounter repeated exposures at very close distances to the sound source because SIO would implement the required shutdown mitigation measures to ensure that observed marine mammals do not approach the applicable exclusion zone for Level A harassment. We also expect that the required vessel-based visual monitoring of the exclusion zone and implementation of mitigation measures would minimize instances of Level A harassment. However, sounds from airguns could result in PTS in a limited number of marine mammals. As such, NMFS proposes to authorize take, in the form of Level A, harassment of one species of marine mammals, specifically as a result of PTS. However, based on the results of our analyses, though PTS may occur in a small number of animals, there is no evidence that SIO's activities could result in serious injury or mortality of marine mammals within the action area. Even in the absence of the required mitigation and monitoring measures, the possibility of serious injury or lethal takes as a result of exposure to sound sources associated with SIO's seismic survey is considered extremely unlikely.

Strandings: In 2013, an International Scientific Review Panel (ISRP) investigated a 2008 mass stranding of approximately 100 melon-headed whales in a Madagascar lagoon system (Southall, Rowles, Gulland, Baird, & Jepson, 2013) associated with the use of a high-frequency mapping system. The report indicated that the use of a 12-kHz MBES was the most plausible and likely initial behavioral trigger of the mass stranding event. This was the first time that a relatively high-frequency mapping sonar system had been associated with a stranding event.

The report notes that there were several site- and situation-specific secondary factors that may have contributed to the avoidance responses that lead to the eventual entrapment and mortality of the whales within the Loza Lagoon system (e.g., the survey vessel transiting in a north-south direction on the shelf break parallel to the shore may have trapped the animals between the sound source and the shore driving them towards the Loza Lagoon). They concluded that for odontocete cetaceans that hear well in the 10-50 kHz range, where ambient noise is typically quite low, high-power active sonars operating in this range may be more easily audible and have potential effects over larger areas than low frequency systems that have more typically been considered in terms of anthropogenic noise impacts (Southall et al., 2013). However, the risk may be very low given the extensive use of these systems worldwide on a daily basis and the lack of direct evidence of such responses previously (Southall et al., 2013).

We have considered the potential for SIO's use of a MBES to result in stranding of marine mammals. Given that SIO proposes to conduct the seismic survey offshore and to transit in a manner that would not entrap marine mammals in shallow water, we believe it is extremely unlikely that the use of the MBES during the seismic survey would entrap marine mammals between the vessel's sound sources and the coastline.

Stranding of marine mammals is not anticipated as a result of the planned seismic survey.

We interpret the anticipated effects on all marine mammals of SIO's planned seismic survey as falling within the MMPA definition of Level A harassment and Level B harassment. We expect these impacts to be minor because we do not anticipate measurable changes to the population or measurable impacts to rookeries, mating grounds, and other areas of similar significance. Furthermore, SIO's proposed activities are not likely to obstruct movements or migration of marine mammals because the survery will occur over a limited time in a relatively small geographic area. Animals would be able to move away from sound soureces without significantly altering migration patterns. We expect that the proposed activities involving use of airguns would result, at worst, in PTS (Level A harassment) to a limited number of marine mammals, as well as temporary modification in behavior and/or temporary changes in animal distribution (Level B harassment) of certain species or stocks of marine mammals. It is likely that sounds from seismic airguns may result in temporary, short term changes in an animal's typical behavior and/or avoidance of the affected area, as described above. We base these conclusions on the results of the studies described above and on previous monitoring reports for similar activities and anecdotal observations for the same activities conducted in other open ocean environments.

Serious Injury or Mortality: SIO did not request authorization to take marine mammals by serious injury or mortality. Based on the results of our analyses, SIO's IHA application, and previous monitoring reports for similar seismic survey activities, we do not expect SIO's planned activities to result in serious injury or mortality of marine mammals within the action area, even in the absence of mitigation and monitoring measures. The required mitigation and monitoring measures would further minimize potential risks to marine mammals. Due in part to required monitoring measures for detecting marine mammals approaching the exclusion zone, and the required mitigation measures for speed or Course Alteration of the vessel and shut downs of the airgun array if a marine mammal is likely to enter the exclusion zone, any Level A harassment potentially incurred by marine mammals as a result of the planned seismic survey is expected to be in the form of some small degree of permanent hearing loss. Neither mortality nor complete deafness of marine mammals is expected to result from SIO's seismic survey.

Vessel Strikes: Vessel traffic has the potential to result in collisions with marine mammals. Studies have associated ship speed with the probability of a ship strike resulting in an injury or mortality of an animal. However, it is highly unlikely that SIO would strike a marine mammal given the *Revelle*'s slow survey speed (9.3 km/hr; 5 kt). Additionally, PSOs would be monitoring exclusion zones around the vessel and would be able to warn of any marine mammals that may be in the path of the *Revelle*. Moreover, mitigation measures would be required of SIO to reduce speed or alter course if a collision with a marine mammal appears likely. Therefore, it is extremely unlikely that the proposed activities would result in a vessel strike of a marine mammal.

4.1.3. Estimated Takes of Marine Mammals by Level A and Level B Harassment

SIO has requested take by Level A harassment and Level B harassment as a result of the acoustic stimuli generated by their proposed seismic survey. As mentioned previously, we estimate that the activities could potentially result in the incidental take of 27 species of marine mammals under NMFS jurisdiction by Level B harassment and of four species of marine mammals under NMFS jurisdiction by Level A harassment. For each species, estimates of take are small numbers relative to the population sizes. Table 4 describes the number of Level A harassment takes and Level B harassment takes that NMFS proposes to authorize, and the percentage of each population or stock proposed for take authorization in the IHA as a result of SIO's activities.

Table 4. Authorized Level A harassment and Level B harassment takes and percentage of marine mammal populations authorized for take.

Species	Density (# / 1,000 km^2)	Authorized Level A Takes	Authorized Level B Takes	Total Authorized Takes	Total Authorized Takes as a Percentage of Population
Gray whale	2.6	0	4	4	< 0.1
Humpback whale	2.1	0	3	3	0.2
Minke whale	1.3	0	2	2	0.3
Sei whale	0.4	0	2	2	0.4
Fin whale	4.2	0	6	6	< 0.1
Blue whale	0.3	0	1	1	< 0.1

Sperm whale	0.9	0	6	6	0.3
Pygmy sperm whale	1.6	0	2	2	< 0.1
Killer whale *West coast transient stock* *Eastern No. Pacific offshore stock*	0.9	0	8	8	3.3 3.3
False killer whale	0	0	5	5	0.3
Short-finned pilot whale	0.2	0	18	18	2.2
Harbor porpoise *No.California / So. Oregon stock* *Northern Oregon/ Washington coast stock*	467.0	44	552	596	1.7 2.7
Dall’s porpoise	58.3	5	69	74	0.3
Bottlenose dolphin	0	0	13	13	6.8
Striped dolphin	7.7	0	109	109	3.7
Risso’s dolphin	11.8	0	28	28	4.4
Short-beaked common dolphi	69.2	0	286	286	< 0.1
Pacific white sided dolphin	40.7	0	62	62	2.3
Northern right whale dolphin	46.4	0	63	63	2.5
Cuvier's beaked whale	2.8	0	4	4	< 0.1

Baird’s beaked whale	10.7	0	14	14	1.7
Mesoplodont beaked whales	1.2	0	2	2	2.9
Northern fur seal	83.4	0	107	107	0.8
California sea lion	33.3	0	43	43	< 0.1
Steller sea lion	15.0	0	20	20	< 0.1
Harbor seal	292.3	4	352	356	1.4
Northern elephant seal	83.1	1	105	106	< 0.1

Take estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound exceeding thresholds for Level B harassment and Level A harassment are predicted to occur (Table 5 and Table 6 respectively). Take estimates are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of a seismic survey. To the extent that marine mammals would be expected to move away from a sound source that represents an aversive stimulus before the sound level reaches the criterion level, these estimates likely overestimate the numbers actually exposed to the specified level of sound.

Table 5. Predicted Radial Distances from R/V Revelle 90 in^3 Seismic Source to Isopleth Corresponding to Level B Harassment Threshold

Water depth	Predicted Distance to Threshold (160 dB re 1 µPa)
> 1000 m	448 m
100 – 1000 m	672 m

Table 6. Modeled radial distances (m) from R/V Revelle 90 in^3 airgun array to isopleths corresponding to Level A harassment thresholds.

Functional Hearing Group (Level A harassment thresholds)	Peak SPL_{flat}	SEL_{cum}
Low frequency cetaceans ($L_{\text{pk,flat}}$: 219 dB; $L_{\text{E,LF,24h}}$: 183 dB)	4.9	7.9
Mid frequency cetaceans ($L_{\text{pk,flat}}$: 230 dB; $L_{\text{E,MF,24h}}$: 185 dB)	0.9	0

High frequency cetaceans ($L_{\text{pk,flat}}$: 202 dB; $L_{\text{E,HF,24h}}$: 155 dB)	34.9	0
Phocid Pinnipeds (Underwater) ($L_{\text{pk,flat}}$: 218 dB; $L_{\text{E,HF,24h}}$: 185 dB)	5.2	0.1
Otariid Pinnipeds (Underwater) ($L_{\text{pk,flat}}$: 232 dB; $L_{\text{E,HF,24h}}$: 203 dB)	0.4	0

As described above, a MBES and a SBP would also be operated from the *Revelle* continuously throughout the survey, but not during transits to and from the project area. Due to the lower source level of the SBP relative to the *Revelle's* airgun array, the sounds from the SBP are expected to be effectively subsumed by the sounds from the airgun array. Thus, any marine mammal that was exposed to sounds from the SBP would already have been exposed to sounds from the airgun array, which are expected to propagate further in the water. As such, the SBP is not expected to result in the take of any marine mammal that has not already been taken by the sounds from the airgun array. Each ping emitted by the MBES consists of four successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore–aft. Given the movement and speed of the vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the MBES would result in no more than one or two brief ping exposures of any individual marine mammal, if any exposure were to occur. Thus take as a result of exposure to sound from the MBES and SBP has therefore not been proposed for authorization.

4.2. Effects of Alternative 2- No Action Alternative

Under the No Action Alternative, we would not issue an IHA to SIO. As a result, SIO would not receive an exemption from the MMPA prohibitions against the take of marine mammals and would be in violation of the MMPA if take of marine mammals were to occur.

The impacts to elements of the human environment resulting from the No Action alternative – conducting the marine geophysical survey in the absence of required protective measures for marine mammals under the MMPA – would be greater than those impacts resulting from Alternative 1, the Preferred Alternative.

4.2.1. Impacts to Marine Mammal Habitat

Under the No Action Alternative, the effects on the physical environment or on components of the biological environment that function as marine mammal habitat would result from SIO's planned geophysical survey, are similar to those described in Section 4.1.1.

4.2.2. Impacts to Marine Mammals

Under the No Action Alternative, SIO's planned geophysical survey activities could result in increased amounts of Level A harassment and Level B harassment to marine mammals, although no takes by serious injury or mortality would be expected even in the absence of mitigation and monitoring measures. While it is difficult to provide an exact number of takes that might occur under the No Action Alternative, the numbers would be expected to be larger than those presented in Table 4 above because SIO would not be required to implement mitigation measures designed to warn marine mammals of the impending increased underwater sound levels, and additional numbers of marine mammals may be incidentally taken because SIO would not be required to shut down seismic survey activities if marine mammals occurred in the project vicinity.

If the activities proceeded without the mitigation and monitoring measures required by Alternative 1, the direct, indirect, and cumulative effects on the human or natural environment of not issuing the IHA would include an increase in the number of animals incurring PTS and behavioral responses because of the lack of mitigation measures that would be required in the IHA. Thus, the incidental take of marine mammals would likely occur at higher levels than we identified and evaluated in the proposed IHA; and NMFS would not be able to obtain the monitoring and reporting data needed to assess the anticipated impact of the activity upon the species or stock nor the increased knowledge of the marine mammal species, as required under the MMPA.

4.3. Unavoidable Adverse Impacts

SIO's application and our notice of proposed IHA, summarize unavoidable adverse impacts to marine mammals or the populations to which they belong or on their habitats occurring in the proposed project area.

We acknowledge that the incidental take authorized could potentially result in adverse impacts to marine mammals including behavioral responses, alterations in the distribution of local populations, and injury. However, we do not expect SIO's activities to have adverse consequences on annual rates of recruitment or survival of marine mammal species or stocks in the northeastern Pacific Ocean, and we do not expect the marine mammal populations in that area to experience reductions in reproduction, numbers, or distribution that might appreciably reduce their likelihood of surviving and recovering in the wild. We expect that the numbers of individuals of all species taken by harassment would be small (relative to species or stock abundance), and that the proposed project and the take resulting from the proposed project activities would have a negligible impact on the affected species or stocks of marine mammals.

4.4. Cumulative Effects

NEPA defines cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7). Cumulative impacts can result from individually minor but collectively significant actions that take place over a period of time.

Past, present, and reasonably foreseeable impacts to marine mammal populations in the central Pacific Ocean include the following: seismic surveys; climate change; marine pollution; disease; and increased vessel traffic. These activities account for cumulative impacts to regional and worldwide populations of marine mammals, many of which are a small fraction of their former abundance. However, quantifying the biological costs for marine mammals within an ecological framework is a critical missing link to our assessment of cumulative impacts in the marine environment and assessing cumulative effects on marine mammals (Clark *et al*., 2009). Despite these regional and global anthropogenic and natural pressures, available trend information indicates that most local populations of marine mammals in the northeastern Pacific Ocean are stable or increasing (Carretta *et al*., 2013).

The proposed seismic survey would add another, albeit temporary, activity to the marine environment in the northeastern Pacific Ocean. This activity would be limited to a small area offshore Oregon and Washington in the northeastern Pacific Ocean and would occur over a relatively short period of time (5 days). SIO's application (LGL, 2017) summarized the potential cumulative effects to marine mammals or the populations to which they belong to and their habitats within the survey area. This section incorporates SIO's application (LGL, 2017) by reference and provides a brief summary of the human-related activities affecting the marine mammal species in the action area.

4.4.1. Future Seismic Survey Activities in the Northeastern Pacific Ocean

There are no other seismic surveys with an IHA issued from us scheduled to occur in the northeastern Pacific Ocean in September 2017. Therefore, we are unaware of any synergistic impacts to marine resources associated with reasonably foreseeable future actions that may be planned or occur within the same region of influence. The impacts of conducting the seismic survey on marine mammals are specifically related to acoustic activities, and these are expected to be temporary in nature, negligible, and would not result in substantial impacts to marine mammals or to their role in the ecosystem. We do not expect that the issuance of an IHA would have a significant cumulative effect on the human environment, due to the required mitigation and monitoring measures described in Section 2.3.1

NMFS does not expect that SIO's 5 days of proposed seismic surveys would have effects that could cause significant or long-term consequences for individual marine mammals or their populations alone or in combination with past or present activities discussed above.

4.4.2. Climate Change

Global climate change could significantly affect the marine resources of northeastern Pacific Ocean. Possible impacts include temperature and rainfall changes and potentially rising sea levels and changes to ocean conditions. These changes may affect marine ecosystems in the proposed action area by increasing the vertical stratification of the water column and changing the intensity and rhythms of coastal winds and upwelling. Such modifications could cause ecosystem regime shifts as the productivity of the regional ecosystem undergoes various changes related to nutrients input and coastal ocean process (USFWS 2011).

The precise effects of global climate change on the action area, however, cannot be predicted at this time because the marine ecosystem is highly variable in its spatial and temporal scales.

4.4.3. Coastal Development

SIO's planned activities would occur in the open ocean environment for a relatively short period. Therefore, the proposed activities would have no cumulative impact on coastal development offshore Oregon and Washingon.

4.4.4. Marine Pollution

Marine mammals are exposed to contaminants via the food they consume, the water in which they swim, and the air they breathe. Point and non-point source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, marine debris, and organic compounds from aquaculture are all lasting threats to marine mammals in the project area. The long-term impacts of these pollutants, however, are difficult to measure.

The persistent organic pollutants tend to bioaccumulate through the food chain; therefore, the chronic exposure of persistent organic pollutants in the environment is perhaps of the most concern to high trophic level predators.

SIO's activities associated with the marine seismic survey are not expected to cause increased exposure of persistent organic pollutants to marine mammals in the project vicinity due to the relatively small scale and localized nature of the activities.

4.4.5. Disease

Disease is common in many marine mammal populations and has been responsible for major die-offs worldwide, but such events are usually relatively short-lived. SIO's survey activities are not expected to affect the disease rate among marine mammals in the project vicinity.

4.4.6. Increased Vessel Traffic

SIO's proposed activities would not result in a cumulative increase in vessel traffic beyond any direct impacts associated with the proposed short-term survey by the *Revelle*. As such, ship traffic should remain constant, underwater sound levels should remain stable and ship strikes of marine animals may occur at the levels they have in the recent past.

Chapter 5 List of Preparers and Agencies Consulted

Prepared By:

Jonathan Molineaux
Senior Analyst
Permits and Conservation Division
Office of Protected Resources
NOAA National Marine Fisheries Service

Jordan Carduner
Fishery Biologist
Permits and Conservation Division
Office of Protected Resources
NOAA National Marine Fisheries Service

Agencies Consulted internal to NOAA

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FINDING OF NO SIGNIFICANT IMPACT
ISSUANCE OF AN INCIDENTAL HARASSMENT AUTHORIZATION
TO THE SCRIPPS INSTITUTION OF OCEANOGRAPHY TO
TAKE MARINE MAMMALS BY HARASSMENT
INCIDENTAL TO A LOW-ENERGY GEOPHYSICAL SURVEY
IN THE NORTHEASTERN PACIFIC OCEAN, FALL 2017

BACKGROUND

The National Oceanic Atmospheric Administration's (NOAA), National Marine Fisheries Service (NMFS) is proposing to issue an Incidental Harassment Authorization (IHA) to the Scripps Institution of Oceanography (SIO) pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. §§ 1631 *et seq*.), and the regulations governing the taking and importing of marine mammals (50 Code of Federal Regulations (CFR) Part 216). This IHA will be valid from September 22, 2017 through September 21, 2018, and authorizes takes, by Level A and Level B harassment, of marine mammals incidental to conducting a marine geophysical survey in the northeastern Pacific Ocean during the fall of 2017.

NMFS' proposed action is a direct outcome of SIO's request which involves a two-dimensional geophysical survey on the R/V *Revelle*, a vessel owned by the Scripps Institution of Oceanography. Acoustic stimuli associated with the marine geophysical survey has the potential to cause marine mammals in the vicinity of the project area to be behaviorally disturbed, and therefore, the survey activities warrant an authorization under section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. §§ 1631 *et seq*.). NMFS' criteria for an IHA requires that the taking of marine mammals authorized by an IHA will have a negligible impact on the species or stock(s), and, where relevant, will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. In addition, the IHA must set forth, where applicable, the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the monitoring and reporting of such takings.

The issuance of an IHA to SIO allows the taking of marine mammals, consistent with provisions under the MMPA, and is considered a major federal action under the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq*.). This Finding of No Significant Impact (FONSI) evaluates the significance of the impacts of the selected alternative – Alternative 1 (Preferred Alternative) – in the Final Environmental Assessment (EA) prepared by NMFS titled, "*Issuance of an Incidental Harassment Authorization to the Scripps Institution of Oceanography to Take Marine Mammals by Harassment Incidental to a Low-Energy Geophysical Survey in the Northeastern Pacific Ocean, Fall 2017*". The preparation of the Final EA and this FONSI were completed in accordance with NEPA and the Council on Environmental Quality (CEQ) regulations in 40 CFR §§ 1500-1508. The EA addresses the potential environmental impacts of two alternatives to meet NMFS' purpose and need under section 101(a)(5)(D) of the MMPA:

- Alternative 1 (Preferred Alternative): Issue an IHA to SIO for take, by harassment, of marine mammals during the marine geophysical survey, taking into account the prescribed means of take, mitigation measures, and monitoring requirements.

- Alternative 2 (No Action Alternative): For NMFS, denial of an MMPA authorization constitutes the NMFS No Action Alternative, which is consistent with our statutory obligation under the MMPA to grant or deny permit applications and to prescribe mitigation, monitoring and reporting with any authorizations. Under NMFS' No Action Alternative, there are two potential outcome scenarios. One is that SIO's activities occur in the absence of an MMPA authorization. In that case, (1) SIO would be in violation of the MMPA if takes occur and (2) mitigation, monitoring and reporting would not be prescribed by NMFS. The second potential outcome is SIO would not proceed with their proposed activities.

ANALYSIS

The CEQ regulations at 40 CFR §1508.27 state that the significance of an action should be analyzed both in terms of "context" and "intensity." Each criterion listed below this section is relevant to making a finding of no significant impact. We have considered each criterion individually, as well as in combination with the others. We analyzed the significance of this action based on CEQ's context and intensity criteria. These include:

1) **Can the proposed action reasonably be expected to cause substantial damage to the ocean and coastal habitats and/or essential fish habitat as defined under the Magnuson-Stevens Act and identified in Fishery Management Plans (FMP)?**

   Response: We do not expect our proposed action of issuing an IHA for the take of marine mammals incidental to the conduct of marine geophysical survey activities would cause substantial damage to the ocean and coastal habitats and/or essential fish habitat because our IHA is limited to the take of marine mammals incidental to geophysical survey activities and does not authorize the activity itself, thus it is limited to activities that do not have an effect on ocean and coastal habitats or essential fish habitat. Similarly, the mitigation and monitoring measures required by the IHA for SIO's proposed activities are limited to actions that minimize take of marine mammals and improve monitoring of marine mammals, and do not alter any aspect of the activity itself.

2) **Can the proposed action be expected to have a substantial impact on biodiversity and/or ecosystem function within the affected area (e.g., benthic productivity, predator-prey relationships, etc.)?**

   Response: We do not expect our proposed action of issuing an IHA for the take of marine mammals incidental to the conduct of geophysical survey activities to have a substantial impact on biodiversity or ecosystem function within the affected environment. Our proposed action of authorizing incidental harassment for SIO's geophysical survey would be limited to temporary behavioral responses (such as brief masking of natural sounds) in marine mammals and temporary changes in animal distribution. These effects would be short-term and localized.

3) **Can the proposed action reasonably be expected to have a substantial adverse impact on public health or safety?**

Response: We do not expect our proposed action of issuing an IHA to have a substantial adverse impact on public health or safety, as the taking, by harassment, of marine mammals would pose no risk to humans.

4) **Can the proposed action reasonably be expected to adversely affect endangered or threatened species, their critical habitat, marine mammals, or other non-target species?**

Response: We have determined that our issuance of an IHA would likely result in limited adverse effects to 27 species of marine mammals. The EA evaluates the affected environment and potential effects of our proposed action, indicating that SIO's geophysical survey has the potential to affect marine mammals in a way that requires authorization under the MMPA. The activities and required mitigation measures would not affect physical habitat features, such as substrates and water quality.

We have determined that the proposed activities may result in some harassment (primarily in the form of short-term and localized changes in behavior and displacement) of small numbers, relative to the population sizes, of 27 species of marine mammals. The impacts of the marine geophysical survey on marine mammals relate to acoustic impacts of SIO's proposed survey, and we expect these to be temporary in nature and not result in a substantial impact to marine mammals or to their role in the ecosystem.

The proposed geophysical survey may have the potential to adversely affect the following marine mammal species listed as threatened or endangered under the Endangered Species Act (ESA; 16 U.S.C. 1531 *et seq*.): fin, sei, blue, sperm, and humpback whale. A Biological Opinion issued on September 21, 2017 under section 7 of the ESA concluded that SIO's project was not likely to jeopardize the continued existence of any ESA-listed species and would not affect critical habitat.

To reduce the potential for disturbance from the activities, SIO would implement several monitoring and mitigation measures for marine mammals, which are outlined in the EA. Taking these measures into consideration, we expect that the responses of marine mammals from the Preferred Alternative would primarily be in the form of temporary displacement from the area and/or short-term behavioral changes, as well as a limited amount of permanent threshold shift (PTS) in a small number of marine mammals, falling within the MMPA definition of "Level A or Level B harassment." We do not anticipate that take by serious injury or mortality would occur, nor have we authorized take by serious injury or mortality. NMFS' predicted estimates for Level A harassment take for some species are likely overestimates of the injury that will occur, as NMFS expects that successful implementation of the required visual and acoustic mitigation measures would avoid Level A take in some instances. Also, NMFS expects that some individuals would avoid the source at levels expected to result in injury. We anticipate that any PTS incurred would be in the form of only a small degree of PTS, and not total deafness. Thus, we expect that impacts would be at the lowest level practicable due to the incorporation of the proposed mitigation measures.

5) **Are significant social or economic impacts interrelated with natural or physical environmental effects?**

Response: We expect that the primary impacts to the natural and physical environment would be temporary in nature and not interrelated with significant social or economic impacts. Issuance of an IHA would not result in inequitable distributions of environmental burdens or access to environmental goods as the action is confined to university personnel and contractors.

We have determined that issuance of the IHA would not adversely affect low-income or a minority population, as our action only affects marine mammals. Further, there would be no impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses. Therefore, we expect that no significant social or economic effects would result from the issuance of an IHA or from SIO's proposed activities.

6) **Are the effects on the quality of the human environment likely to be highly controversial?**

Response: The effects of issuing an IHA to SIO on the quality of the human environment are not likely to be highly controversial. Although there is some lack of agreement within the scientific and stakeholder communities about the potential effects of noise on marine mammals, there is not a substantial dispute about the size, nature, or effect of our proposed action. For several years, we have assessed and authorized incidental take for multiple geophysical surveys conducted within the same year and have developed relatively standard mitigation and monitoring measures, all of which have been vetted during past public comment periods. The scope of this action is no different than past geophysical surveys, is not unusually large or substantial, and would include the same or similar mitigation and monitoring measures required in past surveys. Previous projects of this type required marine mammal monitoring and monitoring reports, which we have reviewed to ensure that the authorized activities have a negligible impact on marine mammals.

To allow other agencies and the public the opportunity to review and comment on the action, NMFS published a notice of the Proposed IHA in the *Federal Register* on July 24, 2017 (82 FR 34352). In response to the notice of the Proposed IHA, NMFS received comments from the Marine Mammal Commission and one comment from the public, and we fully considered all comments in preparing the IHA and the EA. We have determined, based on the best available scientific literature, the limited duration of the project, and the low-level effects to marine mammals, that the issuance of an IHA would have a negligible impact on the affected species or stocks of marine mammals.

7) **Can the proposed action reasonably be expected to result in substantial impacts to unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers, essential fish habitat, or ecologically critical areas?**

Response: The proposed action cannot reasonably be expected to result in substantial impacts to unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers, essential fish habitat, or ecologically critical areas because none of these are found in the project area. Similarly, as described in the response to question 1 above, our IHA is limited to the take of marine mammals incidental to marine geophysical survey activities, and does not authorize the activity itself, thus it is limited to activities that do not have an effect on cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers, essential fish habitat, or ecologically critical areas. The natural processes in the environment are expected to fully recover from any impacts resulting from the activities.

8) **Are the effects on the human environment likely to be highly uncertain or involve unique or unknown risks?**

Response: The potential risks associated with marine geophysical surveys are neither unique nor unknown nor is there significant uncertainty about impacts. We have issued Authorizations for similar activities or activities with similar types of marine mammal harassment in the Atlantic, Pacific, and Southern Oceans, and the Mediterranean Sea, and conducted NEPA analyses on those projects. Therefore, we expect any potential effects from the issuance of our IHA to be similar to prior activities which are not likely to be highly uncertain or involve unique or unknown risks.

9) **Is the proposed action related to other actions with individually insignificant, but cumulatively significant impacts?**

Response: The EA and the documents it references analyzed the impacts of the issuance of an IHA for the take of marine mammals incidental to the conduct of a marine geophysical survey in light of other human activities within the study area. We expect the following combination to result in no more than minor and short-term impacts to marine mammals in the survey area in terms of overall disturbance effects: (a) our issuance of an IHA with prescribed mitigation and monitoring measures for the marine geophysical survey; (b) past, present, and reasonably foreseeable future marine geophysical surveys in the northeastern Pacific Ocean; and (c) climate change.

The proposed action of SIO conducting the marine geophysical survey over the northeastern Pacific Ocean and our proposed action of issuing an IHA to SIO for the incidental take of a small number of marine mammals are interrelated. The survey conducted pursuant to the requirements of an IHA that authorizes harassment of marine mammals is not expected to result in cumulatively significant impacts when considered in relation to other separate actions with individually insignificant effects.

We have issued incidental take authorizations for other marine geophysical surveys that may have resulted in the harassment of marine mammals, but these surveys are dispersed both geographically (throughout the world) and temporally, are short-term in nature, and use mitigation and monitoring measures to minimize impacts to marine mammals and to minimize other potential adverse environmental impacts in the activity area.

We are unaware of any other marine geophysical surveys scheduled to occur in the U.S. EEZ off the coast of Washington and Oregon in the northeastern Pacific Ocean in September 2017. Also, we are unaware of any synergistic impacts to marine resources associated with reasonably foreseeable future actions that may be planned to occur within the same region. The Cumulative Effects section of the EA and the material incorporated by reference go into more detail regarding other past, present, and reasonably foreseeable future actions, but concludes that the impacts of SIO's proposed survey in the northeastern Pacific Ocean are expected to be no more than minor and short-term with no potential to contribute to cumulatively significant impacts.

10) **Is the proposed action likely to adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural or historical resources?**

Response: We have determined that our proposed action is not an undertaking with the potential to affect historic resources because our proposed action is limited to the issuance of an IHA to incidentally harass marine mammals. The issuance of an IHA is not expected to adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or cause loss or destruction of significant scientific, cultural or historical resources either because such resources do not exist within the project area or are not expected to be adversely affected.

11) **Can the proposed action reasonably be expected to result in the introduction or spread of a non-indigenous species?**

Response: Our proposed action does not have the potential to introduce or spread non-indigenous species because it does not encourage or require the R/V *Revelle* to conduct long-range vessel transit that would lead to the introduction or spread of non-indigenous species. The *Revelle* complies with all international and U.S. national ballast water requirements to prevent the spread of a non-indigenous species.

12) **Is the proposed action likely to establish a precedent for future actions with significant effects or does it represent a decision in principle about a future consideration?**

Response: The issuance of an IHA is not expected to set a precedent for future actions with significant effects nor represent a decision in principle regarding future considerations. The issuance of an IHA to take marine mammals incidental to the proposed activities is a routine process under the MMPA. To ensure compliance with statutory and regulatory standards, NMFS' actions under section 101(a)(5)(D) of the MMPA must be considered individually and be based on the best available information, which is continuously evolving. Issuance of an IHA to a specific individual or organization for a given activity does not guarantee or imply that NMFS will authorize others to conduct similar activities. Subsequent requests for incidental take authorizations would be evaluated upon their own merits relative to the criteria established in the MMPA, ESA, and NMFS implementing regulations on a case-by-case basis. The project has no unique aspects that would suggest it would be a precedent for any future actions. For these reasons, the issuance of an IHA to SIO to conduct the proposed action would not be precedent setting.

13) **Can the proposed action reasonably be expected to threaten a violation of any Federal, State, or local law or requirements imposed for the protection of the environment?**

Response: The issuance of an IHA would not violate any federal, state, or local laws for environmental protection. NMFS compliance with environmental laws, regulations and Executive Orders (EOs) is based on NMFS proposed action and the nature of the applicants proposed activities. NMFS consulted under Section 7 of the ESA to determine if the issuance of this IHA would likely jeopardize the continued existence of listed species or result in an adverse modification of critical habitat. The consultation concluded that issuance of an IHA would not jeopardize any listed species or adversely modify critical habitat. There are no other environmental laws, regulations, EOs, consultations, federal permits or licenses applicable to NMFS for issuance of this authorization to SIO. In addition, SIO fulfilled its responsibilities under MMPA for this action and will be required to obtain any additional federal, state and local permits necessary to carry out the proposed activities.

14) Can the proposed action reasonably be expected to result in cumulative adverse effects that could have a substantial effect on the target species or non-target species?

Response: The proposed action would not result in any significant cumulative adverse effects on target or non-target species incidentally taken by harassment due to marine geophysical survey activities. We have determined that marine mammals may exhibit behavioral changes such as avoidance or changes in movement within the action area. However, we do not expect the authorized harassment to result in significant cumulative adverse effects on the affected species or stocks.

We have issued incidental take authorizations for other marine geophysical research surveys that may have resulted in the harassment of marine mammals, but they are dispersed both geographically (throughout the world) and temporally, are short-term in nature, and all use mitigation and monitoring measures to minimize impacts to marine mammals. Because of the relatively short time that the project area would be ensonified, the action would not result in synergistic, or cumulative adverse effects that could have a substantial effect on any species.

DETERMINATION

In view of the information presented in this document, SIO's application and the analysis contained in the Final EA prepared by NMFS, it is hereby determined the issuance of an IHA to SIO for the take, by harassment, of small numbers of marine mammals incidental to the conduct of marine geophysical surveys in accordance with Alternative 1 (Preferred Alternative) will not significantly impact the quality of the human environment. In addition, we have addressed all beneficial and adverse impacts of the action to reach the conclusion of no significant impacts. Accordingly, the preparation of an Environmental Impact Statement for this action is not necessary.

for

Donna S. Wieting
Director, Office of Protected Resources,
National Marine Fisheries Service

3.22.17
Date

APPENDIX B:
INCIDENTAL HARASSMENT AUTHORIZATION

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

INCIDENTAL HARASSMENT AUTHORIZATION

The Scripps Institution of Oceanography (SIO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a low-energy marine geophysical survey in the Northwest Pacific Ocean, when adhering to the following terms and conditions.

1. This incidental harassment authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for marine geophysical survey activity, as specified in the Scripps Institution of Oceanography's (SIO) IHA application and using an airgun array aboard the R/V *Revelle* with characteristics specified in the application, in the Northeast Pacific Ocean.

3. General Conditions

   (a) A copy of this IHA must be in the possession of SIO, the vessel operator and other relevant personnel, the lead protected species observer (PSO), and any other relevant designees of SIO operating under the authority of this IHA.

   (b) The species authorized for taking are listed in Table 1. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (c) The taking by serious injury or death of any species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (d) During use of the airgun(s), if marine mammal species other than those listed in Table 1 are detected by PSOs, the acoustic source must be shut down to avoid unauthorized take.

   (e) SIO shall ensure that the vessel operator and other relevant vessel personnel are briefed on all responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and IHA requirements prior to the start of survey activity, and when relevant new personnel join the survey operations.

4. Mitigation Requirements

   The holder of this Authorization is required to implement the following mitigation measures:

   (a) SIO must use at least three (3) dedicated, trained, NMFS-approved Protected Species Observers (PSO). The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval.

(b) At least one PSO must have a minimum of 90 days at-sea experience working as a PSO during a deep penetration seismic survey. One "experienced" visual PSO shall be designated as the lead for the entire protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator.

(c) Visual Observation

(i) During survey operations (*e.g.*, any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, PSO(s) must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset).

(ii) Visual monitoring must begin not less than 30 minutes prior to ramp-up, including for nighttime ramp-ups of the airgun array, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(iii) PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

(iv) PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours observation per 24 hour period.

(v) During good conditions (*e.g.*, daylight hours; Beaufort sea state 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(d) Exclusion Zone and buffer zone – PSOs shall establish and monitor a 100 m exclusion zone (EZ) and 200 m buffer zone. The zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the EZ but within 200 m from any element of the airgun array shall be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the EZ, or on a course to enter the EZ, shall trigger further mitigation measures as described below. PSOs shall also monitor to the extent of the modeled Level B zone, or as far as possible if the extent of the Level B zone is not visible.

(i) Ramp-up – A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45 in^3 airgun, and the second 45 in^3 airgun would be added after 5 minutes.

(ii) If the airgun array has been shut down due to a marine mammal detection, ramp-up shall not occur until all marine mammals have cleared the EZ. A marine mammal is considered to have cleared the EZ if:

(A) It has been visually observed to have left the EZ; or

(B) It has not been observed within the EZ, for 15 minutes (in the case of small odontocetes) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).

(iii) Thirty minutes of pre-clearance observation of the 100 m EZ and 200 m buffer zone are required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the 100 m EZ during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and 30 minutes for all other species).

(iv) During ramp-up, PSOs shall monitor the 100 m EZ and 200 m buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100 m EZ. If a marine mammal is observed within or approaching the 100 m EZ during ramp-up, a shutdown shall be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100 m EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and 30 minutes for mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).

(v) If the airgun array has been shut down for reasons other than mitigation (*e.g.*, mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant visual observation and no visual detections of any marine mammal have occurred within the buffer zone.

(vi) Ramp-up at night and at times of poor visibility shall only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100 m EZ and 200 m buffer zone have been continually monitored by PSOs for 30 minutes prior to ramp-up with no marine mammal detections.

(vii) The vessel operator must notify a designated PSO of the planned start of ramp-up. The designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.

(e) Shutdown requirements – An exclusion zone of 100 m shall be established and monitored by PSOs. If a marine mammal is observed within, entering, or approaching the 100 m exclusion zone all airguns shall be shut down.

(i) Any PSO on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant PSO(s) must call for such action immediately.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When a shutdown is called for by a PSO, the shutdown must occur and any dispute resolved only following shutdown.

(iv) The shutdown requirement is waived for dolphins of the following genera: *Tursiops*, *Stenella*, *Delphinus*, *Lagenorhynchus* and *Lissodelphis*. The shutdown waiver only applies if dolphins are traveling, including approaching the vessel. If dolphins are stationary and the vessel approaches the dolphins, the shutdown requirement applies. If there is uncertainty regarding identification (*i.e.*, whether the observed animal(s) belongs to the group described above) or whether the dolphins are traveling, shutdown must be implemented.

(v) Upon implementation of a shutdown, the source may be reactivated under the conditions described at 4(d). Where there is no relevant zone (*e.g.*, shutdown due to observation of a calf), a 30-minute clearance period must be observed following the last observation of the animal(s).

(vi) Shutdown of the array is required upon observation of a large whale (*i.e.*, sperm whale or any baleen whale) with calf, with "calf" defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult, at any distance.

(vii) Shutdown of the array is required upon observation of an aggregation (*i.e.*, six or more animals) of large whales of any species (*i.e.*, sperm whale or any baleen whale) that does not appear to be traveling (*e.g.*, feeding, socializing, etc.) at any distance.

(viii) Shutdown of the array is required upon observation of a killer whale at any distance.

(ix) Shutdown of the array is required upon observation of a north Pacific right whale at any distance.

(f) Vessel Strike Avoidance – Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course to avoid striking any marine mammal. These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.

(i) The vessel must maintain a minimum separation distance of 100 m from large whales. The following avoidance measures must be taken if a large whale is within 100 m of the vessel:

(A) The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance.

(B) If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 m.

(ii) The vessel must maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for animals described in 4(e)(iv) that approach the vessel. If an animal is encountered during transit, the vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course.

(iii) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel.

(g) Miscellaneous Protocols

(i) The airgun array must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Operational capacity of 90 in^3 (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.

(ii) Testing of the acoustic source involving all elements requires normal mitigation protocols (*e.g.*, ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring shall be conducted in accordance with the following requirements:

(a) The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.

(b) PSOs must also be equipped with reticle binoculars (*e.g.*, 7 x 50) of appropriate quality (*i.e.*, Fujinon or equivalent), GPS, compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

(c) PSO Qualifications

(i) PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program.

(ii) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection – PSOs must use standardized data forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source to resume survey. If required mitigation was not implemented, PSOs should submit a description of the circumstances. We require that, at a minimum, the following information be reported:

(i) PSO names and affiliations

(ii) Dates of departures and returns to port with port name

(iii) Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort

(iv) Vessel location (latitude/longitude) when survey effort begins and ends; vessel location at beginning and end of visual PSO duty shifts

(v) Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change

(vi) Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions change significantly), including wind speed and direction, Beaufort sea state, Beaufort wind force, swell height, weather conditions, cloud cover, sun glare, and overall visibility to the horizon

(vii) Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (*e.g.*, vessel traffic, equipment malfunctions)

(viii) Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.*, pre-ramp-up survey, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.)

(ix) If a marine mammal is sighted, the following information should be recorded:

(A) Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

(B) PSO who sighted the animal;

(C) Time of sighting;

(D) Vessel location at time of sighting;

(E) Water depth;

(F) Direction of vessel's travel (compass direction) ;

(G) Direction of animal's travel relative to the vessel;

(H) Pace of the animal;

(I) Estimated distance to the animal and its heading relative to vessel at initial sighting;

(J) Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified); also note the composition of the group if there is a mix of species;

(K) Estimated number of animals (high/low/best) ;

(L) Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.) ;

(M) Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics) ;

(N) Detailed behavior observations (*e.g.*, number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior) ;

(O) Animal's closest point of approach (CPA) and/or closest distance from the center point of the acoustic source;

(P) Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other); and

(Q) Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up, speed or course alteration, etc.) and time and location of the action.

6. Reporting

(a) SIO shall submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used must be provided. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the data collected as required under condition 5(d) of this IHA. The report must also provide an estimate of the number (by species) of marine mammals with known exposures to seismic survey activity at received levels greater than or equal to thresholds for Level A and Level B harassment, (based on visual observation) including an estimate of those on the trackline but not detected. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.

(b) Reporting injured or dead marine mammals:

(i) In the event that the specified activity clearly causes the take of a marine mammal in a manner not prohibited by this IHA (if issued), such as serious injury or mortality, SIO shall immediately cease the specified activities and immediately report the incident to the NMFS Office of Protected Resources (301-428-8401) and the NMFS West Coast Stranding Coordinator for Oregon and Washington (206-526-4747). The report must include the following information:

(A) Time, date, and location (latitude/longitude) of the incident;

(B) Vessel's speed during and leading up to the incident;

(C) Description of the incident;

(D) Status of all sound source use in the 24 hours preceding the incident;

(E) Water depth;

(F) Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);

(G) Description of all marine mammal observations in the 24 hours preceding the incident;

(H) Species identification or description of the animal(s) involved;

(I) Fate of the animal(s); and

(J) Photographs or video footage of the animal(s).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS.

(ii) In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), SIO shall immediately report the incident to the NMFS Office of Protected Resources and the NMFS West Coast Stranding Coordinator for Oregon and Washington. The report must include the same information identified in condition 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.

(iii) In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to the NMFS Office of Protected Resources and the NMFS West Coast Stranding Coordinator for Oregon and Washington within 24 hours of the discovery. SIO shall provide photographs or video footage or other documentation of the sighting to NMFS.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

Dated: 9.22.17

for Donna S. Wieting,
Director, Office of Protected Resources,
National Marine Fisheries Service.

Table 1. Numbers of Potential Incidental Take of Marine Mammals Authorized

Species	Authorized Level A Takes	Authorized Level B Takes	Total Authorized Takes
Gray whale	0	4	4
Humpback whale	0	3	3
Minke whale	0	2	2
Sei whale	0	2	2
Fin whale	0	6	6
Blue whale	0	1	1
Sperm whale	0	6	6
Pygmy sperm whale	0	2	2
Killer whale	0	8	8
False killer whale[1]	0	5	5
Short-finned pilot whale	0	18	18
Harbor porpoise	44	552	596
Dall's porpoise	5	69	74
Bottlenose dolphin	0	13	13
Striped dolphin	0	109	109
Risso's dolphin	0	28	28
Short-beaked common dolphin	0	286	286
Pacific white sided dolphin	0	62	62

Northern right whale dolphin	0	63	63
Cuvier's beaked whale	0	4	4
Baird's beaked whale	0	14	14
Mesoplodont beaked whales	0	2	2
Northern fur seal	0	107	107
California sea lion	0	43	43
Steller sea lion	0	20	20
Harbor seal	4	352	356
Northern elephant seal	1	105	106

APPENDIX C:
NMFS BIOLOGICAL OPINION

NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on a Seismic survey by the Scripps Institution of Oceanography, and Issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA)

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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

Publisher: Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved:

Donna S Wieting

Donna S. Wieting
Director, Office of Protected Resources

Date: SEP 22 2017

Consultation Tracking number: FPR-2017-9195

Digital Object Identifier (DOI): *[library assigned DOI]*

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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

The action agency for this consultation are the National Science Foundation (NSF) and the NMFS' Permits and Conservation Division. Two federal actions are considered in this biological opinion. The first is the NSF's proposal to fund a seismic survey off the coast of Oregon in late September 2017, in support of an NSF-funded collaborative research project, led by the Scripps Institution of Oceanography. The second is the NMFS' Permits and Conservation Division proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" by Level B harassment (as defined by the Marine Mammal Protection Act (MMPA)) of marine mammals incidental to the planned seismic survey, pursuant to section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371 (a)(5)(D).

This consultation, biological opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§401-16), and agency policy and guidance was conducted by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we").This biological opinion (opinion) and incidental take statement were prepared by NMFS Office of Protected Resources Endangered Species Act Interagency

Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. §402.

This document represents the NMFS opinion on the effects of these actions on endangered and threatened whales, sea turtles, and fishes and designated critical habitat for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The NSF is proposing to fund a seismic survey off the coasts of Oregon and Washington from September 22 to 29, 2017. In conjunction with this action, the NMFS Permits and Conservation Division would issue an IHA under the MMPA for marine mammal takes that could occur during the NSF seismic survey. This document represents NMFS's ESA Interagency Cooperation Division's opinion on the effects of the two proposed federal actions on threatened and endangered species, and has been prepared in accordance with section 7 of the ESA.

1.2 Consultation History

On March 22, 2017, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation pursuant to section 7 of the ESA from the NSF to incidentally harass marine mammal and sea turtle species during the seismic survey. On the same date, the NMFS' Permits and Conservation Division received an application from the Scripps Institution of Oceanography to incidentally harass marine mammal species pursuant to the MMPA during the proposed seismic survey.

The Permits and Conservation Division and the ESA Interagency Cooperation Division had several questions on the modelling presented in the IHA request, and requested additional explanations. As a result, the NSF submitted three additional revised versions of the IHA request, on May 8, 2017, on July 5, 2017, and July 27, 2017.

A revised draft Environmental Analysis from NSF was received on July 27, 2017. Information was sufficient to initiate consultation with the NSF on this date.

On July 31, 2017, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation under section 7 of the ESA from the NMFS' Permits and Conservation Division.

On August 16, 2017, the NMFS' Permits and Conservation Division sent the application for the proposed seismic survey out to reviewers and published a notice in the Federal Register soliciting public comment on their intent to issue an IHA on August 17, 2017.

This opinion is based on information provided in the:

- MMPA IHA application.
- Draft public notice of proposed IHA.

- Draft environmental assessment prepared pursuant to the National Environmental Policy Act.
- Monitoring reports from similar activities.
- Published and unpublished scientific information on endangered and threatened species and their surrogates.
- Scientific and commercial information such as reports from government agencies and the peer-reviewed literature.
- Biological opinions on similar activities.
- Other sources of information.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. §402.02.

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features. 50 C.F.R. §402.02.

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): we describe the proposed action and those aspects (or stressors) of the proposed action that may have direct or indirect effects on the physical, chemical, and biotic environment.

Action Area (Section 4): we describe the action area with the spatial extent of those stressors.

Interrelated and Interdependent Actions (Section 5): we identify any interrelated and interdependent actions. *Interrelated* actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent use, apart from the action under consideration.

Potential Stressors (Section 6): we identify the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat.

Species and Designated Critical Habitat Not Considered Further in the Opinion (Section 7): we identify those resources will either not be affected or are not likely to be adversely affected.

Species and Critical Habitat Likely to be Adversely Affected (Section 8):we identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors identified in Section 6.

Status of Species and Designated Critical Habitat (Section 9): we identify the status of ESA-listed species and designated critical habitat that are likely to occur in the action area.

*Environmental Baseline (*Section 10): we describe the environmental baseline in the action area including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, impacts of state or private actions that are contemporaneous with the consultation in process.

Effects of the Action (Section 11): we identify the number, age (or life stage), and sex of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. We also consider whether the action “may affect” designated critical habitat. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. We also consider how the action may affect designated critical habitat. This is our response analysis. We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis. The adverse modification analysis considers the impacts of the proposed action on the essential biological features and conservation value of designated critical habitat.

Integration and Synthesis (Section 12): we integrate the analyses in the opinion to summarize the consequences to ESA-listed species and designated critical habitat under NMFS’ jurisdiction.

Cumulative Effects (Section 13): cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area. 50 C.F.R. §402.02. Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Conclusion (Section 14): with full consideration of the status of the species and the designated critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on essential habitat features when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or

- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives. 50 C.F.R. §402.14(h).

In addition, we include an incidental take statement (Section 15) that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures. ESA section 7 (b)(4); 50 C.F.R. §402.14(i). We also provide discretionary conservation recommendations that may be implemented by action agency. 50 C.F.R. §402.14(j). Finally, we identify the circumstances in which reinitiation of consultation is required. 50 C.F.R. §402.16.

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of Google Scholar and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the Permits and Conservation Division and the National Science Foundation.
- Government reports (including NMFS biological opinions and stock assessment reports).
- NOAA technical memos.
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies.

Two federal actions were evaluated in this opinion. The first is the NSF's proposal to fund the research vessel *Roger Revelle*, operated by the Scripps Institution of Oceanography, to conduct a seismic survey off the coast of Oregon in September 2017. The second is the NMFS' Permits and Conservation Division proposal to issue an IHA authorizing non-lethal "takes" by Level B harassment pursuant to section 101 (a)(5)(D) of the MMPA. The information presented here is based primarily upon the Environmental Analysis provided by NSF as part of the initiation package.

3.1 Proposed Activities: National Science Foundation

The NSF proposes to fund the use of the U.S. Navy's research vessel *Roger Revelle* (*Revelle*) to conduct a seismic survey off the coast of Oregon and Washington. An array of two operational airguns will be deployed as an energy source. In addition, a multibeam echosounder and sub-bottom profiler will continuously operate from the *Revelle* during the entire cruise, but not during transit to and from the survey areas.

The proposed survey would take place on an active continental margin to gather data to understand the sediment and crustal structure within the Cascadia continental margin. The study would also serve as a tool to train early career scientists in how to effectively plan a seismic survey.

3.1.1 Survey Overview and Project Objectives

The survey will occur from September 22 to 29, 2017. Seismic operations will take place for five days, allowing approximately two days for the vessel to transit to and from Newport, Oregon. The survey will have two potential survey sites: one off northern Oregon off the mouth of the Columbia River, over a feature called the Astoria Fan, and the other located off the southern Oregon margin (Figure 2). The specific project objectives would depend on the survey site. The Astoria Fan study area covers a major seismic gap, so that study would focus on gathering information on flexure, accretionary wedge mechanisms and gas hydrates. The southern Oregon survey area covers a megaslump[1] segment of the Cascadia subduction zone, which has no previous seismic data. A survey there would focus on paleo objectives related to geological history and performing a detailed survey of the megaslump segment.

The proposed seismic survey would take place in waters from 130 to 2,600 meters deep. The majority of the survey lines for both proposed survey areas will take place in waters over 1,000 meters deep (Table 1). No survey work will take place in shallow waters (i.e., less than 100 meters deep).

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[1] In geological terms, a slump occurs when a coherent mass of loosely consolidated materials or rock layers moves a short distance down a slope.

Table 1. Proposed survey area descriptions.

Survey Area	Amount of survey line kilometers	Percent of line kilometers in intermediate depth (100 to 1,000 meters)	Percent of line kilometers in depth greater than 1,000 meters
Astoria Fan	1,057 kilometers	23%	77%
Southern Oregon	1,013 kilometers	5%	95%

3.1.2 Source Vessel Specifications

The *Revelle* will tow the airgun array along predetermined lines (Figure 2). The operating speed during seismic acquisition is typically nine kilometers per hour (5 knots). When not towing seismic survey gear, the *Revelle* typically cruises at 22 to 23 kilometers per hour (12 to 12.5 knots). The *Revelle* also serves as the platform that protected species visual observers (observers) watch for animals.

3.1.3 Airgun Description

The airgun configuration includes two active 45 cubic inch generator-injector airguns, with its source output directed downward (Table 2). The airguns will be towed 21 meters behind the vessel, two meters apart, at a depth of three meters and fire every eight to ten seconds, or every 20 to 25 meters travelled. An 800-meter streamer would be towed along with the airgun array to receive the reflected signals and transfer the data to the on-board processing system. During firing, a brief (approximately 0.1 second) pulse of sound will be emitted. This signal attenuates as it moves away from the source, decreasing in amplitude, but also increasing in signal duration. Airguns will operate continually during the survey period (i.e., while surveying the tracklines) except for unscheduled shutdowns.

Because the actual source originates from the pair of airguns, rather than a single point source, the highest sound levels measurable at any location in the water are less than the nominal sound source level emitted by the airguns. In addition, the effective source level for sound spreading in near-horizontal directions will be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of sound from the airgun array.

Table 2. Source array specifications for the proposed survey.

Source array specifications	
Energy source	Two inline 45 cubic inches airguns two meters apart
Source output (downward)-4 airgun array	Zero to peak = 230.8 dB re 1 μPa-m Peak to peak = 236.4 dB re 1 μPa-m
Air discharge volume	~ 90 in^3
Dominant frequency components	0 to 188 hertz
Tow depth	3 meters

3.1.4 Multibeam Echosounder and Sub-bottom Profiler

Along with airgun operations, additional acoustical data acquisition systems will operate during the surveys from the *Revelle*. The multibeam echosounder as well as sub-bottom profiler systems will map the ocean floor during the cruise. These sound sources will operate from the *Revelle* simultaneously with the airgun array, as well as when the airguns are shutdown. They will not be in use while the vessel is in transit.

The sub-bottom profiler (Knudsen 3260) is a hull-mounted sonar system that operates at 3.5 to 210 kilohertz with a single 27 degrees bottom-directed beam. The nominal power output is 10 kilowatts, but the actual maximum radiated power is three kilowatts or 222 dB re 1 μPa·m. The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pings at one-second intervals.

The multibeam echosounder (Kongsberg EM 122) is also a hull-mounted system operating at 12 kilohertz. The beam width is one or two degrees fore aft and 150 degrees perpendicular to the ship's line of travel. The maximum source level is 242 dB re 1 $\mu Pa \cdot m_{rms}$. Each "ping" consists of four or eight successive fan-shaped transmissions, each two to 15 milliseconds in duration and each ensonifying a sector that extends one degree fore aft. Four or eight successive transmissions span an overall cross-track angular extent of about 150 degrees.

3.1.5 Proposed Exclusion Zones

The NSF identifies in its EA that the Scripps Institution of Oceanography will implement exclusion zones around the *Revelle* to minimize any potential adverse effects of airgun sound on MMPA and ESA-listed species. These zones are areas where seismic airguns would be powered down or shut down to reduce exposure of marine mammals and sea turtles to sound levels expected to produce potential fitness consequences. These exclusion zones are based upon modeled sound levels at various distances from the *Revelle*, described below.

3.1.5.1 Predicted Sound Levels versus Distance and Depth

The LGL used modeling by Lamont-Doherty Earth Observatory to predict received sound levels, in relation to distance and direction from two 45-in^3 GI airguns in deep water (Figure 1). In 2003, empirical data concerning 190, 180, and 160 dB re: 1 μPa_{rms} distances were acquired during the acoustic calibration study of the *R/V Ewing*'s airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004) and in 2007 to 2009 aboard the *R/V Langseth* (Diebold 2010; Tolstoy et al. 2009). As a two-airgun array at the same tow and water depths were not measured, the estimates provided here were extrapolated from other results, using conservative assumptions. Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the array was different in the Gulf of Mexico calibration study (six meters) from in the proposed survey (three meters). Because propagation varies with array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

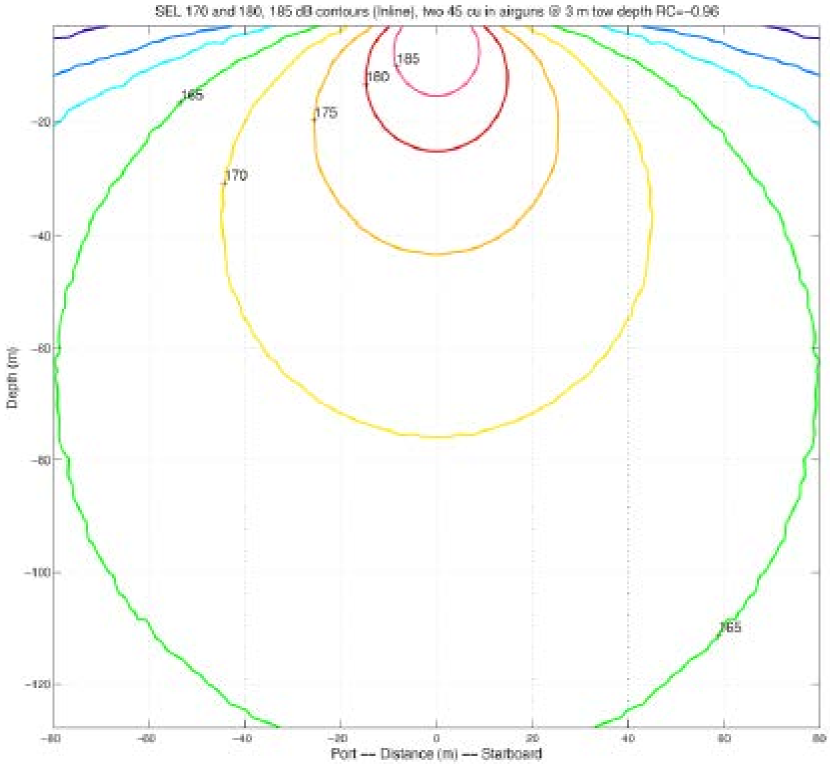

Figure 1. Modeled received sound levels (SELs) from two 45-in3 G airguns operating in deep water at a three-meter tow depth. Received rms levels (SPLs) are likely ~10 dB higher.

Table 3 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the airgun array. The 160 dB re: 1 μPa_{rms} distance is the safety criteria as specified by NMFS (1995) for cetaceans, as required by the NMFS during most other recent Lamont-Doherty Earth Observatory seismic projects (Holst and Smultea 2008b; Holst et al. 2005a; Holst 2008; Holt 2008b; Smultea et al. 2004).

Table 3. Predicted distances to which sound levels ≥160 and 175 dB re: 1 μPa$_{rms}$ could be received from the two-airgun, 90-in3 array towed at 3 m.

Water depth (meters)	Predicted rms radii (meters)	
	160 dB	175 dB
>1,000 m	448	80
100-1,000 m	672	120

The 175 dB isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airguns. The 160 dB re 1 μPa$_{rms}$ distance is the distance at which MMPA take, by Level B harassment, is expected to occur.

3.2 Proposed Activities: NMFS Permits and Conservation Division's Incidental Harassment Authorization

The NMFS' Permits and Conservation Division is proposing to issue an IHA authorizing non-lethal "takes" by Level B harassment of marine mammals incidental to the planned seismic survey. The IHA will be valid for a period of one year from the date of issuance. The IHA will authorize the incidental harassment of the following species: blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), sei whales (*Balaenoptera borealis*), sperm whales (*Physeter macrocephalus*), and other marine mammals listed under the Marine Mammal Protection Act. The proposed IHA identifies the following requirements that Scripps Institution of Oceanography must comply with as part of its authorization:

1. This IHA is valid for a period of one year from the date of issuance.
2. This IHA is valid only for marine geophysical survey activity, as specified in the SIO's IHA application and using an airgun array aboard the R/V *Revelle* with characteristics specified in the application, in the northeast Pacific Ocean.
3. General Conditions
   a. A copy of this IHA must be in the possession of SIO, the vessel operator and other relevant personnel, the lead protected species observer (PSO), and any other relevant designees of SIO operating under the authority of this IHA.
   b. The species authorized for taking are listed in Table 8. The taking, by harassment only, is limited to the species and numbers listed in Table 8. Any taking exceeding the authorized amounts listed in Table 8 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   c. The taking by serious injury or death of any species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.
   d. During use of the airgun(s), if marine mammal species other than those listed in Table 8 are detected by PSOs, the acoustic source must be shut down to avoid unauthorized take.
   e. SIO shall ensure that the vessel operator and other relevant vessel personnel are briefed on all responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and IHA requirements prior to the start of survey activity, and when relevant new personnel join the survey operations.
4. Mitigation Requirements. The holder of this Authorization is required to implement the following mitigation measures:
   a. SIO must use at least three (3) dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval.
   b. At least one PSO must have a minimum of 90 days at-sea experience working as a PSO during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One “experienced” visual PSO shall be designated as the lead for the entire protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator.
   c. Visual Observation
      i. During survey operations (*e.g.*, any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, PSO(s) must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset).
      ii. Visual monitoring must begin not less than 30 minutes prior to ramp-up, including for nighttime ramp-ups of the airgun array, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.
      iii. PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.
      iv. PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours observation per 24 hour period.
      v. During good conditions (*e.g.*, daylight hours; Beaufort sea state 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without

use of the acoustic source and between acquisition periods, to the maximum extent practicable.

d. Exclusion Zone and buffer zone – PSOs shall establish and monitor a 100 m exclusion zone (EZ) and 200 m buffer zone. The zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the EZ but within 200 m from any element of the airgun array shall be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the EZ, or on a course to enter the EZ, shall trigger further mitigation measures as described below.
    i. Ramp-up – A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45-in3 airgun, and the second 45-in3 airgun would be added after 5 minutes.
    ii. If the airgun array has been shut down due to a marine mammal detection, ramp-up shall not occur until all marine mammals have cleared the EZ. A marine mammal is considered to have cleared the EZ if:
        1. It has been visually observed to have left the EZ; or
        2. It has not been observed within the EZ, for 15 minutes (in the case of small odontocetes) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).
    iii. Thirty minutes of pre-clearance observation of the 100 m EZ and 200 m buffer zone are required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the 100 m EZ during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and 30 minutes for all other species).
    iv. During ramp-up, PSOs shall monitor the 100 m EZ and 200 m buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100 m EZ. If a marine mammal is observed within or approaching the 100 m EZ during ramp-up, a shutdown shall be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100 m EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and 30 minutes for mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).
    v. If the airgun array has been shut down for reasons other than mitigation (*e.g.*, mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant visual observation and no visual detections of any marine mammal have occurred within the buffer zone.

   vi. Ramp-up at night and at times of poor visibility shall only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100 m EZ and 200 m buffer zone have been continually monitored by visual PSOs for 30 minutes prior to ramp-up with no marine mammal detections.
   vii. The vessel operator must notify a designated PSO of the planned start of ramp-up. A designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.

e. Shutdown requirements – An exclusion zone of 100 m shall be established and monitored by PSOs. If a marine mammal is observed within, entering, or approaching the 100 m exclusion zone all airguns shall be shut down.
   i. Any PSO on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant PSO(s) must call for such action immediately.
   ii. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.
   iii. When a shutdown is called for by a PSO, the shutdown must occur and any dispute resolved only following shutdown.
   iv. The shutdown requirement is waived for dolphins of the following genera: *Tursiops*, *Stenella*, *Delphinus*, *Lagenorhynchus* and *Lissodelphis*. The shutdown waiver only applies if animals are traveling, including approaching the vessel. If animals are stationary and the vessel approaches the animals, the shutdown requirement applies. If there is uncertainty regarding identification (*i.e.*, whether the observed animal(s) belongs to the group described above) or whether the animals are traveling, shutdown must be implemented.
   v. Upon implementation of a shutdown, the source may be reactivated under the conditions described at 4(e)(vi). Where there is no relevant zone (*e.g.*, shutdown due to observation of a calf), a 30-minute clearance period must be observed following the last observation of the animal(s).
   vi. Shutdown of the array is required upon observation of a whale (*i.e.*, sperm whale or any baleen whale) with calf, with “calf” defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult, at any distance.
   vii. Shutdown of the array is required upon observation of an aggregation (*i.e.*, six or more animals) of large whales of any species (*i.e.*, sperm whale or any baleen whale) that does not appear to be traveling (*e.g.*, feeding, socializing, etc.) at any distance.
   viii. Shutdown of the array is required upon observation of a killer whale at any distance.

f. Vessel Strike Avoidance – Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course, as appropriate, to avoid striking any marine mammal, unless such action represents a human safety concern. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.

  i. The vessel must maintain a minimum separation distance of 100 m from large whales, unless such action represents a human safety concern. The following avoidance measures must be taken if a large whale is within 100 m of the vessel:
    1. The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established unless such action represents a human safety concern.
    2. If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 m unless such action represents a human safety concern.
  ii. The vessel must maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for animals described in 4(e)(iv) that approach the vessel. If an animal is encountered during transit, the vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course unless such action represents a human safety concern.
  iii. Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel unless such action represents a human safety concern.

g. Miscellaneous Protocols
  i. The airgun array must be deactivated when not acquiring data (as in during transit) or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Operational capacity of 90 in^3 (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.
  ii. Testing of the acoustic source involving all elements requires normal mitigation protocols (*e.g.*, ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

h. Monitoring Requirements. The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring shall be conducted in accordance with the following requirements:

    i. The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.
    ii. PSOs must also be equipped with reticle binoculars (*e.g.*, 7 x 50) of appropriate quality (*i.e.*, Fujinon or equivalent), GPS, digital single-lens reflex camera of appropriate quality (*i.e.*, Canon or equivalent), compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

i. PSO Qualifications
    i. PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program.
    ii. PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

j. Data Collection – PSOs must use standardized data forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source to resume survey. If required mitigation was not implemented, PSOs should submit a description of the circumstances. The NMFS Permits and Conservation Division requires that, at a minimum, the following information be reported:
    i. PSO names and affiliations
    ii. Dates of departures and returns to port with port name
    iii. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort
    iv. Vessel location (latitude/longitude) when survey effort begins and ends; vessel location at beginning and end of visual PSO duty shifts
    v. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change

vi. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions change significantly), including wind speed and direction, Beaufort sea state, Beaufort wind force, swell height, weather conditions, cloud cover, sun glare, and overall visibility to the horizon

vii. Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (*e.g.*, vessel traffic, equipment malfunctions)

viii. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.*, pre-ramp-up survey, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.)

ix. If a marine mammal is sighted, the following information should be recorded:

    1. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
    2. PSO who sighted the animal;
    3. Time of sighting;
    4. Vessel location at time of sighting;
    5. Water depth;
    6. Direction of vessel's travel (compass direction);
    7. Direction of animal's travel relative to the vessel;
    8. Pace of the animal;
    9. Estimated distance to the animal and its heading relative to vessel at initial sighting;
    10. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified); also note the composition of the group if there is a mix of species;
    11. Estimated number of animals (high/low/best);
    12. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
    13. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
    14. Detailed behavior observations (*e.g.*, number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
    15. Animal's closest point of approach (CPA) and/or closest distance from the center point of the acoustic source;
    16. Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other); and
    17. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up, speed or course alteration, etc.)

and time and location of the action.

k. Reporting
    i. SIO shall submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used must be provided as an ESRI shapefile with all necessary files and appropriate metadata. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the data collected as required under condition 5(d) of this IHA. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.
    ii. Reporting injured or dead marine mammals:
    iii. In the event that the specified activity clearly causes the take of a marine mammal in a manner not authorized by this IHA (if issued), such as serious injury or mortality, SIO shall immediately cease the specified activities and immediately report the incident to NMFS. The report must include the following information:
        1. Time, date, and location (latitude/longitude) of the incident;
        2. Vessel’s speed during and leading up to the incident;
        3. Description of the incident;
        4. Status of all sound source use in the 24 hours preceding the incident;
        5. Water depth;
        6. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);
        7. Description of all marine mammal observations in the 24 hours preceding the incident;
        8. Species identification or description of the animal(s) involved;
        9. Fate of the animal(s); and
        10. Photographs or video footage of the animal(s).

    Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS.

    iv. In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), SIO shall immediately report the incident to NMFS. The report must include the same information identified in condition 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.

v. In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to NMFS within 24 hours of the discovery. SIO shall provide photographs or video footage or other documentation of the sighting to NMFS.

5. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

4 ACTION AREA

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02).

The proposed action would take place in the northeast Pacific Ocean, off the coasts of Oregon and Washington during September 2017. The survey would take place off the continental margin out to 127.5 degrees West, and between about 43 and 46.5 degrees North (Figure 2). The survey area covers water depths from 130 to 2,600 meters. The action area would also include the area covered by the Revelle while transiting from its port in Newport, Oregon to the survey area. We do not anticipate any effects outside the area shown on the map in Figure 2.

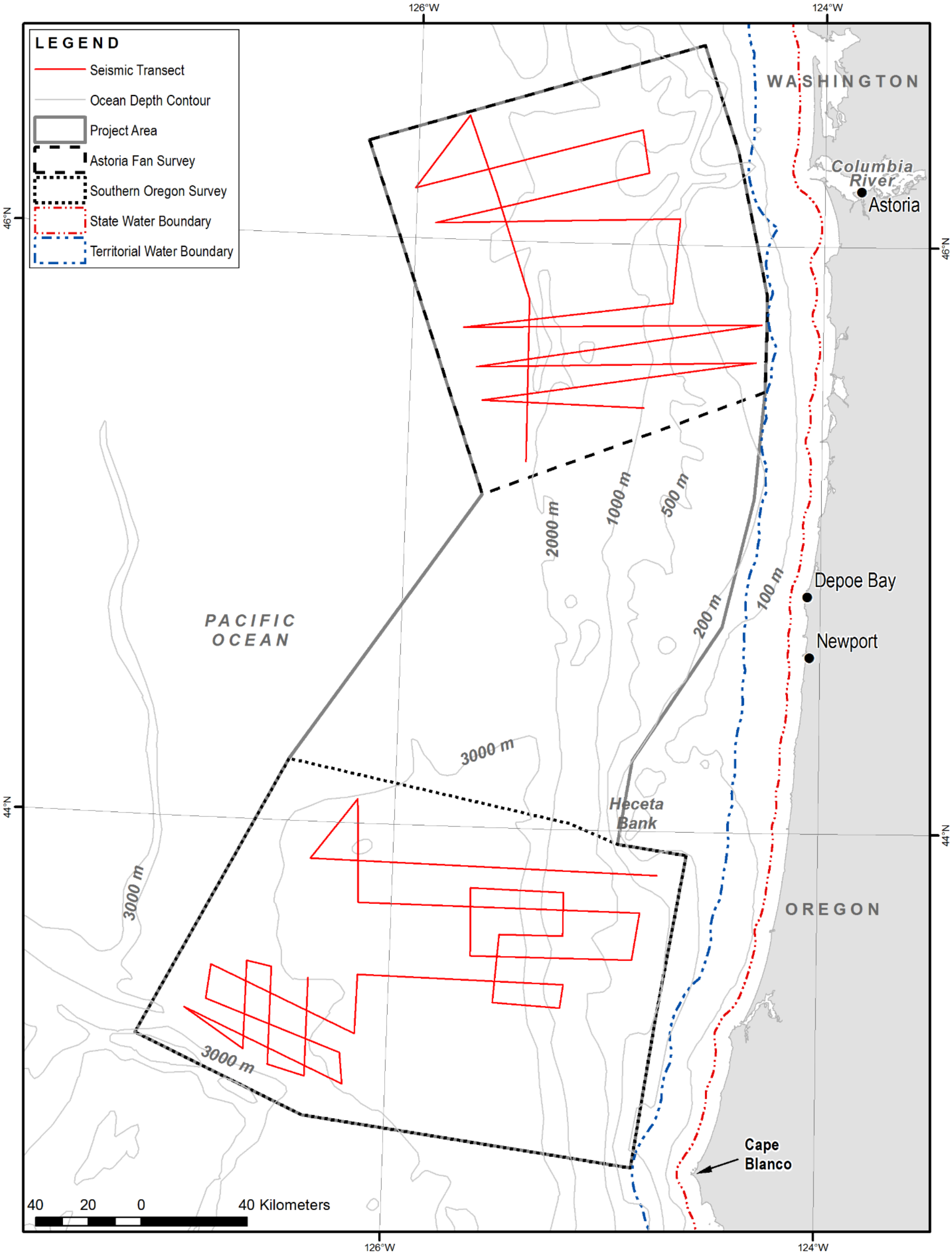

Figure 2. Map of the proposed action area.

5 INTERRELATED AND INTERDEPENDENT ACTIONS

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility apart from the action under consideration.

The two proposed actions considered in this opinion are interdependent. The Permits and Conservation Division's proposal to issue an MMPA authorization is interdependent on NSF's proposed seismic activities, as it would not have an independent use if not for the actual activity NSF proposed. Likewise, NSF's proposed action would not carry forward without the authorization to exempt marine mammal take from the Permits and Conservation Division.

6 POTENTIAL STRESSORS

There are several potential stressors that we expect to occur because of the proposed action. These include those associated with vessel activity (e.g., pollution by oil or fuel leakage, ship strikes, and acoustic interference from engine noise) and research activity (e.g., entanglement in the towed hydrophone streamer and the sound produced by the airguns, sub-bottom profiler, and multibeam echosounder). These stressors are evaluated in detail in Section 11.1.

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

NMFS uses two criteria to identify the ESA-listed or critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are interrelated to or interdependent with the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the 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. ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the species ESA-listed in Table 4 and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial*, *insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species),but it is very unlikely to occur.

7.1 Southern Resident killer whales

Southern Resident DPS killer whales are not expected to occur in the area of the proposed survey as the easternmost track lines of the proposed survey (those that approach nearest to shore) are further west than the migratory range of the Southern Resident stock off Oregon and southern Washington (pers. comm., B. Hanson, NMFS Northwest Fishery Science Center to C. Cairns, NMFS OPR, April 12, 2017). At the time the action will occur, we expect Southern Resident killer whales to be outside of the action area. The summer range (i.e., May through September) of the Southern Resident killer whale is near Haro Strait, Boundary Pass, San Juan Island, and the Strait of Juan de Fuca, Washington and British Columbia. Southern Resident killer whales do occur off the Washington and Oregon coasts, (e.g., around the Columbia River), but in winter, during the months of February and March.[2] In 2012, NSF funded seismic surveys in the Pacific Ocean off the coast of Washington in June and July, and reported no killer whales during those surveys.

However, as the known migratory range of the Southern Resident DPS occurs near the proposed survey area, and due to the precarious conservation status of the Southern Resident killer whale DPS, the NMFS Permits and Conservation Division developed measures that it believes are reasonable, conservative, and also practicable in order to prevent the potential for a Southern Resident killer whale to be exposed to airgun sounds. Thus, the requirement to shut down the array upon observation of a killer whale at any distance is designed to avoid any potential for harassment of any Southern Resident killer whales.

Since the proposed action would take place in a location and time of year when we do not expect Southern Resident killer whales to be present, we do not expect them to be exposed to the proposed action, including the stressors related to vessel activity and the seismic research. In the very unlikely event that Southern Resident killer whales are near the action area, we believe that the requirement to shut down the airgun array upon sighting any killer whales will prevent exposure from the seismic activity. We therefore conclude that the effects of the proposed action to these species are discountable and will not be considered further in this opinion.

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[2] https://www.nwfsc.noaa.gov/news/blogs/display_blogentry.cfm?blogid=5

7.2 ESA-listed fishes

Numerous species of ESA-listed or proposed fish species could occur in and around the action area.

7.2.1 ESA-listed Pacific salmonids

The proposed action would take place in the waters of the Pacific Ocean off Oregon and Washington. There are several distinct population segments or evolutionarily significant units of Pacific salmonids that could occur in the area during their oceanic life phase, including:

- Steelhead trout, (*Oncorhynchus mykiss*)
    - Lower Columbia River, Middle Columbia River, Upper Columbia River, Puget Sound, and Upper Willamette River;
- Chinook salmon, (*Oncorhynchus tshawytscha)*
    - Upper Willamette River, Lower Columbia River, Upper Columbia River Spring-Run, Puget Sound;
- Coho salmon, (*Oncorhynchus kisutch*)
    - Lower Columbia River, Southern Oregon/Northern California Coast, Oregon Coast;
- Chum salmon, (*Oncorhynchus keta*)
    - Columbia River, Hood Canal.

It is not well-understood where in the ocean these (or any) Pacific salmonids go (Meyers 1998); the distinct population segments or evolutionarily significant units noted above are those in the Oregon and Washington region, and thus closest to the action area, and more likely to be present. It is possible that other ESA-listed populations of Pacific salmonids that are farther away (e.g., from California) could be present in the action area, though we consider that less likely due to the distance.

The proposed action will not involve any capture methods or sampling techniques that would capture or impact ESA-listed Pacific salmonids. Since the proposed action would involve vessel operation and seismic activities that are not expected to interact with ESA-listed Pacific salmonids, we do not expect them to be adversely affected by the proposed action. We therefore conclude that the effects of the proposed action to these species are discountable and will not be considered further in this opinion.

7.2.2 ESA-listed and proposed sharks and rays

The giant manta ray (*Manta birostris*) and oceanic whitetip shark (*Carcharhinus longimanus*) are proposed to be listed as threatened under the ESA. Giant manta rays are found as far north as southern California (82 FR 3694), and oceanic whitetip sharks range as far north as 30 degrees north latitude (Young 2016). The proposed action area will be from 43 to 46.5 degrees North, off the coasts of Oregon and Washington, well out of range of both species. We conclude that there will be no effect from the proposed action on giant manta rays or oceanic whitetip sharks.

The scalloped hammerhead (*Sphyrna lewini*) Eastern Pacific DPS is listed as endangered. Each of these species range throughout the Pacific Ocean. Scalloped hammerheads are restricted by water temperature, and are rarely found in waters cooler than 22 degrees Celsius (Wilson 2013). They are typically found in tropical and warm temperate waters around the globe. Average water temperatures in the action area (e.g., Newport, Oregon, and Astoria, Oregon) for the time period the action will be occurring (i.e., late September) are 13 and 16 degrees Celsius, respectively.[3] Since the water temperatures will be far too cold for scalloped hammerheads, we believe that they will not be present in the action area, and there will be no effect from the proposed action.

7.2.3 Bocaccio

Puget Sound/Georgia Basin DPS bocaccio (*Sebastes paucispinis*) are found in Puget Sound, Washington, mostly south of the Tacoma Narrows. Since the action will take place off the coasts of Washington and Oregon, outside of the expected range of Puget Sound/Georgia Basin bocaccio, we conclude that there will be no effect of the proposed action on this species.

7.2.4 Green Sturgeon

Southern DPS green sturgeon (*Acipenser medirostris*) consists of populations originating from coastal watersheds south of the Eel River, California. Sub-adult and adult green sturgeon spend most of their lives in the marine environment, at water depths between 20 and 70 meters (NMFS 2015a). No part of the proposed survey lines will take place in waters less than 100 meters deep; therefore, we do not believe green sturgeon will be exposed to the seismic activities of the proposed action. Green sturgeon are benthic, thus minimizing the risk of ship strike while the *Revelle* transits from port to the action area. We conclude that there will be no effect to Southern DPS green sturgeon from the proposed action.

7.3 ESA-listed sea turtles

Olive ridley sea turtles (*Lepidochelys olivacea*) and hawksbill sea turtles (*Eretmochelys imbricata*) range broadly throughout the Pacific Ocean. However, both species have a circumtropical distribution restricted by ocean temperature, with southern California being the northern limit of their distribution (USFWS 2014). Because olive ridley and hawksbill sea turtles are not found in the action area, we have determined that there will be no effect to either species.

Green turtle (*Chelonia mydas*) East Pacific DPS and loggerhead (*Caretta caretta*) North Pacific DPS range along the West Coast of the United States, within the vicinity of the action area. However, green and loggerhead turtles are only rarely found in Washington or Oregon waters (WDFW 2012). Because of their scarcity in the waters in and around the action area, we believe it is extremely unlikely that green or loggerhead sea turtles will be exposed to the proposed action, and the effects are discountable. We conclude that the action is not likely to adversely affect these species.

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[3] See water temperature data at: https://www.nodc.noaa.gov/dsdt/cwtg/npac.html

7.4 Designated critical habitat

Critical habitat has been designated in or near the action area for the following species: Southern Resident killer whale, Eastern DPS Steller sea lion, and Southern DPS eulachon. The proposed action—including vessel transit and seismic activities—will occur outside each of these critical habitat designations. We conclude that there will be no effect from the proposed action to the critical habitat designations for Southern Resident killer whale, Eastern DPS Steller sea lion, and Southern DPS eulachon.

Designated critical habitat for several evolutionarily significant units and distinct population segments of steelhead and chinook, sockeye and chum salmon includes nearshore marine waters contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters (98 feet) relative to mean lower low water (70 FR 52630; September 2, 2005). The primary constituent elements for these critical habitat designations include nearshore marine areas free of obstruction and excessive predation with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; natural cover; and offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation. There would be no effect to these critical habitat areas because the proposed activities would not cause obstruction or significantly affect predation, would not cause any significant changes to water quality in designated critical habitat, would not affect forage or the ability for critical habitat areas to support growth and maturation of ESA-listed salmon and would not affect the natural cover in these areas. Therefore, the proposed activities are not expected to adversely affect the conservation value of designated critical habitat for these species.

Green sturgeon critical habitat was designated in several locations throughout Washington, Oregon, and California. The coastal marine habitat designation is the only unit that falls within the action area. Green sturgeon coastal marine critical habitat is defined as waters up to 110 meters deep, from Monterey Bay, California, to Cape Flattery, Washington. The proposed seismic activities will take place mostly in deep waters (greater than 1,000 meters deep); with some survey lines in waters between 100 and 1,000 meters deep (see Table 1). Vessel activity associated with the proposed action would involve transit through the critical habitat. The essential biological features of coastal marine habitat are migratory corridors for safe passage of green sturgeon, water quality (i.e., appropriate dissolved oxygen levels and low levels of contaminants), and adequate food resources. The proposed action will involve seismic activities and vessel transit, which will not degrade water quality, impede green sturgeon migration, or reduce available prey. We conclude that there will be no effect to green sturgeon critical habitat.

Critical habitat for leatherback sea turtles on the Pacific coast was designated in 2012 (77 FR 4170). It includes approximately 16,910 square miles (43,798 square kilometers) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square kilometers) from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The proposed activity would take place off the coasts of Washington and Oregon, and would occur within leatherback designated critical habitat.

Only one primary constituent element was identified for leatherback critical habitat: the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *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.

The proposed action would involve activities in critical habitat areas for leatherback sea turtles, including vessel activities and seismic research, but the action is not expected to adversely affect any aspect of prey availability that forms the primary constituent element for the critical habitat. As such, the proposed action is expected to have no effect on designated critical habitat for leatherback sea turtle and will not be discussed further in this opinion.

8 SPECIES AND CRITICAL HABITAT LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species that occur within the action area Figure 2 that may be affected by NSF's proposed seismic activities off the coasts of Washington and Oregon, and the Permits and Conservation Division's issuance of an IHA (Table 4). All of the species potentially occurring within the action area are ESA-listed in Table 4 along with their regulatory status.

Table 4. Threatened and endangered species that may be affected by NSF and the NMFS Permits and Conservation Division's proposed action of seismic activities off the coast of Washington and Oregon and the issuance of an Incidental Harassment Authorization.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538
Sei Whale (Balaenoptera borealis)	E – 35 FR 18319	-- --	76 FR 43985
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T -- 81 FR 62259	-- --	55 FR 29646
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E -- 81 FR 62259	-- --	55 FR 29646
Sea Turtles			
Leatherback turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	63 FR 28359

9 STATUS OF SPECIES AND CRITICAL HABITAT LIKELY TO BE ADVERSELY AFFECTED

This section examines the status of each species that would be affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on these NMFS Web sites: [http://www.nmfs.noaa.gov/pr/species/index.htm].

This section also examines the condition of critical habitat throughout the designated area (such as various watersheds and coastal and marine environments that make up the designated area), and discusses the condition and current function of designated critical habitat, including the essential physical and biological features that contribute to that conservation value of the critical habitat.

One factor affecting the range wide status of ESA-listed whales and leatherback sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in the Environmental Baseline section.

9.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 3).

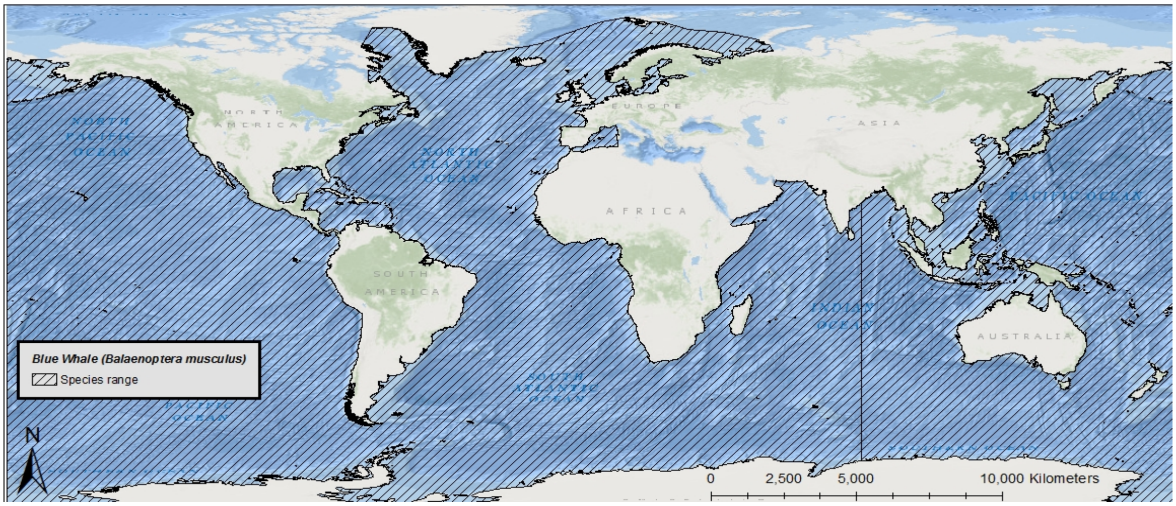

Figure 3. Map identifying the range of the blue whale.

Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, --proportionally smaller dorsal fin, and are a mottled gray color that appears light blue when seen through the water (Figure 4). The blue whale was originally listed as endangered on December 2, 1970 (35 FR 18319) (Table 5).

Figure 4. Blue whale. Photo: NOAA.

Table 5. Blue whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Balaenoptera musculus	**Blue whale**	**None**	**Endangered** range wide	None	35 FR 18316	1998 Intent to update (77 FR 22760)	None Designated

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (COSEWIC 2002) were used to summarize the life history, population dynamics and status of the species as follows. There are three stocks of blue whales designated in U.S. waters: the eastern North Pacific stock occupies the U.S. West Coast, and individuals from this stock are likely to be affected by the proposed action.

Life History

The average life span of blue whales is eighty to ninety years. They have a gestation period of ten to twelve months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and fifteen years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 meters.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the blue whale.

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007b). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic, North Pacific, and Southern Hemisphere. The eastern North Pacific stock and has a population estimate of N = 1,647 (N_{min} = 1,551) (Calambokidis and Barlow 2013).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis 2009). An overall population growth rate for the species or a growth rate for the eastern North Pacific stock are not available at this time.

Little genetic data exist on blue whales globally. Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore (Figure 3). In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off of the Aleutian Islands and the Bering Sea.

Vocalization and Hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5 to 400 hertz, with dominant frequencies from 16 to 25 hertz, and songs that span frequencies from 16 to 60 hertz that last up to 36 seconds repeated every one to two minutes (see Cummings and Thompson 1971; Cummings 1977; Edds-Walton 1997a; Edds 1982; McDonald et al. 1995a; Thompson 1982). Non-song vocalization are also low-frequency in nature (generally below 200 hertz, but one of six types up to 750 hertz) between 0.9 and 4.4 seconds long (Redalde-Salas 2014). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0 to 78.7 hertz. Reported source levels are 180 to 188 dB re 1µPa, but may reach 195 dB re 1µPa (Aburto et al. 1997; Clark and Ellison 2004; Ketten 1998; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re: 1 μPa_{rms} at 1 meter in the 17 to 30 hertz range and pygmy blue whale calls at 175± 1 dB re: 1 μPa_{rms} at 1 meter in the 17 to 50 hertz range. Source levels around Iceland have been 158 to 169 dB re: 1 μPa_{rms} (Rasmussen 2013). Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish 1971; Cummings et al. 1972; Cummings and Thompson 1971; Cummings and Thompson 1994; Cummings 1977; Rivers 1997; Thompson 1996). Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

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 1997b; Payne and Webb 1971; Thompson et al. 1992a). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently during summer in high-latitude feeding areas. Short, rapid sequences of 30 to 90 hertz calls are associated with socialization and may be displays by males based on call seasonality and structure.

Status

The blue whale is endangered because of past commercial whaling. In the North Pacific, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because blue whales in the North Pacific appear to be increasing in size, the population appears to be somewhat resilient to current threats; however, it has not recovered to pre-exploitation levels.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

See the 1998 Final Recovery Plan for the Blue whale for complete down listing/delisting criteria for each of the following recovery goals.

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere
2. Estimate the size and monitor trends in abundance of blue whale populations
3. Identify and protect habitat essential to the survival and recovery of blue whale populations
4. Reduce or eliminate human-caused injury and mortality of blue whales
5. Minimize detrimental effects of directed vessel interactions with blue whales

6. Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales
8. Establish criteria for deciding whether to delist or down list blue whales.

9.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* is found in the Northern Hemisphere (Figure 5). On the U.S. West Coast, fin whales are distributed off California, Oregon, and Washington.

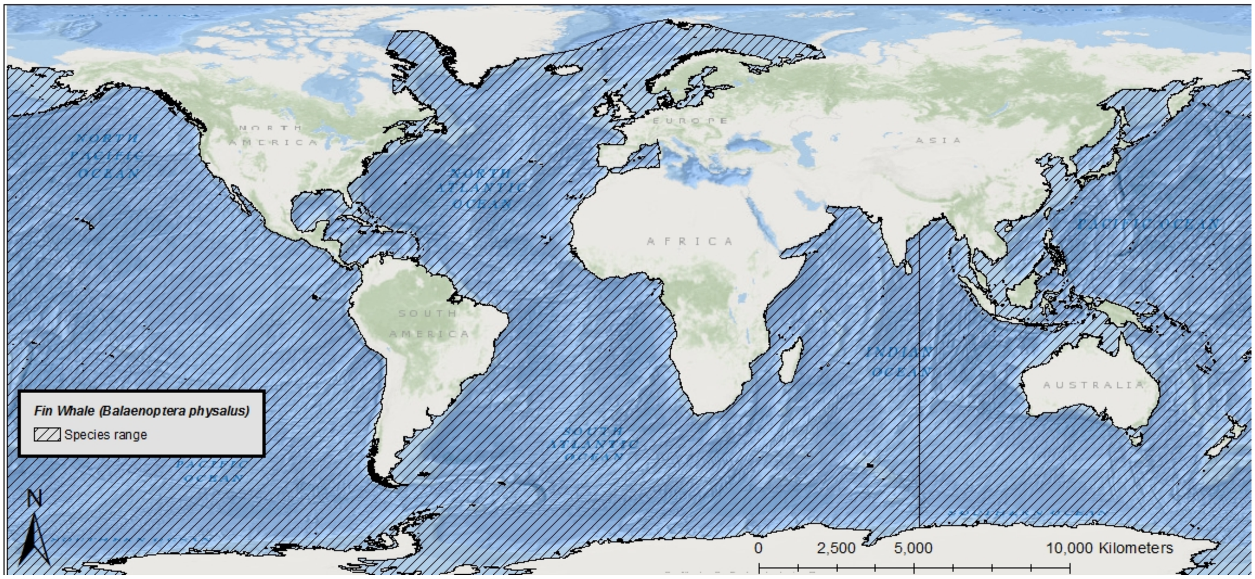

Figure 5. Map identifying the range of the fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body with a V-shaped head, a tall, falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface (Figure 6). The fin whale was originally listed as endangered on December 2, 1970 (35 FR 18319) (Table 6).

Figure 6. Fin whale. Photo: NOAA

Table 6. Fin whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Balaenoptera physalus	**Fin whale**	**None**	**Endangered** range wide	2011	35 FR 18319	2010	None Designated

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Fin whales can live, on average, eighty to ninety years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific was 42,000 to 45,000 (Ohsumi 1974). In the North Pacific, at least 74,000 whales were killed between 1910 and 1975. Currently, The best current estimate of abundance for fin whales off of California, Washington, and Oregon is approximately 9,029 (N_{min}=8,127) individuals (Nadeem et al. 2016).

Current estimates indicate a 7.5 percent increase in the California/Oregon/Washington fin whale population (Nadeem et al. 2016).

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mtDNA genome for 154 fin whales sampled in the North Atlantic, North Pacific, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within ocean basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some population's having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

There are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic, North Pacific, and Southern Hemisphere (Figure 5) where they appear to be reproductively isolated. The availability of sand lice, in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

Vocalization and Hearing

Fin whales produce a variety of low-frequency sounds in the 10 to 200 hertz range (Edds 1988; Thompson et al. 1992a; Watkins 1981; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to 2 seconds) in the 18 to 35 hertz range, but only males are known to produce these (Croll et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995a) reported the most common sound as a one second vocalization of about 20 hertz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns during winter. Au (2000b) reported moans of 14 to 118 hertz, with a dominant frequency of 20 hertz, tonal vocalizations of 34 to 150 hertz, and songs of 17 to 25 hertz (Cummings and Thompson 1994; Edds 1988; Watkins 1981). Source levels for fin whale vocalizations are 140 to 200 dB re 1μPa·m (Clark and Ellison. 2004; Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 meters (Watkins et al. 1987). In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). Short sequences of rapid pulses in the 20 to 70 hertz band are associated with animals in social groups (McDonald et al. 1995b). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Although their function is still debated, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997b; 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). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins 1987), while the individual counter-calling data of McDonald et al. (1995b) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson et al. 1992b).

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. 1995c).

Status

The fin whale is endangered because of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. Fin whales in California, Oregon, and Washington have a relatively large population size and increasing trend may provide some resilience to current threats, but the population is still well below pre-harvest levels.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

See the 2010 Final Recovery Plan for the fin whale for complete down listing/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

9.3 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 7). Sei whales in the Eastern North Pacific are found off the coasts of California, Oregon, and Washington.

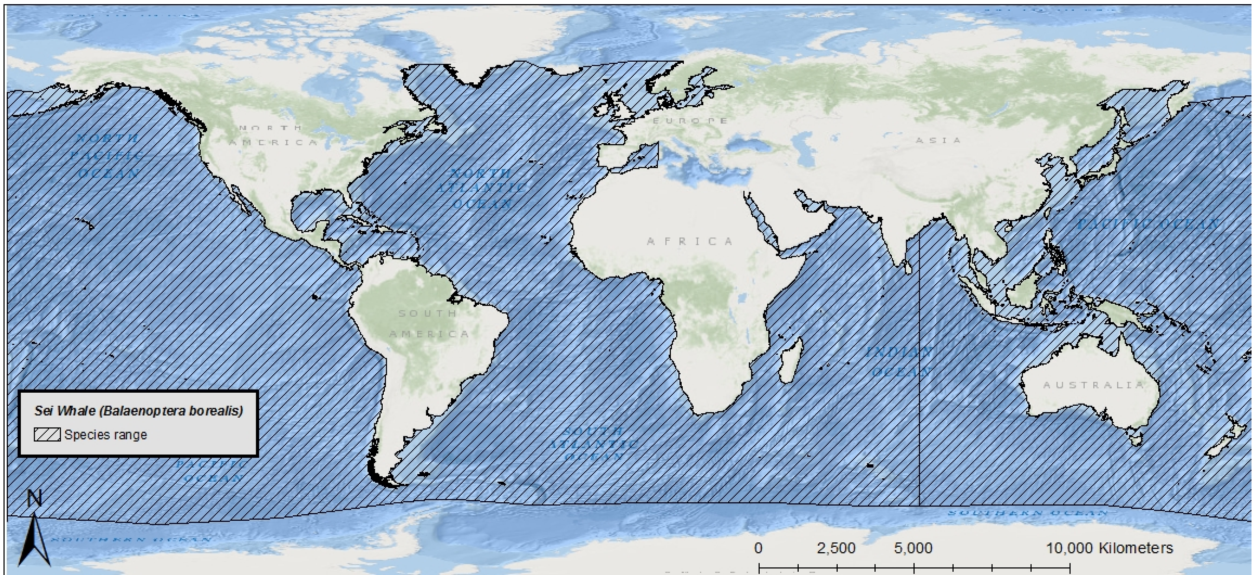

Figure 7. Map identifying the range of the sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum (Figure 8). Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. The sei whale was originally listed as endangered on December 2, 1970 (35 FR 18319).

Figure 8. Sei whale. Photo: NOAA

Table 7. Sei whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Balaenoptera borealis	**Sei whale**	**None**	**Endangered** range wide	2012	35 FR 18316	2011	None Designated

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (NMFS 2012) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Sei whales can live, on average, between fifty and seventy years. They have a gestation period of ten to twelve months, and calves nurse for six to nine months. Sexual maturity is reached between six and twelve years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sei whale.

Models indicate that total sei whale abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific. Sei whale abundance in the Eastern North Pacific is estimated at 519 individuals (N_{min}=374) (Barlow 2016).

A population growth rate for sei whales in the Eastern North Pacific is not available at this time.

While some genetic data exist sei whales, current samples sizes are small limiting our confidence in their estimates of genetic diversity (NMFS 2011b). However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

There are approximately 80,000 sei whales worldwide, occurring in the North Atlantic, North Pacific, and Southern Hemisphere (Figure 7).

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 hertz range with 1.5 seconds duration and tonal and upsweep calls in the 200 to 600 hertz range of one to three second durations (McDonald et al. 2005). Source levels of 189 ±5.8 dB re: 1 µPa at 1 meter have been established for sei whales in the northeastern Pacific (Weirathmueller 2013). Differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007). The first variation consisted of sweeps from 100 to 44 hertz, over 1.0 second. During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency down swept calls. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 to 21 hertz over 1.3 seconds. These vocalizations are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters. Vocalizations from the North Atlantic consisted of paired sequences (0.5 to 0.8 second, separated by 0.4 to 1.0 second) of 10 to 20 short (four milliseconds) frequency module sweeps between 1.5 to 3.5 kilohertz (Thomson and Richardson 1995).

Status

The sei whale is endangered because of past commercial whaling. Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and noise. The species' large population size may provide some resilience to current threats, but trends are largely unknown.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

See the 2011 Final Recovery Plan for the sei whale for complete down listing/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

9.4 Sperm Whale

The sperm whale is a widely distributed whale found in all major oceans (Figure 9). Off the U.S. West Coast, sperm whales are found in Washington and Oregon in spring, summer, and fall, and in California year-round.

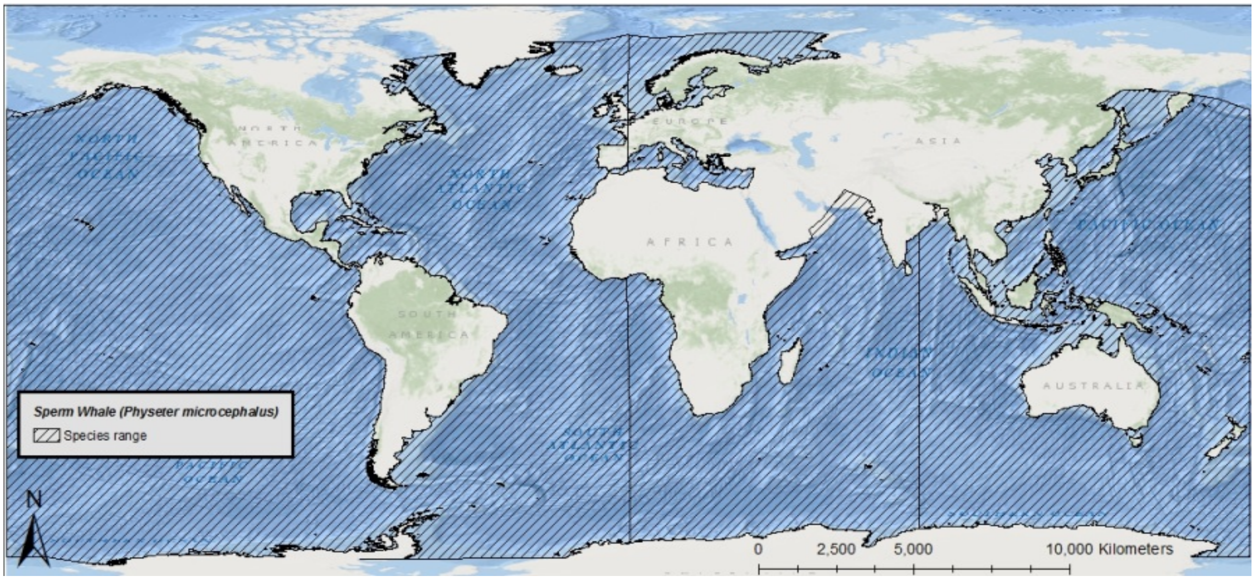

Figure 9. Map identifying the range of the sperm whale.

Sperm whales are the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up to twenty-five percent to thirty-five percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip (Figure 10). The sperm whale was originally listed as endangered on December 2, 1970 (35 FR 18319) (Table 8).

Figure 10. Sperm whale. Photo: NOAA.

Table 8. Sperm whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Physeter microcephalus	**Sperm whale**	**None**	**Endangered:** range wide	2015	35 FR 18319	2010	None Designated

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (NMFS 2015b) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between seven and thirteen years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 meters (1,968 feet) or more, and are uncommon in waters less than 300 meters (984 feet) deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sperm whale.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. There are six recognized stocks of sperm whales that exist in U.S. waters: abundance for the California/Oregon/Washington stock of sperm whales is estimated at N=2,106 (N_{min}=1,332) (Moore and Barlow 2014).

The is insufficient data to evaluate trends in abundance and growth rates of sperm whales off of California, Oregon, and Washington at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and

Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and ‘Allee’ effects, although the extent to which is currently unknown.

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins (Figure 9). While both males and females can be found in latitudes less than 40º, only adult males venture into the higher latitudes near the poles. In shipboard and aerial surveys, they are commonly sighted near the 1,000-meter isobaths.

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 hertz to 20 kilohertz that can be extremely loud for a biological source (200 to 236 dB re: 1μPa), although lower source level energy has been suggested at around 171 dB re: 1 μPa (Goold and Jones 1995; Møhl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around two to four kilohertz and 10 to 16 kilohertz (Goold and Jones 1995; NMFS 2006d; Weilgart and Whitehead 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972; Norris and Harvey. 1972). Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intragroup interactions (Weilgart and Whitehead 1993). They may also aid in intra-specific communication. Another class of sound, “squeals”, are produced with frequencies of 100 hertz to 20 kilohertz (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 to 60 kilohertz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999).

Status

The sperm whale is endangered because of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, pollution, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

See the 2010 Final Recovery Plan for the sperm whale for complete down listing/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

9.5 Humpback Whale Mexico and Central America Distinct Population Segments

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 11). Two distinct population segments may be found in the proposed action area: the Central America and Mexico DPSs (areas five and six on the map). Both are discussed in this section.

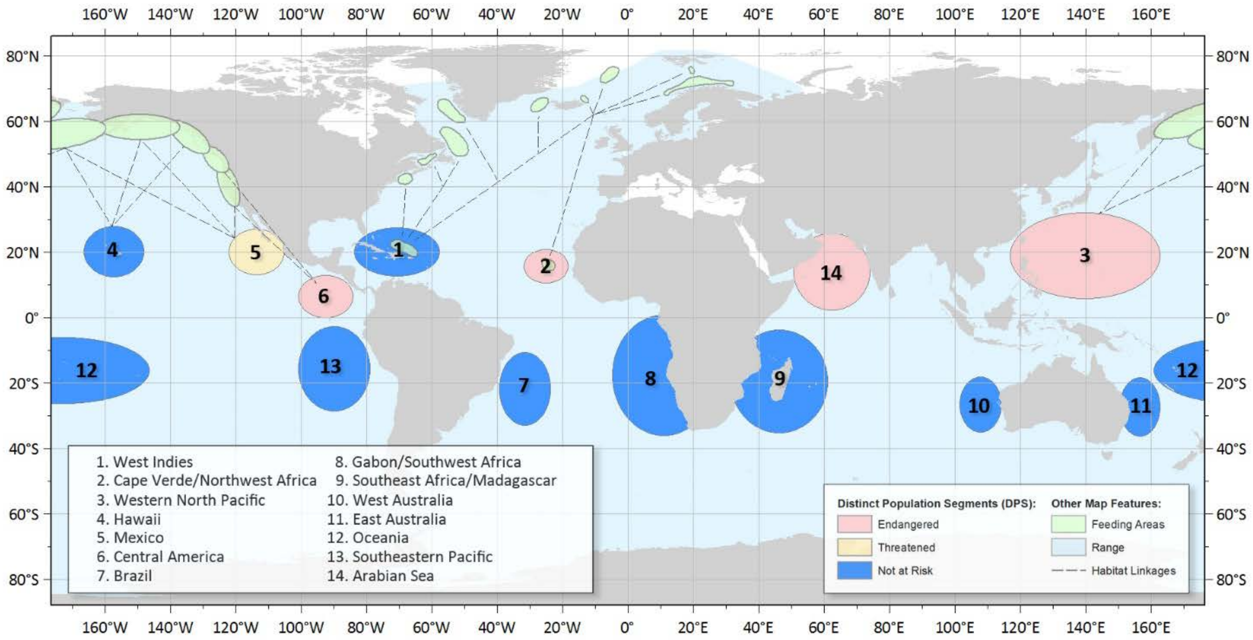

Figure 11: Map identifying 14 distinct population segments with one threatened and four endangered, based on primary breeding location of the humpback whale, their range, and feeding areas (Bettridge 2015).

Humpbacks are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white (Figure 12). The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated fourteen DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific,

Figure 12. Humpback whale. Photo: NOAA.

Central America, and Arabian Sea) and one as threatened (Mexico) (81 FR 62259) (Table 9).

Table 9. Humpback whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Megaptera novaeangliae	**Humpback whale**	**Mexico**	**Threatened**	2015	81 FR 62259	1991	None Designated
Megaptera novaeangliae	**Humpback whale**	**Central America**	**Endangered**	2015	81 FR 62259	1991	None Designated

Information available from the recovery plan (NMFS 1991), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016b), the status review (Bettridge 2015), and the final listing (81 FR 62259) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpbacks can live, on average, fifty years. They have a gestation period of eleven to twelve months, and calves nurse for one year. Sexual maturity is reached between five to eleven years of age with an average calving interval of two to three years. Humpbacks mostly inhabit coastal and continental shelf waters. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpbacks exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge 2015).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Mexico and Central American humpback whale DPSs.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman 2003). The abundance and population trends of ESA-listed humpback whale Mexico and Central America DPSs are summarized in Table 10.

Table 10: Abundance and population trend estimates for humpback whale distinct population segments as listed under the Endangered Species Act (81 FR 62259).

Distinct Population Segment	ESA Status	Abundance	Population Trend
Central America	Endangered	411	Unknown
Mexico	Threatened	3,264	Unknown

Population growth rates are currently unavailable for the Mexico and Central America humpback whale DPSs (Table 10).

For humpback whales, distinct population segments that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population five hundred individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Populations at low densities (less than one hundred) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes. The Central America has below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance (81 FR 62259, Bettridge 2015).

The Mexico DPS consists of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands and transit through the Baja California Peninsula coast. The DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington – southern British Columbia, northern and western Gulf of Alaska and Bering Sea feeding grounds (Figure 11) (81 FR 62259). The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras and Nicaragua. This DPS feeds almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds (Figure 11) (81 FR 62259).

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 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 hertz to 4 kilohertz with estimated source levels from 144 to 174 decibels (Au 2000b; Au et al. 2006; Frazer and Mercado 2000; Payne 1970; Richardson et al. 1995c; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 hertz to 10 kilohertz and having most energy below three kilohertz (Silber 1986a; Tyack 1983). Such sounds can be heard up to nine kilometers away (Tyack and Whitehead 1983). Other social sounds from 50 hertz to ten kilohertz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995c; Tyack and Whitehead 1983). While in northern feeding areas, both sexes vocalize in grunts (25 hertz to 1.9 kilohertz), pulses (25 to 89 hertz), and songs (ranging from 30 hertz to eight kilohertz but dominant frequencies of 120 hertz to four kilohertz) which can be very loud (175 to 192 dB re 1 μPa at 1 m; (Au 2000b; Erbe 2002a; Payne and Payne 1985; Richardson et al. 1995c; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the Central America and Mexico DPSs that remain listed have likely not yet recovered from this. Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whale watching, noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size indicates that it may be resilient to current threats, but the Mexico DPS still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range. The Central America DPS still faces a risk of extinction due to its small population size.

Critical Habitat

No critical habitat has been designated for any distinct population segment of humpback whales.

Recovery Goals

See the 1991 Final Recovery Plan for the Humpback whale for complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

9.6 Leatherback Turtle

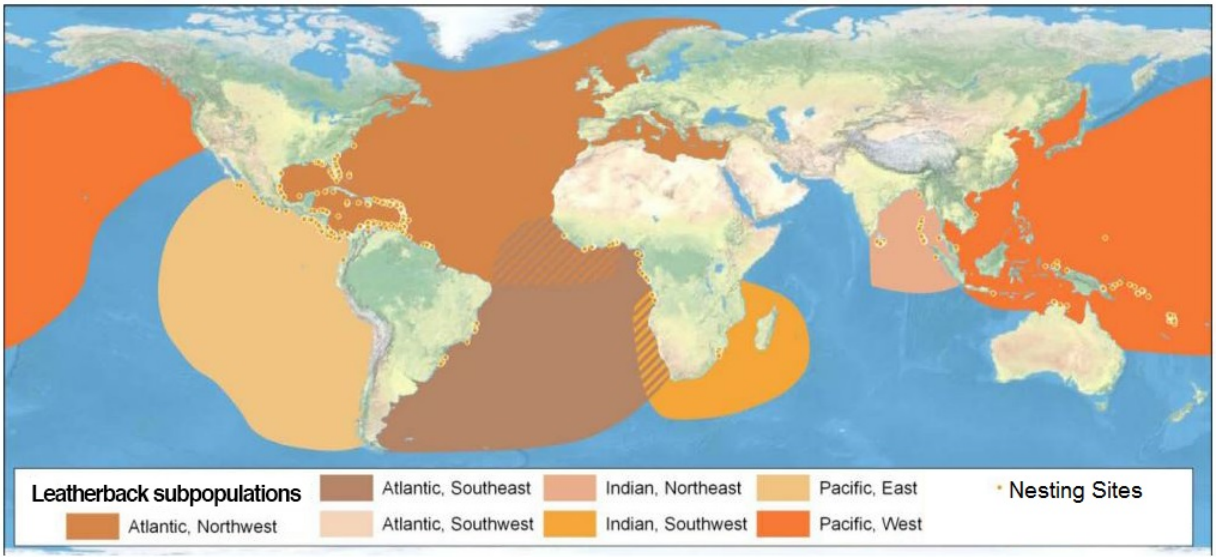

Figure 13. Map identifying the range of the leatherback sea turtle. Adapted from (Wallace et al. 2010).

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 13).

Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly (Figure 14).

Figure 14. Leatherback turtle. Photo: R.Tapilatu.

The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973 (Table 11).

Table 11. Leatherback turtle summary information.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Dermochelys coriacea	**Leatherback sea turtle**	**None**	**Endangered** range wide	2013	E – 35 FR 8491	U.S. Caribbean, Atlantic and Gulf of Mexico	44 FR 17710 and 77 FR 4170

We used information available in the five year review (NMFS 2013) and available literature to summarize the life history, population dynamics and status of the species, as follows.

Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to twenty-nine years (Avens 2009; Spotila 1996). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (Reina et al. 2002; Wallace 2007). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately fifty percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh about thirty-three percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James 2005; Wallace 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the leatherback sea turtle.

Leatherbacks are globally distributed, with nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Leatherback populations in the Pacific are much lower than in the Atlantic, where the population has been increasing. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and sub adults (Spotila et al. 2000).

Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu 2013).

Analyses of mitochondrial DNA from leatherback sea turtles worldwide and in the Pacific indicate a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton 1999).

Leatherback sea turtles are distributed in oceans throughout the world. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

Vocalization and Hearing

Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 hertz, with a range of maximum sensitivity between 100 and 800 hertz (Bartol 1999; Lenhardt 1994a; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found leatherback hatchlings capable of hearing underwater sounds at frequencies of 50 to 1,200 hertz (maximum sensitivity at 100 to 400 hertz). Hearing below 80 hertz is less sensitive but still possible (Lenhardt 1994a).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 hertz, with slow declines below 100 hertz and rapid declines above 700 hertz and almost no sensitivity above 3 kilohertz (Wever 1956). Wood turtles are sensitive up to about 500 hertz, followed by a rapid decline above one kilohertz and almost no responses beyond three or four kilohertz (Patterson 1966).

Status

The leatherback sea turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise. The species' resilience to additional perturbation is low. Leatherback populations in the Pacific are in particular danger due to the severe declines, and the threats have not abated (NMFS 2016).

Recovery Goals

See the 1998 Recovery Plan for the U.S. Pacific leatherback sea turtles for complete down-listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan:

1. Reduce fisheries interactions.
2. Improve nesting beach protection and increase reproductive output.
3. International cooperation.
4. Monitoring and research.
5. Public engagement.

10 ENVIRONMENTAL BASELINE

The "environmental baseline" includes the past and present impacts of all Federal, state, 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 C.F.R. §402.02).

10.1 Climate Change

We primarily discuss climate change as a threat common to all species addressed in this opinion, rather than in each of the species-specific narratives.

The 2014 Assessment Synthesis Report from the Working Groups on the Intergovernmental Panel on Climate Change concluded climate change is unequivocal (IPCC 2014). The report concludes oceans have warmed, with ocean warming the greatest near the surface (e.g., the upper 75 meters (246 feet) have warmed by 0.11 degrees Celsius per decade over the period 1971 to 2010) (IPCC 2014). Global mean sea level rose by 0.19 meters (0.62 feet) between 1901 and 2010, and the rate of sea-level rise since the mid-19th century has been greater than the mean rate during the previous two millennia (IPCC 2014). Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney 2012). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, heat waves, and droughts (IPCC 2014). Climate change has the potential to impact species abundance, geographic distribution, migration patterns, timing of seasonal activities (IPCC 2014), and species viability into the future. Though predicting the precise consequences of climate change on highly mobile marine species, such as many of those considered in this opinion, is difficult (Simmonds 2007), recent research has indicated a range of consequences already occurring.

Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney 2012). Hazen et al.

(2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. He predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback sea turtles were predicted to gain core habitat area, whereas loggerhead sea turtles are predicted to experience losses in available core habitat. McMahon and Hays (2006) predicted increased ocean temperatures would expand the distribution of leatherback sea turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. MacLeod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, with 47 percent likely to be negatively affected. Willis-Norton et al. (2015) acknowledge there would be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback sea turtles in the eastern south Pacific Ocean.

Similarly, climate-mediated changes in important prey species populations are likely to affect predator populations. For ESA-listed sea turtles that undergo long migrations (e.g., leatherbacks), if either prey availability or habitat suitability is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009).

Changes in global climatic patterns are expected to have profound effects on coastlines worldwide, potentially having significant consequences for the ESA-listed species considered in this opinion that are partially dependent on terrestrial habitat areas (i.e., sea turtles). For example, rising sea levels are projected to inundate some sea turtle nesting beaches (Caut et al. 2009; Wilkinson 2008), change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and increase the number of sea turtle nests destroyed by tropical storms and hurricanes (Wilkinson 2008). The loss of nesting beaches may have catastrophic effects on global sea turtle populations if they are unable to colonize new beaches, or if new beaches do not provide the habitat attributes (e.g., sand depth, temperature regimes, refuge) necessary for egg survival. Additionally, increasing temperatures in sea turtle nests, as is expected with climate change, alters sex ratios, reduces incubation times (producing smaller hatchlings), and reduces nesting success due to exceeded thermal tolerances (Fuentes 2009; Fuentes et al. 2009; Fuentes et al. 2010; Glen 2003). All of these temperature related impacts have the potential to significantly impact sea turtle reproductive success and ultimately, long-term species viability. Poloczanska (2009) noted that extant sea turtle species have survived past climatic shifts, including glacial periods and warm events, and therefore may have the ability to adapt to ongoing climate change (e.g., by finding new nesting beaches). However, the authors also suggested since the current rate of warming is very rapid, expected change might outpace sea turtles' ability to adapt.

Previous warming events (e.g., El Niño, the 1977 through 1998 warm phase of the Pacific Decadal Oscillation) may illustrate the potential consequences of climate change. Off the U.S.

west coast, past warming events have reduced nutrient input and primary productivity in the California Current, which also reduced productivity of zooplankton through upper-trophic level consumers (Doney 2012; Sydeman et al. 2009; Veit et al. 1996).

This is not an exhaustive review of all available literature regarding the potential impacts of climate change to the species considered in this opinion. However, this review provides some examples of impacts that may occur. While it is difficult to accurately predict the consequences of climate change to the species considered in this opinion, a range of consequences are expected, ranging from beneficial to catastrophic.

10.2 Harvest

Prior to 1900, aboriginal hunting and early commercial whaling on the high seas, using hand harpoons, took an unknown number of whales (Johnson and Wolman 1984). Modern commercial whaling removed about 50,000 whales annually. In 1965, the International Whaling Commission banned the commercial hunting of whales. Although commercial harvesting no longer targets whales in the proposed action area, prior exploitation may have altered the population structure and social cohesion of the species such that effects on abundance and recruitment can continue for years after harvesting has ceased.

Directed harvest of sea turtles and their eggs for food and other products has existed for years and was a significant factor causing the decline of several sea turtle species, including leatherback sea turtles. At present, despite conservation efforts such as bans and moratoriums by the responsible governments, the harvest of leatherbacks and their eggs on nesting beaches still occurs throughout the action area. Countries including Papua Barat Indonesia, Mexico, Peru and the Philippines have attempted to reduce the threats to sea turtles, but illegal harvesting still occurs (NMFS 2016). In Vietnam and Fiji, harvest of turtle meat and eggs remains unregulated.

10.3 Noise

Noise generated by human activity has the potential to affect whales and sea turtles, although effects to sea turtles are not well understood. This includes sound generated by commercial and recreational vessels, aircraft, commercial sonar, military activities, seismic exploration, in-water construction activities and other human activities. These activities all occur within the action area to varying degrees throughout the year. Whales generate and rely on sound to navigate, hunt and communicate with other individuals. As a result, anthropogenic noise can interfere with these important activities. The effects of noise on marine mammals can range from behavioral effects to physical damage (Richardson et al. 1995b).

Commercial shipping traffic is a major source of low-frequency anthropogenic noise in the oceans (NRC 2003a). Although large vessels emit predominantly low-frequency sound, studies report broadband noise from large cargo ships that includes significant levels above 2 kHz, which may interfere with important biological functions of cetaceans (Holt 2008a). Commercial sonar systems are used on recreational and commercial vessels and may affect marine mammals (NRC 2003a). Although, little information is available on potential effects of multiple commercial sonars to marine mammals, the distribution of these sounds would be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Richardson et al. 1995b).

Seismic surveys using towed airguns occur within the action area and are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. Airguns generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10 to 20 seconds for extended periods (NRC 2003a). Most of the energy from the guns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 decibels at dominant frequencies of 5 to 300 hertz (NRC 2003a). Most of the sound energy is at frequencies below 500 hertz.

10.4 Fisheries Interactions

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in marine mammals (see Dietrich et al. 2007). These entanglements also make animals more vulnerable to additional dangers (e.g., predation and ship strikes) by restricting agility and swimming speed. Marine mammals that die from entanglement in commercial fishing gear often sink rather than strand ashore thus making it difficult to accurately determine the extent of such mortalities.

Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Therefore, competition with humans for prey is a potential concern for whales. Reductions in fish populations, whether natural or human-caused, may affect listed whale populations and their recoveries. Whales are known to feed on several species of fish that are harvested by humans (Waring et al. 2008); however, the magnitude of competition is unknown.

Leatherbacks in the Pacific migrate about 7,000 miles from nesting beaches in the tropical Pacific (e.g., Indonesia, Papua New Guinea, Costa Rica, Mexico) to foraging grounds (e.g., off the U.S. West Coast. This migration puts leatherbacks in proximity of numerous fisheries, especially longlines, increasing bycatch risk. Roe et al. (Roe 2014) found areas of high bycatch risk in the north and central Pacific. By far, however, the greatest areas of bycatch risk were in the jurisdictional waters of several Indo-Pacific nations, largely affecting nesting individuals. The authors pointed to the difficulty in coordinating management efforts between several countries as a barrier to reducing risk of bycatch and supporting leatherback recovery.

10.5 Vessel Strike

Ships have the potential to affect whales through strikes, noise and disturbance by their physical presence. Responses to vessel interactions include interruption of vital behaviors and social groups, separation of mothers and young and abandonment of resting areas (Boren et al. 2001; Constantine 2001; Mann et al. 2000; Nowacek 2001; Samuels et al. 2000). Whale watching, a profitable and rapidly growing business with more than 9 million participants in 80 countries and territories, may increase these types of disturbance and negatively affect the species (Hoyt 2001).

Ship strikes are considered a serious and widespread threat to marine mammals. This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle 1993; Wiley et al. 1995). In the region, blue whales are especially susceptible where shipping lanes overlap with common feeding areas, as they do in the Santa Barbara Channel (Redfern 2013). There is a concern that many ship strikes go undetected and unreported because the whale's carcass sinks (Cassoff 2011). As ships continue to become faster and more widespread, an increase in ship interactions with marine mammals is to be expected. For whales, studies show that the probability of fatal injuries from ship strikes increases as vessels operate at speeds above 14 knots (Laist et al. 2001).

Boat collisions can result in serious injury and death and may pose a threat to sea turtles in the action area although the extent of this threat is unknown.

10.6 Pollution

Within the action area, pollution poses a threat to ESA-listed whales and leatherback sea turtles. Pollution can come in the form of marine debris, pesticides, contaminants, and hydrocarbons.

10.6.1 Marine Debris

Marine debris is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources. Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment. Whales often become entangled in marine debris. They may also ingest it while feeding, potentially leading to digestive problems, injury, or death. Types of marine debris include plastics, glass, metal, polystyrene foam, rubber and derelict fishing gear from human marine activities or transported into the marine environment from land. The sources of this debris include littering, dumping and industrial loss and discharge from land. Whales become entangled in marine debris, or ingest it, which may lead to injury or death. Given the limited knowledge about the impacts of marine debris on whales, it is difficult to determine the extent of the threats that marine debris poses to whales.

Ingestion of marine debris can be a serious threat to leatherback sea turtles. When feeding, leatherback sea turtles can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, a primary prey. Some types of marine debris may be directly or indirectly toxic, such as oil. Other types of marine debris, such as discarded or derelict fishing gear, may entangle and drown sea turtles. Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky 2009).

10.6.2 Pesticides and Contaminants

Exposure to pollution and contaminants has the potential to cause adverse health effects in marine species. Marine ecosystems receive pollutants from a variety of local, regional and international sources, and their levels and sources are therefore difficult to identify and monitor (Grant and Ross 2002). Marine pollutants come from multiple municipal, industrial and household as well as from atmospheric transport (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata 1993).

The accumulation of persistent pollutants through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2008), including immune system abnormalities, endocrine disruption and reproductive effects (Krahn et al. 2007). Recent efforts have led to improvements in regional water quality and monitored pesticide levels have declined, although the more persistent chemicals are still detected and are expected to endure for years (Grant and Ross 2002; Mearns 2001).

In sea turtles, heavy metals, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc, have been found in a variety of tissues in levels that increase with turtle size (Anan et al. 2001; Barbieri 2009; Fujihara et al. 2003; Garcia-Fernandez et al. 2009; Gardner et al. 2006; Godley et al. 1999; Saeki et al. 2000; Storelli et al. 2008). Cadmium has been found in leatherbacks at the highest concentration compared to any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996).

Sea turtle tissues have been found to contain organochlorines, including chlorobiphenyl, chlordane, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT and PCB (Alava et al. 2006; Corsolini et al. 2000; Gardner et al. 2003; Keller et al. 2005; Keller et al. 2004a; Keller et al. 2004b; McKenzie et al. 1999; Miao et al. 2001; Monagas 2008; Oros 2009; Perugini et al. 2006; Rybitski et al. 1995; Storelli et al. 2007). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight; Davenport 1990; Oros 2009). PCBs have been found in leatherback sea turtles at concentrations lower than expected to cause acute toxic effects, but might cause sub-lethal effects on hatchlings (Stewart 2011).

Organochlorines could cause deficiencies in endocrine, developmental and reproductive health (Storelli et al. 2007) and are known to depress immune function in loggerhead sea turtles (Keller et al. 2006). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation.

10.6.3 Hydrocarbons

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant and Ross 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990). Cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin and Saulitis 1997). Hydrocarbons also have the potential to impact prey populations and therefore may affect listed species indirectly by reducing food availability. Oil can also be hazardous to sea turtles, with fresh oil causing significant mortality and morphological changes in hatchlings, but aged oil having no detectable effects (Fritts and McGehee 1981).

10.7 Science and Research Activities

Scientific research permits issued by the NMFS currently authorize studies of listed species in the North Pacific Ocean, some of which extend into portions of the action area for the proposed project. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, and exposure to acoustic activities, and breath sampling. These research activities were not expected to jeopardize the survival or recovery of ESA-listed species and were largely anticipated to have short-term behavioral or stress effects to impacted individuals.

Authorized research on leatherback sea turtles includes capture, handling, and restraint, satellite, sonic, and passive integrated transponder tagging, blood and tissue collection, lavage, ultrasound, captive experiments, laparoscopy, and imaging. Research activities involve "takes" by harassment, with some resulting mortality. There have been numerous permits[4] issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles all over the world, including for research in the action area. The consultations which took place on the issuance of these ESA scientific research permits each found that the authorized activities would have no more than short-term effects and would not result in jeopardy to the species or adverse modification of designated critical habitat.

Additional "take" is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below represent the maximum number of "takes" authorized in a given year, monitoring and reporting indicate that the actual number of "takes" rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these "takes" will occur since they have been authorized. It is also noteworthy that these "takes" are distributed across the Pacific Ocean. Although whales and sea turtles are generally wide-ranging,

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[4]. See https://apps.nmfs.noaa.gov/index.cfm for additional details.

we do not expect many of the authorized “takes” to involve individuals that would also be “taken” under the proposed research.

10.8 The Impact of the Baseline on ESA-listed Species

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. Any foreign 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 also impact listed resources. However, the impact of those activities on the status, trend, or the demographic processes of threatened and endangered species remains largely unknown. To the best of our ability, we summarize the effects we can determine based upon the information available to us in this section.

10.8.1 Marine Mammals

Climate change has wide-ranging impacts, some of which can be experienced by ESA-listed whales in the action area. Climate change has been demonstrated to alter major current regimes and may alter those in the action area as they are studied further (Johnson 2011; Poloczanska et al. 2009). Considering the sensitivity that North Atlantic right whales have to warm water temperatures during their southbound migration, warming water temperatures may delay their migratory movements. The availability and quality of prey outside the action area in northern feeding areas can also influence the body condition of individuals in the action area and potentially reduce the number of individuals that undertake migration through the action area.

Effects from anthropogenic acoustic sources, whether they are vessel noise, seismic sound, military activities, oil and gas activities, construction, or wind energy, could also have biologically significant impacts to ESA-listed whales in the action area. These activities increase the level of background noise in the marine environment, making communication more difficult over a variety of ranges. We expect that this increased collective noise also reduces the sensory information that individuals can gather from their environment; an important consideration for species that gather information about their environment primarily through sound. At closer ranges to some of anthropogenic sound sources, behavioral responses also occur, including deflecting off migratory paths and changing vocalization, diving, and swimming patterns. At even higher received sound levels, physiological changes are likely to occur, including temporary or permanent loss of hearing and potential trauma of other tissues. Although this exposure is a small fraction of the total exposure individuals receive, it is expected to occur in rare instances.

High levels of morbidity and mortality occur as a result of ship strike (particularly for humpback whales) and entanglement in fishing gear. Ship-strike and entanglement occur broadly along the U.S. West Coast, including in the action area. These two factors represent known mortality sources for all other ESA-listed whales in the action area. On the West Coast, NMFS has collaborated with the U.S. Coast Guard and NOAA Sanctuaries to make changes to shipping lanes to reduce the risk of vessel strikes for large whales. These changes should help to reduce these impacts, but data are not yet available to demonstrate their long-term effectiveness. However, these measures are likely reducing the severity and frequency of these interactions.

Authorized research on ESA-listed whales can have significant consequences for these species, particularly when viewed in the collective body of work that has been authorized. Researchers have noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Responses were different depending on the age, life stage, social status of the whales being observed (i.e., males, cows with calves) and context (feeding, migrating, etc.). Beale and Monaghan (2004) 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.

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 et al. (1981) 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.

Although these responses are generally ephemeral and behavioral in nature, populations within the action area can be exposed to several thousand instances of these activities per year, with some species having so many authorized activities that if they were all conducted, every individual in the population would experience multiple events. This can collectively alter the habitat use of individuals, or make what would normally be rare, unexpected effects (such as severe behavioral responses or infection from satellite tagging or biopsy work) occur on a regular basis.

10.8.2 Leatherback Sea Turtles

Several of the activities described in this environmental baseline have significant and adverse consequences for leatherback sea turtle that occur in the action area.

Climate change has and will continue to impact leatherback sea turtles throughout the action area as well as throughout the range of the species. Sex ratios are showing a bias, sometimes very strongly, towards females due to higher incubation temperatures in nests. We expect this trend will continue and possibly may be exacerbated to the point that nests may become entirely feminized, resulting in severe demographic issues for affected populations in the future. Hurricanes may become more intense and/or frequent, impacting the nesting beaches of sea turtles and resulting in increased loss of nests and nesting habitat over wide areas. Similarly, sea-level rise may result in loss of nesting habitat over wide areas. Disease and prey distributions may well shift in response to changing ocean temperatures or current patterns, altering the morbidity and mortality regime faced by sea turtles and the availability of prey.

Fisheries interactions are the largest in-water threat to leatherback sea turtle recovery. Leatherbacks are also caught incidentally in high seas longline fishery, which involves more than 2000 vessels, the majority of which are from Japan, Korea, and Taiwan. Current fishing effort is 400 million hooks per year in the western and central Pacific and 200 million hooks per year in the eastern Pacific (Dutton and Squires 2008). Other fisheries that incidentally catch sea turtles include: high seas drift gillnet, coastal driftnet, purse seining, groundfish trawling, and pound nets (Dutton and Squires 2008). Additional mortalities each year along with other impacts remain a threat to the survival and recovery of this species and could slow recovery for sea turtles.

11 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. This effects analyses section is organized following the stressor, exposure, response, risk assessment framework.

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The destruction and adverse modification analysis considers whether the action produces "a direct or indirect alteration that appreciably diminished the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." 50 C.F.R. 402.02.

11.1 Stressors Associated with the Proposed Action

The potential stressors we expect to result from the proposed action are:

1. Pollution by oil or fuel leakage.
2. Ship-strikes.
3. Acoustic interference from engine noise.
4. Entanglement in towed hydrophone streamer.

5. Sound fields produced by airguns, sub-bottom profiler, and multibeam echosounder.

Based on a review of available information, this opinion determined which of these possible stressors would be likely to occur and which would be discountable or insignificant.

11.1.1 Pollution by Oil or Fuel Leakage

The potential for fuel or oil leakages is extremely unlikely. An oil or fuel leak would likely pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately to the extent possible. In the event that a leak should occur, the amount of fuel and oil onboard the *Revelle* is unlikely to cause widespread, high dose contamination (excluding the remote possibility of severe damage to the vessel) that would impact listed species directly or pose hazards to their food sources. Because the potential for fuel or oil leakage is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that pollution by oil or fuel leakage is not likely to adversely affect ESA-listed whales or leatherback sea turtles.

11.1.2 Ship Strike

We are not aware of a ship-strike by a seismic survey vessel. The *Revelle* will be traveling at generally slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a ship-strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Our expectation of ship strike is discountably small due to the hundreds of thousands of kilometers the *Revelle* has traveled without a ship strike, general expected movement of marine mammals away or parallel to the *Revelle*, as well as the generally slow movement of the *Revelle* during most of its travels (Hauser and Holst 2009; Holst 2009; Holst 2010; Holst and Smultea 2008a). All factors considered, we have concluded the potential for ship strike from the research vessel is highly improbable. Because the potential for ship strike is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that ship strike is not likely to adversely affect ESA-listed whales or leatherback sea turtles.

11.1.3 Disturbance from Engine Noise

We expect that the *Revelle* will add to the local noise environment in its operating area due to the propulsion and other noise characteristics of the vessel's machinery. This contribution is likely small in the overall regional sound field. The *Revelle's* passage past a whale or sea turtle would be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of whales to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006). In addition, the *Revelle* will be traveling at slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a ship strike for whales and sea turtles (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Because the potential acoustic interference from engine noise would be undetectable or so minor that it could not be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise is not likely to adversely affect ESA-listed whales or leatherback sea turtles.

11.1.4 Gear Entrapment

The towed hydrophone streamer could come in direct contact with a listed species and sea turtle entanglements have occurred in towed seismic gear. For example, a seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley sea turtle in the foil of towed seismic gear; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the streamer design as well as observations of sea turtles investigating the streamer and not becoming entangled or operating in regions of high turtle density and entanglements not occurring (Hauser 2008; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). To the best of our knowledge, leatherback sea turtles do not occur in high densities in the action area. Instances of such entanglement events with ESA-listed whales are unknown to us. Although the towed hydrophone streamer or passive acoustic array could come in direct contact with a listed species, entanglements are highly unlikely and considered discountable.

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

11.2 Mitigation to Minimize or Avoid Exposure

NSF’s proposed action includes the use of exclusion zones, protected species observers and operational shutdown in the presence of ESA-listed species. The NMFS’ Permits and Conservation Division’s proposed IHA would contain additional mitigation measures to minimize or avoid exposure. Both are described in the description of the action, exposure and response analysis were considered throughout our analysis.

11.3 Exposure and Response 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. The *Response Analysis* also considers information on the potential for stranding and the potential effects on the prey of ESA-listed whales and leatherback sea turtles in the action area.

11.3.1 Exposure Analysis

Although there are multiple acoustic and non-acoustic stressors associated with the proposed action, the stressor of primary concern is the acoustic impacts of airguns.

As part of the application for the IHA pursuant to the MMPA, the NSF provided an estimate of the number of marine mammals that would be exposed to levels of sound in which they would be considered “taken” during the proposed survey. NSF did not provide any take estimates from sound sources other than the airguns, although other equipment producing sound will be used during airgun operations (e.g., the multibeam echosounder and the sub-bottom profiler). In their Federal Register Notice of the proposed IHA, the NMFS’ Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed that of the airgun array. Therefore, the NMFS’ Permits and Conservation Division did not expect additional exposure from sound sources other than the airguns. Since the sub-bottom profiler and the multibeam echosounder have a lower or roughly equivalent source output as the airgun array (Table 2 and section 3.1.4), we agree with this assessment and similarly focus our analysis on exposure from the airgun array.

During the development of the IHA, the NMFS’ Permits and Conservation Division conducted an independent exposure analysis. In this section, we describe both the NSF and the NMFS analytical methods to estimate the number of ESA-listed species that might be exposed to the sound field and considered “taken” as required under the ESA.

The methodology for estimating the number of ESA-listed species that might be exposed to the sound field used by NSF and the NMFS’ Permits and Conservation Division were largely the same. Both estimated the number of marine mammals predicted to be exposed to sound levels that would result in harassment by using radial distances to predicted isopleths. Both used those distances to calculate the ensonified area around the airgun array (204.2 square kilometers). To account for possible delays during the survey (e.g., weather, equipment malfunction), a 25 percent contingency was added in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed.

Both NSF and the NMFS Permits and Conservation Division used density estimates from Barlow (2016). The estimated density of each marine mammal species within an area (animals/km^2) is multiplied by the total ensonified areas (km^2) that correspond to the Level B harassment thresholds for the species. The product (rounded) is the estimated number of instances of take for each species. The number of instances of take for each species is then multiplied by 1.25 to account for the 25 percent contingency, as described above. The result is an estimate of the number of instances that marine mammals are predicted to be exposed to airgun sounds above the Level B harassment threshold over the duration of the proposed survey. The total area estimated to be ensonified to the Level B harassment threshold for the proposed survey is 204.2 km^2.

After performing the calculations, NSF increased their take authorization request to one percent of the population size (based on Barlow 2016 estimates). Their purpose in doing so is to ensure that the proposed action has an adequate amount of take authorization. This resulted in a substantial increase between the calculated take and the requested take. For example, for humpback whales, the number of calculated exposures was three; increased to one percent, the requested take authorization was 218. Based on what we know about the marine mammal densities in the action area, we believe that for a cruise of relatively short duration, it is extremely unlikely that this level of take would be reached.

Upon discussions with the NMFS' Permits and Conservation Division, we agreed to adopt the take numbers developed through the calculation method described above. In cases where the calculated take numbers were lower than the mean group size (i.e., sei and sperm whales), we increased the take request to the mean group size. Our rationale was that in the event that a group was encountered during the survey, it was reasonable to expect that the number of individuals in that group would more likely be the mean group size, and less likely that it would be less than that amount.

For our ESA consultation, we evaluated both methods for estimating the number of ESA-listed individuals that would be "taken" relative to the definition of harassment discussed above. We concur with the NMFS' Permits and Conservation Division's analysis.

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," under the MMPA. These thresholds are used to develop exclusion radii around a source and the necessary power-down or shut down criteria to limit marine mammals and sea turtles' exposure to harmful levels of sound (NMFS 1995). The 175 dB isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airguns, and would serve as the exclusion radii for sea turtles. The 160 dB re 1 μPa_{rms} distance is the distance at which MMPA take, by Level B harassment, is expected to occur, and the threshold at which the NMFS' Permits and Conservation Division is proposing to issue take authorizations for marine mammals. The ESA does not define harassment nor has the NMFS defined the term pursuant to the ESA through regulation. The MMPA 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 similar to language in the USFWS's regulatory definition of "harass"[5] pursuant to the ESA. For this opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

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

Airguns contribute a massive amount of anthropogenic energy to the world's oceans ($3.9\text{x}10^{13}$ joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kilohertz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

The exposure analysis for this opinion is concerned with the number of fin, sei, blue, humpback, and sperm whales, as well as leatherback sea turtles likely to be exposed to received levels greater than 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ (175 dB for sea turtles), which constitute the best estimate of adverse response by listed whales and leatherback sea turtles. The NSF and NMFS' Permits and Conservation Division estimated the expected number of ESA-listed whales exposed to receive levels ≥160 dB re 1 $\mu\text{Pa}_{\text{rms}}$. The NMFS' Permits and Conservation Division's data and methodology used were adopted in this opinion because the NMFS' ESA Interagency Cooperation Division believed they represent the best available information and methods to evaluate exposure to listed species.

11.3.2 Whales

Throughout consultation, we worked with the Permits and Conservation Division to develop exposure estimates. We agreed with and adopted the Permits and Conservation Division's methodology for estimating exposure of ESA-listed marine mammals to the proposed action.

Blue, fin, sei, sperm and humpback whales of all age classes are likely to be exposed. Given that the survey will take place in late September, we expect that most whales will be on their feeding grounds or beginning to migrate to their breeding grounds. Whales are expected to be feeding, traveling, or migrating in the area and some females would have young-of-the-year accompanying them. We would normally assume that sex distribution is even for fin, sei, humpback, and blue whales, and sexes are exposed at a relatively equal level. However, sperm whales in the area likely consist of groups of adult females and their offspring and generally consist of more females than males in the group. Therefore, we expect a female bias to sperm whale exposure. For sperm whales, exposure for adult male sperm whales is expected to be lower than other age and sex class combinations.

Table 12. Exposure estimates of ESA-listed species in the action area.

Species	NMFS Exposure Estimate
Humpback Whale*	3
Fin Whale	6
Sei Whale	2
Sperm Whale	6
Blue Whale	1

*See discussion below for details on humpback whale exposure by distinct population segment.

11.3.2.1 Humpback Whale Exposure

In 2016, NMFS revised the listing of humpback whales to identify fourteen distinct population segments (DPS) and listed four as endangered and one as threatened (81 FR 62260). There are three humpback whale distinct population segments that are found off the coasts of California, Washington, and Oregon, while foraging within the region during summer: the Mexico DPS, listed as threatened, and the Central America DPS, listed as endangered. The Hawaii DPS is found off Washington and southern British Columbia, but it is not listed under the ESA. The ESA-listed Mexico and Central America DPSs could both be present within the action area, and it would not be possible for the protected species observers to identify an individual humpback to either DPS during the proposed activities.

To address the difficulty in assigning take given the humpback whale DPS revision of listing, the NMFS West Coast Region Protected Species Division developed guidance to assist in assigning take of humpback whales to a particular DPS based on information of the distribution and abundance of the DPSs off the West Coast. Three DPSs may be present off the U.S. West Coast: Mexico, Central America, and Hawaii DPSs. The Mexico DPS breeding population is estimated at about 3,200, while the Central America DPS breeding population has about 400 individuals. The Hawaii DPS, which is not listed under the ESA, has about 11,400 individuals (Wade et al. 2016).

Humpbacks feed in aggregations off northern Washington and southern British Columbia, in and around Vancouver Island, Queen Charlotte Island, and Cape Flattery. The feeding areas off California and Oregon are well documented, but there is a gap in sightings of humpback whales between central Oregon and central Washington (Calambokidis et al. 2008; Wade et al. 2016). The action area falls between the summer feeding areas off California and Oregon, and those in northern Washington and southern British Columbia.

The action will take place in late September. At that time, we expect that humpbacks will still be either on the summer feeding grounds, or starting to migrate south towards their breeding areas. Since the summer feeding grounds off California and Oregon are south of the action area, we do not believe that individuals from this feeding area will be exposed to the proposed action.

Individuals from the northern Washington and southern British Columbia feeding area may be exposed to the proposed action as they transit through on their migration south.

The West Coast Region put forth a calculation method to determine the DPS origin of humpback whales in summer feeding areas along the U.S. West Coast based on estimates of abundance developed by Wade et al. (2016), and the probability of encountering individual humpbacks from a particular DPS. The probability of humpbacks of DPS origin present on the northern Washington and southern British Columbia is presented in (Table 13).

Table 13. Probability of distinct population segment origin for humpbacks on the northern Washington and southern British Columbia.

	DPS Origin (CV)	DPS Origin (CV)	DPS Origin (CV)
	Mexico (Threatened)	Central America (Endangered)	Hawaii (Not ESA-listed)
	41.9% (0.14)	5.2% (0.91)	52.9% (0.15)
95% confidence interval	30.2 – 53.6%	0 – 14.7%	37 – 69%

Humpback whales on (or migrating from) the northern Washington and southern British Columbia feeding grounds would primarily be from either the non ESA-listed Hawaii DPS (53 percent), or the Mexico DPS (42 percent). A smaller proportion of those humpbacks would be from the Central America DPS. In order to take a cautious approach to assessing impacts to the endangered Central America DPS, the West Coast Region applies a 15 percent probability of encountering a Central America DPS individual, the upper 95 percent confidence interval.

We expect that a total of three humpbacks may be exposed to the proposed action. There is about a 57 percent chance that the action could expose an ESA-listed humpback (42 percent Mexico and 15 percent Central America). By applying the guidance, we would expect that either up to two exposed humpbacks would be from the Mexico DPS (1.26 rounded to two individuals), and that one humpback would be from the Central America DPS (0.45 rounded to one individual). The incidental take statement still would only allow a maximum of three humpbacks taken as a result of the action.

11.3.3 Sea Turtles

NSF did not provide estimates for the expected number of ESA-listed sea turtles exposed to received levels greater than or equal to 175 dB re: 1 $\mu\text{Pa}_{\text{rms}}$. Our exposure estimates stem from the best available information on sea turtle densities and a predicted RMS radius of approximately 120 meters along survey track lines. Based on information presented in the

Response Analysis, we expect all exposures at the 175 dB re 1 μPa_{rms} level and above to constitute “take”.

11.3.3.1 Exposure of ESA-listed turtles to airguns

NSF presented estimated distances for the 175 dB re: 1 μPa_{rms} sound levels presented by the two 45 cubic inch GI guns. When the array is towed at three meters, in waters 100 to 1,000 meters deep, the predicted established distance at received levels in 120 meters. Sea turtles could experience fitness consequences as a result of the sound created by the airguns at these distances.

As discussed in the *Status of listed resources* section, there is one ESA-listed sea turtle species that is likely to be affected by the proposed action: leatherback sea turtles.

Estimating exposure for leatherback sea turtles in the action area was challenging, as there is scant information on sea turtle density or population estimates specific to the waters off the Pacific Ocean, off the coasts of Washington and Oregon. To estimated exposure for leatherback sea turtles, we relied on recent reports and scientific literature focusing on leatherbacks in the area.

Significant leatherback nesting sites occur in the western Pacific Ocean on beaches in Papua Barat Indonesia, Papua New Guinea, and the Solomon Islands, and in the eastern Pacific on beaches in Mexico, Costa Rica, and elsewhere throughout Central America (NMFS 2016). Leatherbacks in the Pacific nest from late fall through spring, with dates varying by region. Nesting typically occurs during November through March in Papua New Guinea (Benson 2007), and from October through January for leatherbacks nesting in Mexico (Fritts 1982). Since there are no nesting sites in or near the action area, we do not expect nesting females or leatherback hatchlings to be exposed to the proposed action.

After nesting, adults undergo long-distance migrations to foraging grounds. Leatherbacks tagged in Indonesia took ten to twelve months to travel across the Pacific to foraging areas about 50 to 100 kilometers off the coasts of Oregon and Washington (Benson 2007; Benson 2011). During aerial surveys, leatherbacks were sighted in the same area between June and September, mostly over slope waters (200 to 2,000 meters deep) and continental shelf waters (less than 200 meters deep) (Bowlby 1994). The fact that leatherback prey, cnidarians (i.e., jellyfish), occurs in high densities in the region and supports leatherback foraging was a primary reason for designating the area as critical habitat in 2012 (77 FR 41705). Based on this information, and the timing and location of the activities, we expect that foraging leatherbacks would be exposed to the proposed action.

We are unable to quantify the level of leatherback sea turtle exposure. We expect leatherback sea turtle exposure to occur because the available information indicates that the species is present in the action area during the proposed seismic activities. As discussed earlier, there are no reliable leatherback sea turtle population estimates for the South Atlantic. Thus, it is not possible to quantify the proportion of the overall population that may be exposed to the proposed activity.

11.3.3.2 Exposure of leatherback sea turtles to multibeam echosounder and sub-bottom profiler

Sea turtles hear in the low frequency range. The multibeam echosounder operates at 10.5 to 13 kilohertz and the sub-bottom profiler operates at 3.5 kilohertz, which emit sounds outside the hearing frequency of sea turtles. Thus, sea turtles are not expected to respond to sounds emitted by multibeam echosounder or sub-bottom profiler.

11.3.4 Response Analysis

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 ESA-listed whales and leatherback sea turtles considered in this opinion. Possible responses considered in this analysis consist of:

- hearing threshold shifts,
- auditory interference (masking),
- behavioral responses, and
- non-auditory physical or physiological effects

The *Response analysis* also considers information on the potential for stranding and the potential effects on the prey of ESA-listed whales and sea turtles in the action area.

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

11.3.4.1 Potential responses of ESA-listed whales to acoustic sources

Marine mammals and threshold shifts. Exposure of marine mammals to very strong sound pulses can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Threshold shift depends upon the duration, frequency, sound pressure, and rise time of the sound. A temporary threshold shift (TTS) results in a temporary hearing change (Finneran 2013), and can last minutes to days. Full recovery is expected. However, a recent mouse study has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur, meaning lost auditory sensitivity is unrecoverable. These conditions can result either from a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action) (Kastak 2005; Ketten 2012; Schlundt 2000).

Few data are available to precisely define each listed species' hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Low-frequency baleen whales (e.g., sei, fin, and humpback) have an estimated functional hearing frequency range of 7 hertz to 35 kilohertz (Table 14).

Table 14. Marine functional mammal hearing groups and their generalized hearing ranges.

Hearing Group	Generalized Hearing Range*
Low Frequency Cetaceans (Baleen Whales)	7 Hz to 35 kHz
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales)	150 Hz to 160 kHz
High Frequency Cetaceans (True Porpoises, Kogia spp., River Dolphins, Cephalorhynchid, Lagenorhynchus cruciger, and Lagenorhynchus australis)	275 Hz to 160 kHz

*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall 2007).

Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency would need to be approximately 186 dB SEL or approximately 196 to 201 dB re 1 μPa_{rms} in order to produce a low-level TTS from a single pulse (Southall et al. 2007). PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007). In terms of exposure to the *Revelle's* airgun array, an individual would need to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re 1 μPa peak (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 190 dB re 1 μPa_{rms}, PTS could occur. A marine mammal would have to be within 100 meters of the *Revelle's* airgun array to be within the 190 dB re 1 μPa_{rms} isopleth and risk a TTS. Estimates that are conservative for species impact evaluation are 230 dB re 1 μPa (peak) for a single pulse, or multiple exposures to approximately 198 dB re 1 $\mu Pa^2 s$.

Overall, we do not expect TTS or PTS to occur to any ESA-listed whale because of airgun exposure for several reasons. We expect that individuals will move away from the airgun array as it approaches. As the survey proceeds along each transect line and approaches ESA-listed individuals, the sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the vessel and sound source and thus avoid exposures that would induce TTS or PTS. Ramp-ups would also reduce the probability of TTS-inducing exposure at the start of seismic surveys for the same reasons, as acoustic intensity increases, animals will move away. Furthermore, mitigation measures would be in place to initiate a power-down if individuals enter or are about to enter the 180 dB or 190 dB isopleth during full airgun operations, which is below the levels believed to be necessary for potential TTS. As stated in the *Exposure analysis*, each individual is expected to be potentially exposed dozens of times to 160 dB re 1 μPa_{rms} levels. We do not expect this to produce a cumulative TTS, PTS, or other injury for several reasons. We expect that individuals will recover between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful.

Marine mammals and auditory interference (masking). Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Francis 2013). Masking can interfere with an individual’s ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Marshall 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

There is frequency overlap between airgun sounds and vocalizations of ESA-listed whales, particularly baleen whales but also sperm whales. The proposed seismic surveys could mask whale calls at some of the lower frequencies. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Most of the energy of sperm whales clicks is concentrated at two to four kilohertz and ten to 16 kilohertz, 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 hertz (zero to 188 hertz for the *Revelle* airguns). Any masking that might occur would likely be temporary because seismic sources are not continuous and the seismic vessel would continue to transit through the area.

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 somewhat greater risk of masking. The *Langseth*’s airguns will emit a 0.1-second pulse when fired every five seconds. Therefore, pulses will not “cover up” the vocalizations of listed whales to a significant extent (Madsen et al. 2002).

We address the response of listed whales stopping vocalizations because of airgun sound in the *Marine mammals and behavioral responses* section below.

Although seismic sound pulses begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as shallow water environments, seismic sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add significantly to acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

The sound localization abilities of marine mammals suggest that, if signal and sound come from different directions, masking would not be as severe as the usual types of masking studies might suggest (Marshall 1995). The dominant background noise may be directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin, beluga whale, and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain 1993; Bain 1994; Dubrovskiy 2004). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au 1975; Au 1974; Lesage 1999; Moore 1990; Romanenko 1992; Thomas 1990). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Au 1993; Dahlheim 1987; Foote 2004; Holt 2009; Lesage 1999; Lesage 1993; Parks 2009; Parks 2007; Terhune 1999).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Akopian (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kilohertz, in contrast to the pronounced effect at higher frequencies. Studies have noted directional hearing at frequencies as low as 0.5 to two kilohertz in several marine mammals, including killer whales (Marshall 1995). This ability may be useful in reducing masking at these frequencies. In summary, high levels of sound generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such masking.

Marine mammals and behavioral responses. We expect the greatest response to airgun sounds in terms of number of responses and overall impact to be in the form of changes in behavior. Listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case the effects can equate to take but are unlikely to be significant at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Francis 2013). Although some studies are available which address responses of listed whales considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-listed or species outside the action area are also considered here. Individual differences in responding to stressful stimuli also appear to exist and appear to have at least a partial genetic basis in trout (Laursen 2011). Animals generally respond to anthropogenic perturbations as they would predators, increasing vigilance and altering habitat selection (Reep et al. 2011). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis 2013).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to airgun sound. Whales continue calling while seismic surveys are operating locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002; McDonald et al. 1993; McDonald et al. 1995a; Nieukirk et al. 2004; Richardson et al. 1986; Smultea et al. 2004; Tyack et al. 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995a). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al. 2012). Dunn (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* (*Ewing*) in 2007 and did not observe changes in call rates and found no evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re 1 μPa. Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re 1 μPa_{p-p} (Madsen et al. 2002; McCall Howard 1999). Some exposed individuals may cease calling in response to the *Revelle's* airguns. If individuals ceased calling in response to the *Revelle's* airguns during the course of the proposed survey, the effect would likely be temporary.

There are numerous studies of the responses of some baleen whale to airguns. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re 1 μPa_{rms} as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c). Activity of individuals seems to influence response (Robertson 2013), as feeding individuals respond less than mother/calf pairs and migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999). Surface duration decreased markedly during seismic sound exposure, especially while individuals were engaged in traveling or non-calf social interactions (Robertson 2013). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re 1 μPa_{rms} exposures at distances of 20 to 30 kilometers, but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152 to 178 dB re 1 μPa_{rms}) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999; Richardson et al. 1986). Responses such as stress may occur and the threshold for displacement may simply be higher while feeding. Bowhead calling rate was found to decrease during migration in the Beaufort Sea as well as temporary displacement from seismic sources (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at received levels of 116 to 129 dB re 1 μPa (possibly but not knowingly due to whale movement away from the airguns), but did not change at received levels of 99 to 108 dB re 1 μPa (Blackwell 2013). Despite the above information and exposure to repeated seismic surveys, bowheads continue to return to summer feeding areas and when displaced, appear to reoccupy areas within a day (Richardson et al. 1986). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether individuals that tolerate repeat exposures may still experience a stress response.

Gray whales respond similarly. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re 1 μPa_{rms} (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007b; Malme and Miles 1985; Malme et al. 1984; Malme et al. 1986; Malme et al. 1988; Würsig et al. 1999; Yazvenko et al. 2007a; Yazvenko et al. 2007b). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re 1 μPa and slight behavioral changes at 140 to 160 dB re 1 μPa_{rms} (Malme and Miles 1985; Malme et al. 1984). As with bowheads, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984). Johnson et al. (2007a) reported that gray whales exposed to seismic airguns off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002–2005.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re 1 μPa_{rms} when females with calves were present, or seven to 12 kilometers from the seismic source (McCauley et al. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re 1 μPa_{rms}. Closest approaches were generally limited to three to four kilometers, although some individuals (mainly males) approached to within 100 meters on occasion where sound levels were 179 dB re 1 μPa_{rms}. Changes in course and speed generally occurred at estimated received level of 157 to 164 dB re 1 μPa_{rms}.

Natural sources of sound also influence humpback behavior. Migrating humpbacks showed evidence of a Lombard effect in Australia, increasing vocalization in response to wind-dependent background noise (Dunlop 2014a). Since natural sources of noise alone can influence whale behavior, additional anthropogenic sources could also add to these effects.

Multiple factors may contribute to the degree of response exhibited by migrating humpbacks. In a preliminary study examining the responses by migrating humpbacks of exposure to a 20 cubic inch air gun, researchers found that the whales' behavior seemed to be influenced by social effects; "whale groups decreased dive time slightly and decreased speed towards the source, but there were similar responses to the control" (i.e., a towed air gun, not in operation) (Dunlop 2014b). Whales in groups may pick up on responses by other individuals in the group and react. The results of this continued study are still pending, and will examine the effects of a full size commercial air gun array on humpback behavior (Dunlop 2014b).

Feeding humpbacks appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150 to 169 dB re: 1 μPa and no clear evidence of avoidance was apparent at received levels up to 172 re: 1 μPa_{rms} (Malme et al. 1984; Malme et al. 1985). Potter et al. (2007) found that humpbacks on feeding grounds in the Atlantic did exhibit localized avoidance to airguns. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

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

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found Atlantic sperm whales to show little or no response (Davis et al. 2000; Madsen et al. 2006;

Miller et al. 2009; Moulton et al. 2006a; Moulton and Miller 2005; Stone 2003; Stone and Tasker 2006; Weir 2008). Detailed study of Gulf of Mexico sperm whales suggests some alteration in foraging from less than 130 to 162 dB re: 1 μ$Pa_{p–p}$, although other behavioral reactions were not noted by several authors (Gordon et al. 2006; Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2004; Jochens 2003; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a nonrandom distribution of satellite-tagged sperm whales at and beyond five kilometers from seismic airgun arrays, suggesting individuals were not displaced or move away from the array at and beyond these distances in the Gulf of Mexico (Mate 2013). However, no tagged whales within five kilometers were available to assess potential displacement within five kilometers (Mate 2013). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 188 hertz) pulses produced by seismic airguns (Richardson et al. 1995c). Sperm whales are exposed to considerable energy above 500 hertz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 μPa lower at one kilohertz and 60 dB re: 1 μPa lower at 80 kilohertz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions to impulse noise likely vary depending on the activity at time of exposure – for example, in the presence of abundant food or during breeding encounters toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2006b).

For whales exposed to seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area at least temporarily. We also expect secondary foraging areas to be available that would allow whales to continue feeding. Although breeding may be occurring, we are unaware of any habitat features that whales would be displaced from that is essential for breeding if whales depart an area as a consequence of the *Revelle*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities. Individuals engaged in travel or migration would continue with these activities, although potentially with a deflection of a few kilometers from the route they would otherwise pursue.

Marine mammals and physical or physiological effects. Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress, that can significantly affect life history. Other effects like neurological effects, bubble formation, and other types of organ or tissue damage could occur, but similar to stress, these effects are not readily observable.

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Busch 2009; Gregory 2001; Gulland 1999; St. Aubin 1988; St. Aubin 1996; Thomson 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch 2009; Cattet 2003; Dickens 2010; Dierauf 2001; Elftman 2007; Fonfara 2007; Kaufman 1994; Mancia 2008; Noda 2007; Thomson 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner 1997; Hunt 2006; Keay 2006; Romero et al. 2008; St. Aubin 1996). Stress is lower in immature right whales than adults are and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt 2006; Keay 2006).

Loud noises generally increase stress indicators in mammals (Kight 2011). Romano (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re: 1 $\mu\text{Pa} \cdot \text{m}_{\text{p–p}}$) and single pure tones (up to 201 dB re: 1 µPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern United States; this decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to baseline after 24 hours of traffic resuming. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities would be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006g). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NMFS 2006g; NRC 2003b). As we do not expect individuals to experience

TTS or PTS, (see *Marine mammals and threshold shifts*), we also do not expect any listed individual to experience a stress response at high levels. We assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, the stressor (sounds associated with the airgun, multibeam echosounder, or sub-bottom profiler) will dissipate in a short period as the vessel (and stressors) transects away without significant or long-term harm to the individual via the stress response.

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

It is possible that an animal's prior exposure to seismic sounds influences its future response. We have little information available to us as to what response individuals would have to future exposures to seismic sources compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response would likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (Andre 1997; André 1997; Gordon et al. 2006). We do not believe sensitization would occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to seismic sounds that would be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis*).

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

Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil were not well founded (IAGC 2004) (IWC 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The *R/V Maurice Ewing* had been operating a 20-airgun, 8,490 cubic inch airgun array 22 kilometers offshore the general area at the time that strandings occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002) as some vacationing marine mammal researchers who happened upon the stranding were ill-equipped to perform an adequate necropsy. Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between seismic sound sources and beaked whale strandings (Cox 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Creel 2005; Fair 2000; Kerby 2004; Moberg 2000; Relyea 2005; Romero 2004). At present, the factors of seismic airguns that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed to for use will cause marine mammal strandings. We do not expect listed whales to strand because of the proposed seismic survey.

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

Some support has been found for fish or invertebrate mortality resulting from airgun exposure, and this is limited to close-range exposure to high-amplitudes (Bjarti 2002; D'Amelio 1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). We expect fish to be capable of moving away from the airgun array if it causes them discomfort.

More evidence exists for sub-lethal effects. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 $\mu Pa^2 \cdot s$, but pike did show ten to 15 dB of hearing loss with recovery within one day (Popper et al. 2005). Caged pink snapper have experienced PTS when exposed over 600 times to receive seismic sound levels of 165 to 209 dB re 1 μPa_{p-p}. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish and capelin eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 μPa (Falk and Lawrence 1973).

By far the most common response by fishes is a startle or distributional response, where fish react shortly by changing orientation or swimming speed, or change their vertical distribution in the water column. Although received sound levels were not reported, caged *Pelates* spp., pink snapper, and trevally generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (Fewtrell 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1 $\mu Pa_{0\text{-}p}$ and alarm responses at greater than 177 dB re: 1 $\mu Pa_{0\text{-}p}$ (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after seismic firing ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 re 1 $\mu Pa_{0\text{-}p}$. Caged European sea bass showed elevated stress levels when exposed to airguns, but levels returned to normal after 3 days (Skalski 1992). These fish also showed a startle response when the survey vessel was as much as 2.5 kilometers away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity. Whiting exhibited a downward distributional shift upon exposure to 178 dB re: 1 $\mu Pa_{0\text{-}p}$ airgun sound, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to192 dB re: 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from airgun sound (Dalen and Knutsen 1986). Hake may redistribute downward (La Bella et al. 1996). Lesser sand eels exhibited initial startle responses and upward vertical movements before fleeing from the survey area upon approach of an active seismic vessel (Hassel et al. 2003; Hassel et al. 2004). McCauley et al. (2000; 2000a) found smaller fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 dB re: 1 μPa_{rms}, but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock did not respond to airgun sounds received at 195 to 218 dB re: 1 $\mu Pa_{0\text{-}p}$, but did exhibit continual startle responses and fled from the seismic source when visible (Wardle et al. 2001). Blue whiting and mesopelagic fishes were found to redistribute 20 to 50 meters deeper in response to airgun ensonification and a shift away from the survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 $\mu Pa_{p\text{-}p}$ sound levels from an airgun (Thomsen 2002). Cod and haddock likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 $\mu Pa_{0\text{-}p}$ (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994). Increased swimming activity in response to airgun exposure, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1 $\mu Pa_{0\text{-}p}$ (Turnpenny and Nedwell

1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no differences in trawl catch data before and after seismic operations and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching airguns.

Squid responses to airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 μPa_{rms} by first ejecting ink and then moving rapidly away from the area (Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 dB re 1 μPa_{rms}. Tenera Environmental (2011) reported that Norris and Mohl (1983, summarized in Mariyasu et al. 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after three to 11 minutes. André (2011) exposed four cephalopod species (*Loligo vulgaris, Sepia officinalis, Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 hertz at 157 plus or minus five dB re 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 plus or minus five dB re: 1 µPa, with peak levels at 175 dB re: 1 µPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the surveys in time and space, as well as pathological information from the carcasses. Another laboratory story observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013). Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Christian 2013). However, feeding did increase in exposed individuals (Christian 2013).

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

Marine mammal response to multibeam echosounder and sub-bottom profiler. We expect listed whales to experience ensonification from not only airguns, but also seafloor and ocean current mapping systems. The multibeam echosounder and sub-bottom profiler used in this survey operate at frequencies of 10.5 to 13 kilohertz, and 3.5 kilohertz, respectively. These frequencies are within the functional hearing range of baleen whales, such as the ESA-listed humpback, blue, fin and sei whales.[6] We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kilohertz within the 80 to 90 dB re: 1 μPa range, it is difficult to determine the significance of this because the source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4.0 kilohertz mid-frequency sonar at received levels below 90 dB re: 1 μPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen 2013). Hearing is poorly understood for listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multibeam echosounder and sub-bottom profiler systems (Ketten 1997; Oleson 2007; Richardson et al. 1995c).

Assumptions for humpback and sperm whale hearing are much different than for other listed whales. Humpback and sperm whales vocalize between 3.5 to 12.6 kilohertz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000a; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986b; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Weir et al. 2007; Winn et al. 1970). The response of a blue whale to 3.5 kilohertz sonar supports this species ability to hear this signal as well (Goldbogen 2013). Maybaum (1990; 1993) observed that Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kilohertz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal would have to pass at close range and be swimming at speeds similar to the vessel. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to casue TTS. Sperm whales have stopped vocalizing in response to six to 13 kilohertz pingers, but did not respond to 12 kilohertz echo-sounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975). Sperm whales exhibited a startle response to ten-kilohertz pulses upon exposure while resting and feeding, but not while traveling (Andre 1997; André 1997).

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[6] http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kilohertz multibeam echosounder, similar in operating characteristics as that proposed for use aboard the *Revelle*, suggest that this sonar played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data to suggest a direct physical affect are lacking and the authors acknowledge that although the use of this type of sonar is widespread and common place globally without noted incidents like the Madagascar stranding, all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multibeam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Revelle*'s multibeam echosounder. Although effects such as this have not been documented for ESA-listed species, the combination of exposure to this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than would otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis 2013).

Stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by Scripps Institution of Oceanography differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multibeam echosounder and sub-bottom profiler. The sound energy received by any individuals exposed to the multibeam echosounder and sub-bottom profiler sources during the proposed activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multibeam echosounder and sub-bottom profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Although thousands of vessels around the world operate navigational sonars routinely, strandings have not been correlated to use of these sonars. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, fin, sei, sperm, or humpback whale communications to appreciably occur due to multibeam echosounder or sub-bottom profiler signal directionality, low duty cycle, and the brief period when an individual could be within its beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multibeam echosounder was less than three percent that of ship strike. Behavioral responses to the mulitbeam echosounder and sub-bottom profiler are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. However, the pulsed signals from the sub-bottom profiler are considerably weaker than those from the multibeam echosounder. In addition, we do not expect hearing impairment and other physical effects if the animal is in the area, and it would have to pass the transducers at close range and in order to be subjected to sound levels that could cause temporary threshold shift.

11.3.4.2 Potential responses of leatherback sea turtles to acoustic sources

As with marine mammals, leatherback sea turtles may experience:

- hearing threshold shifts,
- behavioral responses and
- non-auditory physical or physiological effects.

Sea turtles and threshold shifts. Although leatherback sea turtles detect low frequency sound, the potential effects on sea turtle biology remain largely unknown (Samuel et al. 2005). Few data are available to assess sea turtle hearing, let alone the effects seismic equipment may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead experienced TTS upon multiple airgun exposures in a shallow water enclosure, but recovered within one day.

As with marine mammals, we assume that sea turtles will not move towards a source of stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sources (McCauley et al. 2000a; McCauley et al. 2000b; Moein et al. 1994), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of seismic airgun pulses (Smultea and Holst 2003). For this reason, mitigation measures are also in place to limit sea turtle exposure. Although data on the precise levels that can result in TTS or PTS are lacking, because of the mitigation measures and our expectation that turtles would move away from sounds from the airgun array, we do not expect turtles to be exposed to sound levels that would result in TTS or PTS.

Sea turtles and behavioral responses. As with ESA-listed marine mammals, it is likely that sea turtles will experience behavioral responses in the form of avoidance. We do not have much information on how leatherback sea turtles specifically will respond, but we present the available information on other sea turtle species. O’Hara and Wilcox (1990) found loggerhead sea turtles exhibited an avoidance reaction at an estimated sound level of 175 to 176 dB re: 1 µPa $_{\text{rms}}$ (or slightly less) in a shallow canal. Green and loggerhead sea turtles avoided airgun sounds at received sound levels of 166 dB re 1 µPa and 175 dB re 1 µPa, respectively (McCauley et al. 2000a; McCauley et al. 2000b). Sea turtle swimming speed increased and becomes more erratic at 175 dB re 1 µPa, with individuals becoming agitated. Loggerheads also appeared to move towards the surface upon airgun exposure (Lenhardt 1994b; Lenhardt et al. 1983). However, loggerheads resting at the ocean surface were observed to startle and dive as active seismic source approached them (DeRuiter 2012). Responses decreased with increasing distance of closest approach by the seismic array (DeRuiter 2012). The authors developed a response curve based upon observed responses and predicted received exposure level. Recent monitoring studies show that some sea turtles move away from approaching airguns, although sea turtles may approach active seismic arrays within ten meters (Holst 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006e; NMFS 2006h).

A sea turtle's behavioral responses to sound are assumed variable and context specific. For instance, a single impulse may cause a brief startle reaction. A sea turtle may swim farther away from the sound source, increase swimming speed, change surfacing time, and decrease foraging if the stressor continues to occur. For each potential behavioral change, the magnitude of the change ultimately would determine the severity of the response; most responses would be short-term avoidance reactions.

Some studies have investigated behavioral responses of sea turtles to impulsive sounds emitted by airguns (McCauley 2000; Moein Bartol 1995; O'Hara 1990). There are no studies of sea turtle behavioral responses to sonar. Cumulatively, available airgun studies indicate that perception and a behavioral reaction to a repeated sound may occur with sound pressure levels greater than 166 dB re 1 µPa root mean square, and that more erratic behavior and avoidance may occur at higher thresholds around 175 to 179 dB re 1 µPa root mean square (McCauley 2000; Moein Bartol 1995; O'Hara 1990). When exposed to impulsive acoustic energy from an airgun above 175 dB re 1 µPa root mean square, sea turtle behavior becomes more erratic, possibly indicating the turtles were in an agitated state (McCauley et al. 2000). A received level of 175 dB re 1 µPa root mean square is more likely to be the point at which avoidance may occur in unrestrained turtles, with a comparable sound exposure level of 160 dB re 1 µPa2 -s (McCauley 2000). Airgun studies used sources that fired repeatedly over some duration. For single impulses at received levels below threshold shift (hearing loss) levels, the most likely behavioral response is assumed to be a startle response. Since no further sounds follow the initial brief impulse, the biological significance is considered minimal.

Behavioral responses of sea turtles to airgun exposures in caged enclosures are likely to be different from those from turtles exposed to impulsive acoustic sources from seismic activities in the open environment. Although information regarding the behavioral response of sea turtles to acoustic stressors is generally lacking, McCauley (2000) provides an indication that 175 dB re 1 µPa root mean square is a reasonable threshold criterion in the absence of more rigorous experimental or observational data. The 175 dB re 1 µPa root mean square threshold criterion for behavioral take in sea turtles may change with better available information in the future, but currently is the best available science. To assess the number of sea turtles expected to behaviorally respond to acoustic stress all turtles exposed to sound equal to, or greater than, 175 dB and less than the criterion for TTS were summed. No attempt to process these exposures or evaluate the effectiveness of mitigation measures was made, suggesting any behavioral take estimates of sea turtles from acoustic stressors are likely overestimates. We are unaware of any sea turtle response studies to non-impulsive acoustic energy; therefore, we used the same criteria as those for impulsive acoustic stressors.

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re: 1 µPa. At 175 dB re: 1 µPa, we anticipate some change in swimming patterns and a stress response of exposed individuals. Some turtles may approach the active seismic array to closer proximity, but we expect them to eventually turn away. We expect temporary displacement of exposed individuals from some portions of the action area while the *Revelle* transects through.

Sea turtles and stress. Direct evidence of seismic sound causing stress is lacking in sea turtles. However, we expect sea turtles to generally avoid high-intensity exposure to airguns in a fashion similar to predator avoidance. As predators generally induce a stress response in their prey (Dwyer 2004; Lopez 2001; Mateo 2007), we assume that sea turtles experience a stress response to airguns when they exhibit behavioral avoidance or when they are exposed to sound levels apparently sufficient to initiate an avoidance response (approximately 175 dB re: 1 µPa). We expect breeding adult females may experience a lower stress response, as female loggerhead, hawksbill, and green sea turtles appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). Individuals may experience a stress response at levels lower than approximately 175 dB re: 1 µPa, but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

Sea turtle response to multibeam echosounder and sub bottom profiler. Sea turtles do not possess a hearing range that includes frequencies emitted by these systems. Therefore, listed sea turtles will not hear these sounds even if they are exposed and are not expected to respond to them.

11.4 Risk Analysis

In this section, we assess the consequences of the responses to the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. For designated critical habitat, we assess the consequences of these responses on the value of the critical habitat for the conservation of the species for which the habitat had been designated.

We measure risks to individuals of endangered or threatened species using changes in the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success. When we do not expect ESA-listed animals exposed to an action's effects 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.

We expect that up to one blue, two fin, six sei, three humpback, and six sperm whales, or any leatherback sea turtles within the 120-meter area during airgun operations, to be exposed to the airguns during the seismic survey. Because of the mitigation measures in the IHA, and the relatively low-energy nature of the seismic survey, we do not expect any mortality to occur from the harassment or incidental capture that may occur because of the proposed action. The proposed action will result in temporary stress to the exposed whales or leatherback sea turtles that is not expected to have more than short-term effects on individual blue, fin, sei, sperm, or humpback whales, or leatherback sea turtles.

12 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat because of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 11) to the *Environmental Baseline* (Section 10) and the *Cumulative Effects* (Section 13) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species and Critical Habitat* (Section 9).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion.

For whales exposed to seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area at least temporarily. We also expect secondary foraging areas to be available that would allow whales to continue feeding. Although breeding may be occurring, we are unaware of any habitat features that whales would be displaced from that is essential for breeding if whales depart an area as a consequence of the *Revelle*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities. Individuals engaged in travel or migration would continue with these activities, although potentially with a deflection of a few kilometers from the route they would otherwise pursue.

We expect exposed leatherback sea turtles to experience some degree of stress response upon exposure the airguns. We also expect many of these individuals to respond behaviorally by exhibiting a startle response or by swimming away. We do not expect more than temporary displacement or removal of individuals for a period of hours from small areas because of the proposed actions. Individuals responding in such ways may temporarily cease feeding, breeding, resting, or otherwise disrupt vital activities. However, we do not expect that these disruptions will cause a measureable impact to any individual's growth or reproduction. Overall, we do not expect any population to experience a fitness consequence because of the proposed actions and, by extension, do not expect species-level effects.

13 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). 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, we searched for information on future state, tribal, local or private (non-Federal) actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline (Section 10), which we expect will continue in the future. Anthropogenic effects include climate change, ship strikes, sound, military activities, fisheries, pollution, and scientific research, although some of these activities would involve a federal nexus and thus, but subject to future ESA section 7 consultation. 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. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-listed whale or leatherback sea turtle populations.

14 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of blue, fin, sei, sperm, and Mexico DPS or Central America DPS humpback whales, or leatherback sea turtles. No critical habitat will be affected.

15 INCIDENTAL TAKE STATEMENT

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 ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental take of endangered or threatened species. Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a 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 regulation to include significant habitat modification or degradation that results in death or injury to ESA-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.

NMFS also must provide reasonable and prudent measures that are necessary or appropriate to minimize the impacts to the species, and terms and conditions to implement the measures.

Section 7(o)(2) provides that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited under section 9(a) the ESA and regulations issued pursuant to section 4(d) if that action is performed in compliance with the terms and conditions of this incidental take statement.

15.1 Amount or Extent of Take

If the amount or location of track line surveyed changes, or the number of survey days is increased, then incidental take for marine mammals and sea turtles may be exceeded. As such, if more track lines are surveyed, an increase in the number of survey days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun source levels occur, re-initiation of consultation will be necessary.

15.1.1 Whales

The NMFS anticipates the proposed seismic survey in the East Pacific Ocean off the coast of Oregon and Washington is likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 15). We expect up to 1 blue, 2 fin, 6 sei, 3 humpback (two Mexico and one Central America DPS), and 6 individual sperm whales could be exposed to airgun sounds during the course of the proposed seismic survey, which will elicit a behavioral response that would constitute harassment. Harassment is expected to occur at received levels above 160 dB re: 1 μPa for ESA-listed whales.

For all species of marine mammals, this incidental take would result from exposure to acoustic energy during seismic operations and would be in the form of harassment, and is not expected to result in the death or injury of any individuals that are exposed.

Table 15. Amount of incidental take of ESA-listed marine mammals authorized by the Incidental Take Statement.

Species	**Number of Individuals Authorized for Incidental Take**
Blue whale	1
Fin whale	2
Sei whale	6
Humpback whale	3
Sperm whale	6

15.1.2 Sea turtles

We also expect individual leatherback sea turtles could be exposed to airgun sounds during the course of the proposed seismic survey that will elicit a behavioral response that would constitute harassment. No death or injury is expected for individual sea turtles who are exposed to the seismic activities.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take.

Because there are no reliable estimates of sea turtle population density in the action area, it is not practical to develop numerical estimates of sea turtle exposure. We are relying on the extent of the 175 dB exclusion zone as a surrogate for sea turtle take. Harassment for sea turtles is expected to occur at received levels above 175 dB re: 1 μPa, which includes a 14.4 km^2 area in the northeastern Pacific based upon the propagation and track line estimates provided by the NSF. A sea turtle within the 14.4 km^2 area during airgun operations would be affected by the stressor, and thus taken by harassment.

The extent of the ensonified area is calculated based on the number of airguns used during seismic operations, the tow depth of the airgun array, and the depth of the water in the action area. The tow depth and the water depth can change the predicted distances to which sound levels 175 dB re: 1 μPa are received, so we are assuming the largest predicted established distance of 14.4 km^2 for the 175 dB exclusion zone so as not to underestimate the effect of the stressor. As we cannot determine the number of individuals to which harassment will occur, we expect the extent of exposure will occur within the 175 dB isopleth of the *Revelle's* airgun array.

15.2 Effects of the Take

In this Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat. Reasonable and Prudent Measures

NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS' Permits and Conservation Division and the NSF must ensure that the SIO implements and monitors the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of blue, fin, sei, humpback, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA and as specified below for leatherback sea turtles. In addition, the NMFS' Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and to inform the NMFS' ESA Interagency Cooperation Division if take is exceeded.

15.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the NSF, SIO, and NMFS' Permits and Conservation Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. The terms and conditions described below are nondiscretionary, and must be undertaken by NSF, Scripps Institution of Oceanography, and the Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply.

These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the NSF, SIO, and NMFS' Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the reasonable and prudent measures, the SIO, and the NMFS' Permits and Conservation Division shall ensure the conditions listed in this section.

Mitigation Requirements

The holder of the IHA is required to implement the following mitigation measures:

- SIO must use at least three dedicated, trained, NMFS-approved protected species observers. The protected species observers must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. The protected species observers' resumes shall be provided to NMFS for approval.
- At least one protected species observer must have a minimum of 90 days at-sea experience working as a protected species observer during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One "experienced" visual protected species observer shall be designated as the lead for the entire protected species observation team. The lead protected species observer shall serve as primary point of contact for the vessel operator.

Visual Observation

- During survey operations (e.g., any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, protected species observer(s) must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset).
- Visual monitoring must begin not less than 30 minutes prior to ramp-up, including for nighttime ramp-ups of the airgun array, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.
- Protected species observers shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

- Protected species observers may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours observation per 24-hour period.
- During good conditions (e.g., daylight hours; Beaufort sea state 3 or less), visual protected species observers shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

Exclusion Zone and Buffer Zone

- Protected species observers shall establish and monitor a 100-meter exclusion zone and 200-meter buffer zone. The zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the exclusion zone but within 200 meter from any element of the airgun array shall be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the exclusion zone, or on a course to enter the exclusion zone, shall trigger further mitigation measures as described below.

Ramp-up

- A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45 cubic inch airgun, and the second 45 cubic inch airgun would be added after five minutes.
- If the airgun array has been shut down due to a marine mammal detection, ramp-up shall not occur until all marine mammals have cleared the exclusion zone. A marine mammal is considered to have cleared the exclusion zone if:
    - It has been visually observed to have left the exclusion zone; or
    - It has not been observed within the exclusion zone, for 15 minutes (in the case of small odontocetes) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).
- Thirty minutes of pre-clearance observation of the 100-meter exclusion zone and 200-meter buffer zone are required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the 100 meter exclusion zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the exclusion zone or until an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).
- During ramp-up, protected species observers shall monitor the 100-meter exclusion zone and 200-meter buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100 meter exclusion zone. If

a marine, mammal is observed within or approaching the 100-meter exclusion zone during ramp-up, a shutdown shall be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100-meter exclusion zone or until an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes and 30 minutes for mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).

- If the airgun array has been shut down for reasons other than mitigation (e.g., mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if protected species observers have maintained constant visual observation and no visual detections of any marine mammal have occurred within the buffer zone.
- Ramp-up at night and at times of poor visibility shall only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100-meter exclusion zone and 200-meter buffer zone have been continually monitored by visual protected species observers for 30 minutes prior to ramp-up with no marine mammal detections.
- The vessel operator must notify a designated protected species observer of the planned start of ramp-up. A designated protected species observer must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the protected species observer to proceed.

Shutdown Requirements

- An exclusion zone of 100 meters shall be established and monitored by protected species observers. If a marine mammal is observed within, entering, or approaching the 100-meter exclusion zone all airguns shall be shut down.
- Any protected species observer on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant protected species observer must call for such action immediately.
- The operator must establish and maintain clear lines of communication directly between protected species observers on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing protected species observers to maintain watch.
- When a shutdown is called for by a protected species observer, the shutdown must occur and any dispute resolved only following shutdown.
- Upon implementation of a shutdown, the source may be reactivated under the conditions described previously (i.e., instructions for ramping up at night). Where there is no relevant zone (e.g., shutdown due to observation of a calf), a 30-minute clearance period must be observed following the last observation of the animal(s).

- Shutdown of the array is required upon observation of a whale (i.e., sperm whale or any baleen whale) with calf, with "calf" defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult, at any distance.
- Shutdown of the array is required upon observation of an aggregation (i.e., six or more animals) of large whales of any species (i.e., sperm whale or any baleen whale) that does not appear to be traveling (e.g., feeding, socializing, etc.) at any distance.
- Shutdown of the array is required upon observation of a killer whale at any distance.

Vessel Strike Avoidance

- Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course, as appropriate, to avoid striking any marine mammal, unless such action represents a human safety concern. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.
- The vessel must maintain a minimum separation distance of 100 meters from large whales, unless such action represents a human safety concern. The following avoidance measures must be taken if a large whale is within 100 meters of the vessel:
  - The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established unless such action represents a human safety concern.
  - If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 meters unless such action represents a human safety concern.
- The vessel must maintain a minimum separation distance of 50 meters from all other marine mammals, with an exception made for animals described previously above (i.e., protected species observer monitoring of the ramp-up) that approach the vessel. If an animal is encountered during transit, the vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course unless such action represents a human safety concern.
- Vessel speeds must be reduced to ten knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel unless such action represents a human safety concern.

Miscellaneous Protocols

- The airgun array must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Operational capacity of 90 cubic inches (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the protected species observer(s) on duty and fully documented. The lead protected species observer must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.

- Testing of the acoustic source involving all elements requires normal mitigation protocols (e.g., ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring shall be conducted in accordance with the following requirements:

- The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the protected species observers. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.
- Protected species observers must also be equipped with reticle binoculars (e.g., 7 by 50) of appropriate quality (i.e., Fujinon or equivalent), global positioning system, digital single-lens reflex camera of appropriate quality (i.e., Canon or equivalent), compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

Protected Species Observer Qualifications

- Protected species observers must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program.
- Protected species observers must have successfully attained a bachelor’s degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the protected species observer has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to protected species observer duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a protected species observer; the protected species observer should demonstrate good standing and consistently good performance of protected species observer duties.

Data Collection

- Protected species observers must use standardized data forms, whether hard copy or electronic. Protected species observers shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source to resume survey. If required mitigation was not implemented, protected species observers should submit a description of the circumstances. We require that, at a minimum, the following information be reported:
    - Protected species observer who sighted the animal;
    - Time of sighting;
    - Vessel location at time of sighting;
    - Water depth;
    - Direction of vessel's travel (compass direction);
    - Direction of animal's travel relative to the vessel;
    - Pace of the animal;
    - Estimated distance to the animal and its heading relative to vessel at initial sighting;
    - Identification of the animal (e.g., species/genus, lowest possible taxonomic level, or unidentified); also note the composition of the group if there is a mix of species;
    - Estimated number of animals (high/low/best);
    - Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
    - Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics).
    - Detailed behavior observations (e.g., number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior).
    - Animal's closest point of approach and/or closest distance from the center point of the acoustic source.
    - Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
    - Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up, speed or course alteration, etc.) and time and location of the action.

Reporting

- SIO shall submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used must be provided as an ESRI shapefile with all necessary files and appropriate metadata. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the data collected as required under the condition described above concerning data collection. The draft report must be accompanied by a certification from the lead protected species observer as to the accuracy of the report, and the lead protected species observer may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.

- In the event that a humpback whale is taken during the survey, protected species observers must make all reasonable attempts to obtain a photograph of the animal, and submit it with the report (as described above). This is so that NMFS could compare this record to its own humpback whale photo-id catalogue and possibly identify it to a distinct population segment.

Reporting Injured or Dead Marine Mammals

- In the event that the specified activity clearly causes the take of a marine mammal in a manner not prohibited by this IHA (if issued), such as serious injury or mortality, SIO shall immediately cease the specified activities and immediately report the incident to NMFS. The report must include the following information:
    - Time, date, and location (latitude and longitude) of the incident;
    - Vessel speed's during and leading up to the event;
    - Description of the incident;
    - Status of all sound source use in the 24 hours preceding the incident;
    - Water depth;
    - Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
    - Description of all marine mammal observations in the 24 hours preceding the incident;
    - Species identification or description of the animal(s) involved;
    - Fate of the animal(s); and
    - Photographs or video footage of the animal(s).
- Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS.

- In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), SIO shall immediately report the incident to NMFS. The report must include the same information identified previously in the IHA (i.e., condition regarding the reporting of injured or dead marine mammals). Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.
- In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to NMFS within 24 hours of the discovery. SIO shall provide photographs, video footage, or other documentation of the sighting to NMFS.

Authorization

- The IHA may be may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

16 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 the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

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. The NSF should promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle species.
2. The NSF should develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun sources.

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 critical habitat, the NMFS' Permits and Conservation

Division should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

17 REINITIATION NOTICE

This concludes formal consultation for the NSF and the NMFS Permits and Conservation Division. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

SEP 22 2017

Refer to NMFS No.: FPR-2017-9195

Mr. Bauke (Bob) Houtman, Integrative Programs Section Head
OCE Environmental Operations
Division of Ocean Sciences
National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

RE: Endangered Species Act Section 7 Formal Consultation on the National Science Foundation's use of the research vessel *Roger Revelle* to conduct a low-energy marine geophysical survey in the northeastern Pacific Ocean

Dear Mr. Houtman:

Enclosed is the National Marine Fisheries Service's (NMFS) biological opinion on the effects of the National Science Foundation's use of the research vessel *Roger Revelle* to conduct a low-energy marine geophysical survey in the northeastern Pacific Ocean on endangered and threatened species under NMFS's jurisdiction and critical habitat that has been designated for those species. We have prepared the biological opinion pursuant to section 7(a)(2) of the Endangered Species Act, as amended (ESA; 16 U.S.C. 1536(a)(2)).

Based on our assessment, we concluded that the proposed seismic survey is not likely to jeopardize the continued existence of threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify critical habitat that has been designated for those species. However, we expect some ESA-listed species to be taken incidental to the proposed survey. Terms and conditions are included. The incidental take statement enclosed in the biological opinion allows for exemption to take under ESA section 9(a) and includes measures that must be undertaken in order for the exemption prescribed in section 7(o)(2) of the ESA to apply.

This concludes section 7 consultation on this action. The National Science Foundation is required to reinitiate formal consultation on this action, where it retains discretionary involvement or control over the action 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 consultation; (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 consultation; or (4) a new species is listed or critical habitat designated that may be affected by the action.

If you have any questions regarding this biological opinion, please contact me at (301) 427-8495 or cathy.tortorici@noaa.gov.

Sincerely,

FOR
Cathryn E. Tortorici
Chief, ESA Interagency Cooperation Division
Office of Protected Resources

APPENDIX D:
ESSENTIAL FISH HABITAT CONSULTATION LETTER

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
Oregon Washington Coastal Area Office
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Refer to NMFS No.:
WCR-2017-6901

August 11, 2017

Ms. Holly E. Smith
Environmental Compliance Officer
National Science Foundation
4201 Wilson, Blvd, Room 725
Arlington, VA 22230

Re: Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Low-Energy Marine Geophysical Surveys by the R/V *Roger Revelle* in the Northeastern Pacific Ocean off the Coast of Oregon and Washington.

Dear Ms. Smith:

On May 11, 2017, the National Marine Fisheries Service (NMFS) received your environmental assessment and your request from the National Science Foundation (NSF) for essential fish habitat (EFH) consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Low-Energy Marine Geophysical Surveys by the R/V *Roger Revelle* in the Northeastern Pacific Ocean for September 2017 pursuant to the National Environmental Policy Act (42 U.S.C. 4321 *et seq*.).

The NMFS reviewed the proposed action for potential effects on EFH designated under the MSA, including conservation measures and any determination you made regarding the potential effects of the action. This review was pursuant to section 305(b) of the MSA, implementing regulations at 50 CFR 600.920.

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the environmental assessment provided by the NSF and descriptions of EFH for Pacific Coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), highly migratory species (PFMC 2016), and Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

This letter underwent pre-dissemination review under standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The EFH letter will be available through NMFS" Public Consultation Tracking System. A complete record of this consultation is on file at our Roseburg, Oregon office.

Consultation History

On May 11, 2017 the NSF sent an environmental assessment accompanied by a letter requesting EFH consultation under the Endangered Species Act. In their letter, the NSF determined that the proposed action may adversely affect EFH for Pacific Coast groundfish, coastal pelagic species, Pacific salmon, and highly migratory species.

Proposed Action

The proposed action proposes to conduct an Early Career Seismic Chief Scientist Training Cruise involving low-energy seismic surveys on the research vessel *Revelle* in the Northeastern Pacific Ocean off the Oregon and Washington Coasts. Beginning on or around September 22, 2017, the *Revelle* would depart from Newport, Oregon for approximately 7 days (transit to and from Newport would take ~ 2 days) to conduct seismic operations (seismic operations would take ~4 to 5 days) using two 45-cubic inch (in^3) generator-injector (GI) airguns as the energy source with a total volume of 90 in^3. The airguns will emit seismic pulses at intervals of approximately 8 to 10 seconds (20 to 25 meters) and will be towed 21 meters behind the *Revelle* at 2 meters apart side by side and at 3 meters depth. The receiving system would consist of one 800 meter hydrophone streamer which would receive the returning acoustic signals and transfer the data to the on-board processing system. In addition to the operation of the airgun array, the *Revelle* will continuously operate a multi-beam echosounder (MBES) and a sub-bottom profiler (SBP) during the seismic survey to map the ocean floor, but not during transit to the survey areas.

The NSF proposed the following mitigation measures to minimize effects to EFH:

1. The *Revelle* will use a multi-channel seismic system (two 45-in^3 GI guns at tow depth of 3 meters) of which the energy source is one of the smallest source levels used for conducting seismic research.
2. The *Revelle* will conduct observations for potential impacts of acoustic sources on fish.

Action Area

The surveys will take place off the Oregon Continental Margin out to 127.5°W and between 43 and 46.5°N (Figure 1). The *Revelle* will conduct the surveys within the exclusive economic zone of the United States, in water depths ranging from approximately 130 to 2600 meters. Although the proposed activities could take place anywhere within the project area as shown in Figure 1, two survey sites have been proposed within this area which includes the Astoria Fan and the Southern Oregon Survey areas. Figure 1 shows the representative survey track lines; however, some deviation in actual track lines could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. The total length of the Astoria Fan survey is 1,057 kilometers, with approximately 23 percent of line kilometers in intermediate water (100 to 1,000 meters depth) and the remainder in water depths greater than 1,000 meters. The Southern Oregon survey is 1,013 kilometers, of which approximately 5 percent is in intermediate waters with the remainder in water depths greater than 1,000 meters.

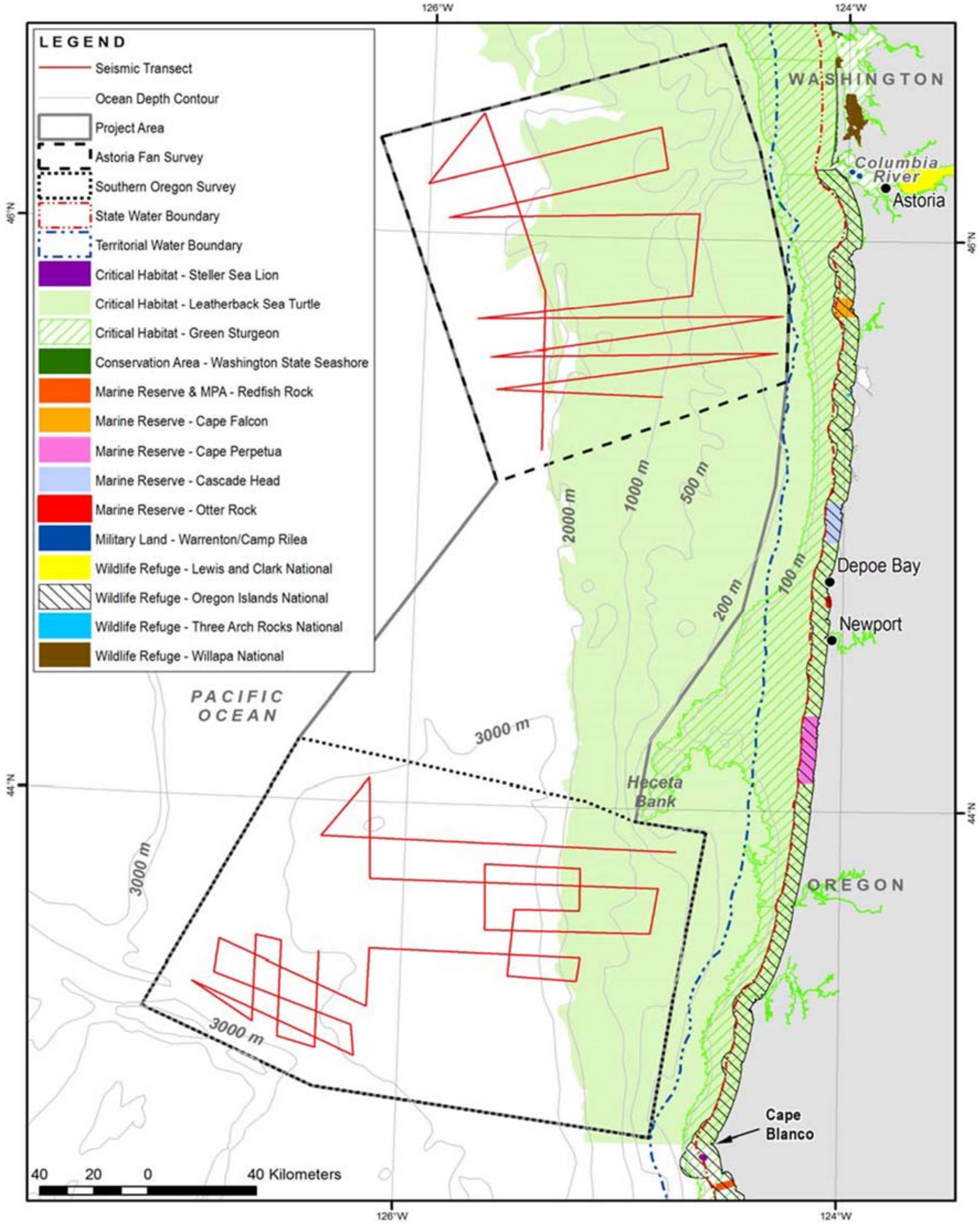

Figure 1. Locations and survey track lines of the proposed low-energy seismic surveys in the northeastern Pacific Ocean.

Essential Fish Habitat Affected by the Proposed Action

The PFMC described and identified EFH for Pacific coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), highly migratory species (PFMC 2007), and Pacific salmon (PFMC 2014). The action area includes areas designated as EFH for various species and life-history stages of Pacific Coast groundfishes, coastal pelagic species, highly migratory species, and Pacific Coast salmon. In addition, the following habitat areas of particular concern (HAPC) are present in the action area: rocky reefs and the Daisy Bank/Nelson Island HAPC.

Adverse Effects on Essential Fish Habitat

Based on information provided in the environmental assessment, we determined the proposed action would adversely affect EFH as follows:

Seismic surveys – Pacific Coast groundfish, coastal pelagic species, highly migratory species, and Pacific Coast salmon. The seismic surveys will increase the underwater sound resulting in noise disturbance in the affected area. Species with designated EFH inhabit the affected area and will be exposed to the noise disturbance, as will their forage. Forage species of those species with designated EFH in the action area include invertebrates and all life stages of various fish species.

Noise effects on marine invertebrates are varied, ranging from no response to exposure to behavioral and physiological responses, injury, and death (Aguilar de Soto 2016, Carroll *et al.* 2016). Fewtrell and McCauley (2012) and Solé *et al.* (2013) reported behavioral responses including startle responses, stressed behavior, and decreased activity and physical injury and loss of muscle tone in cephalopod species. Wale *et al.* (2013a,b) showed increased oxygen consumption and effects on feeding and righting behavior of shore crabs when exposed to increased sound. Conversely, Pearson *et al.* (1994), DFO (2004), and Day *et al.* (2016) observed no change in physiology, physical appearance, or behavior of crustacean embryos or larvae exposed to seismic sounds. Effects on fish exposed to the intense sounds from seismic surveys include behavioral modification (Wardle *et al.* 2001, Boeger *et al.* 2006, Fewtrell and McCauley 2012), temporary auditory threshold shifts (Popper *et al.* 2005), physical injury (Svedrup *et al.* 1994, McCauley *et al.* 2003), and death (Booman *et al.* 1996, as cited in Hastings and Popper 2005).

The severity of effects on marine invertebrates and fish is dependent on the species, life history stage, proximity to sound source at the time of exposure, and the duration, magnitude, and intensity of exposure. The proposed action will result in effects on EFH that may modify spawning, breeding, feeding, and growth to maturity behaviors of species with designated EFH in the action area. The adverse effects of the proposed seismic survey will be short-term (5 days for the seismic survey and days to weeks for the effect on forage species) and will not occur in a single location for long periods because the survey vessel will be continuously moving during the survey. Therefore, the proposed action will not result in long-term significant adverse effects to EFH in the action area.

Essential Fish Habitat Conservation Recommendations

While the proposed action will result in some level of adverse effects on EFH, much of the research available to date on the effects of seismic survey methods and how to minimize and mitigate those effects have been focused on marine mammals and not fish and benthic invertebrates. Therefore, we offer the following EFH conservation recommendation pursuant to section 305(b) of the MSA at this time.

1. Additional research and monitoring should be undertaken to gain a better understanding of the potential effects these seismic surveys may have on EFH, federally managed species, their prey and other NMFS trust resources. This research should be a component of future NSF funded seismic survey activities. This will aid in the development of site and project specific EFH conservation recommendations for future projects as appropriate.

As required by section 305(b)(4)(B) of the MSA, the NSF must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to this consultation, you clearly identify the number of conservation recommendations accepted.

The NSF must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

Be advised that separate correspondence will be provided by the NMFS Office of Protected Resources regarding their evaluation of the Incidental Harassment Authorization request and section 7 of the Endangered Species Act consultation for this proposed action.

If you have any questions regarding this EFH consultation, please contact Jeff Young, fish biologist in the Oregon Coast Branch of the Oregon Washington Coastal Office at 541.957.3389 or jeff.young@noaa.gov.

Sincerely,

For Barry A. Thom
Regional Administrator

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APPENDIX E:
USFWS LETTER OF CONCURRENCE[3]

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[3] On 19 September 2019, USFWS agreed that Scripps could use a 100-m exclusion zone (instead of the 160-dB exclusion zone) to implement shut downs for listed seabirds that are observed diving/foraging within the EZ.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

SEP 18 2017

In Reply Refer To:
FWS/ AES/DER/BER/066591

Ms. Holly Smith
Environmental Compliance Officer
National Science Foundation
Division of Ocean Sciences
4201 Wilson Blvd., Suite 25
Arlington, VA 22230

Subject: NSF Marine Geophysical Surveys by the R/V *Revelle* in the Northeast Pacific Ocean, September 2017

Dear Ms. Smith:

This letter is in response to your request dated May 11, 2017, describing the proposal by the National Science Foundation (NSF) to conduct low-energy marine geophysical surveys, in September 2017, in the Northeast Pacific Ocean off the coast of Oregon and Washington (Proposed Action). You have requested concurrence by the U.S. Fish and Wildlife Service (Service) that the Proposed Action may affect, but is not likely to adversely affect threatened or endangered species or critical habitat under Service jurisdiction pursuant to Section 7 of the Endangered Species Act of 1973 (ESA; 16 U.S.C. 15 3 1- 15 44), as amended. This consultation is based upon information provided in the draft Environmental Assessment entitled "Draft Environmental Assessment of a Low-Energy Marine Geophysical Survey by the R/V Roger Revelle in the Northeastern Pacific Ocean, September 2017," and tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF-USGS 2011) and Record of Decision (NSF 2012).

Project Description

Principal Investigators from multiple academic institutions, with funding from NSF, propose to conduct seismic surveys from the research vessel (R/V) *Revelle,* operated by Scripps Institution of Oceanography (SIO). The purpose of the Proposed Action is to provide an Early Career Seismic Chief Scientist Training Cruise to train scientists on how to effectively plan seismic surveys, acquire data and manage activities at sea, and to understand the sediment and crustal structure within the Cascadia continental margin. During the cruise, high-resolution multichannel seismic (MCS) profiles would be collected on the active continental margin of the west coast of the United States, off the coast of Oregon and Washington in the northeastern Pacific. The seismic surveys would use a pair of low-energy Generator-Injector airguns with a total discharge volume of approximately 90 cubic inches. The receiving systems for the returning acoustic signals would be a towed hydrophone streamer. As the airguns are towed along the survey lines, the towed hydrophone array in the 800-meter streamer would receive the reflected signals and transfer the data to the on-board processing system.

The seismic survey is proposed to occur within the U.S. Exclusive Economic Zone (EEZ), but outside of territorial waters (i.e., at least 22 kilometers from the coast), in water depths of 130 – 2600 meters. Two potential survey sites off the Oregon continental margin have been proposed. One survey option (Astoria Fan) is located off northern Oregon off the mouth of the Columbia River and near the Astoria Canyon; the other (southern Oregon) is located off the southern Oregon margin. The scientists on board would be responsible for modifying the survey within the designated project area to fit the allocated cruise length while meeting the project objectives, including choosing which survey or what portion of each survey to conduct.

The total line for the Southern Oregon survey is 1,013 kilometers, 5% of which are in intermediate water depths (100 –1000 m), with the remainder in water deeper than 1,000 meters. The total length for the Astoria Fan survey is 1,057 kilometers, with 23% of the line in intermediate water depths and the remainder in water deeper than 1,000 meters. No effort during either survey would occur in shallow water less than 100 meters deep. The total track distance to be surveyed is estimated to be no greater than 1,057 kilometers (the distance of the longest survey). There would be additional seismic operations in the survey area associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard.

In addition to the operations of the airgun array, a multibeam echosounder and a sub-bottom profiler would also be operated from the *Revelle* continuously throughout the seismic survey, but not during transits to and from the survey areas. All planned data acquisition and sampling activities would be conducted by SIO with on-board assistance by the scientists who have proposed the project. The vessel is self-contained, and the crew will live aboard the vessel.

The proposal is to depart from Newport, OR, on or about September 22, 2017, and return to Newport on or about September 29, 2017. Some deviation in timing could result from unforeseen events such as weather or logistical issues. Seismic operations would take four to five days, and the transit to and from Newport would take two days.

Description of Federally-list Seabirds and Critical Habitats

NSF has identified three bird species that are listed under the Endangered Species Act (ESA) that could occur in or near the proposed survey areas. Only two of the three species nest in the area. The marbled murrelet *(Brachyramphus marmoratus)* is federally listed as threatened. It is fairly common along the Pacific Coast but unlikely to occur very far offshore (beyond five kilometers). The Pacific Coast population of the western snowy plover *(Charadrius alexandrinus nivosus)* is a coastal species that would not be encountered offshore. It is federally listed as threatened. The federally-endangered short-tailed albatross (*Phoebastria albatrus*) could occur as a seasonal visitor to the project area.

Marbled Murrelet

The marbled murrelet is a small, robin-sized, diving seabird that feeds primarily on fish and invertebrates in near-shore marine waters. It ranges from the Aleutian Islands and southern

Alaska to central California. The largest portion of the population occurs in Alaska and British Columbia. The marbled murrelet spends the majority of its time on the ocean, roosting and feeding, but comes inland up to 70 miles to nest in forest stands with old growth forest characteristics. The primary cause of marbled murrelet population decline is the loss and modification of nesting habitat in old growth and mature forests through commercial timber harvests, human-induced fires, and land conversions, and to a lesser degree, through natural causes such as wild fires and wind storms. In the murrelet's marine habitat, oil spills and gill-net fishing also threaten the population. They are widespread along the Pacific Coast and generally found in nearshore waters, usually within five kilometers of shore.

Marbled murrelets nest from mid-April to late September. Murrelet chicks are virtually helpless at hatching and rely on the adults for food. The adults feed the chick at least once a day, flying in (primarily at dawn and dusk) from feeding on the ocean, carrying one fish at a time. The young fledge from the nest in about 28 days and appear to fly directly to the sea upon leaving the nest. Marbled murrelets tend to forage in relatively shallow water, most birds foraging in waters less than 50 – 100 meters (164 – 328 feet) deep. Feeding habitat for marbled murrelets is mostly within two kilometers of shore. Although they have been observed more the 40 kilometers from shore, the mean offshore distance over a three year tracking study was 1.4 kilometers. They generally prefer to feed both near the surface and at midwater depths, based on their known capture depths in gill nets (most less than 10 meters), in short dive times (28 – 69 seconds), and in mixed-species feeding flocks foraging on schools of fish near the surface. They also may forage along the ocean bottom, especially when diving near shore. Marbled murrelets are not likely to be encountered in the offshore waters of the proposed project area.

Marbled Murrelet – Critical Habitat

Critical habitat has been designated for the marbled murrelet. Designation of critical habitat focuses on the following primary constituent elements (PCEs) specific to the marbled murrelet: (1) individual trees with potential nesting platforms, and (2) forested areas within 0.5 mile (0.8 kilometer) of individual trees with potential nesting platforms, and with a canopy height of at least one-half the site-potential tree height. This includes all such forest, regardless of contiguity. These PCEs are essential to provide and support suitable nesting habitat for successful reproduction of the marbled murrelet.

Western Snowy Plover

The western snowy plover is a small shorebird in the family Charadriidae. It is pale gray-brown above and white below, with a white hindneck collar and dark lateral breast patches, forehead bar, and eye patches. The Pacific coast population of the western snowy plover breeds primarily on coastal beaches from southern Washington to southern Baja California, Mexico. Sand spits, dune-backed beaches, beaches at creek and river mouths, and salt pans at lagoons and estuaries are the main coastal habitats for nesting. In western North America, they winter late October to mid-February, mainly in coastal areas from southern Washington to Central America.

These plovers are primarily visual foragers, using the run-stop-peck feeding method. They forage on invertebrates in the wet sand and surf-cast kelp within the intertidal zone, in dry sand areas above the high tide, on salt pans, on spoil sites, and along the edges of salt marshes, salt ponds, and lagoons. These plovers would be unlikely to occur in the offshore waters of the proposed project area.

Western Snowy Plover – Critical Habitat
Critical habitat has been designated for the Pacific Coast population of the western snowy plover. The PCEs essential to the conservation of the western snowy plover include sandy beaches, dune systems immediately inland of an active beach face, salt flats, mud flats, seasonally exposed gravel bars, artificial salt ponds and adjoining levees, and dredge spoil sites, that are relatively undisturbed, sparsely vegetated shorelines above daily high tides, and support invertebrate prey species.

Short-tailed albatross
Short-tailed albatross require remote islands for breeding habitat, nesting in open, treeless areas with low or no vegetation. Short-tailed albatross spend much of their time feeding in continental shelf-break areas (200 – 1000 meter depth, where the continental shelf ends and depths begin to increase markedly) east of Honshu, Japan during breeding, and in shelf (0 – 200 meter depth) and shelf break areas of the Bering Sea, Aleutian chain and in other Alaskan, Japanese and Russian waters. Existing human-induced threats include incidental catch in commercial fisheries, ingestion of plastics, contamination by oil and other pollutants, the potential for depredation or habitat degradation by non-native species, and adverse effects related to global climate change.

The range of the short-tailed albatross covers most of the North Pacific Ocean, as well as a few observations from the Sea of Okhotsk and the East China Sea. The species occurs throughout international waters and within the Exclusive Economic Zones (EEZ) of Mexico, the United States, Canada, Russia, Japan, China, North and South Korea, the Federated States of Micronesia, and the Republic of the Marshall Islands. Telemetry data indicate that short-tailed albatross do not commonly disperse widely throughout the subarctic North Pacific. From December through April, the distribution of adult and immature short-tailed albatross is primarily concentrated near the breeding colonies, although foraging trips may extend hundreds of miles or more from the colony sites. Immature birds may move relatively rapidly north to the western Aleutian Islands, or they may stay within the coastal waters of northern Japan and the Kuril Islands throughout the summer. In early September these individuals also move into the western Aleutian Islands. Once in the Aleutians, most birds travel east toward the Gulf of Alaska. Both satellite data and at-sea opportunistic sightings indicate a prevalence of juvenile and sub-adult short-tailed albatross off the west coasts of Canada and the U.S. Because short-tailed albatross forage extensively along continental shelf margins, the majority of time is spent within national EEZs, particularly the United States (off Alaska), Russia, and Japan, rather than over international waters. Overall, short-tailed albatross spend the greatest proportion of time off Alaska, and secondarily Russia, during the post-breeding season.

With a wingspan of over two meters (over seven feet), the short-tailed albatross is the largest seabird in the North Pacific. Its long, narrow wings are adapted to soaring low over the ocean. Their size and flight behavior will likely facilitate their observation during monitoring surveys. Short-tailed albatrosses forage widely across the temperate and subarctic North Pacific. The North Pacific marine environment most heavily used by short-tailed albatross is characterized by regions of upwelling and high productivity along the northern edge of the Gulf of Alaska, along the Aleutian Chain, and along the Bering Sea shelf break from the Alaska Peninsula out towards

St. Matthew Island. Often described as a continental shelf specialist, the short-tailed albatross feeds at the ocean surface, mainly at night. They feed on squid, fish, flying fish eggs, shrimp, and other crustaceans. They also are known to follow fishing vessels and feed on discarded bait. The short-tailed albatross could be encountered in very small numbers in the proposed project area.

No critical habitat has been designated for the short-tailed albatross.

Project Effects and Minimization Measures

The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) has recently been investigated, and the peak hearing sensitivity was found to be between 1500 and 3000 Hz (Crowell 2016). Great cormorants were also found to respond to underwater sounds and may have special adaptations for hearing underwater (Hansen et al. 2016; Johansen et al. 2016). While there could be transitory disturbance, it is unlikely that there would be significant impacts of NSF-funded marine seismic research on seabirds or their populations. NSF has established an exclusion zone, defined by the 160 dB received sound level from the source, where airgun operations would cease if a seabird enters, as well as a designated buffer zone for additional protection. Given the proposed activities and the mitigation measures, no significant impacts on seabirds would be anticipated. Nevertheless, given the high levels of sound emitted by an array of airguns, a precautionary approach is warranted. The planned monitoring and mitigation measures in place for seabirds will reduce the possibility of injurious effects. Protection measures designed to mitigate the potential environmental impacts to listed species include:

1) There will be typically two, however minimally one, dedicated Protected Species Observers (PSOs) maintaining a visual watch during all daytime airgun operations;
2) Two observers will be present before and during ramp ups (starting the equipment) throughout the day;
3) Ramp-up would be allowed at night and during poor visibility if the exclusion zone and buffer zone have been monitored by visual PSOs for 30 minutes prior to ramp-up.
4) PSOs will train watchstanders/bridge personnel to identify ESA-listed species, their habitat and behavior (e.g. foraging); and,
5) During night time survey operations watchstanders/bridge personnel will monitor for these species and contact PSOs should these species be observed near the vessel. Power down or (if necessary) shutdown will occur should ESA-listed birds be observed foraging or diving in the designated exclusion zones.

Given the protection measures, the range, occurrence, and biology of the listed species, and the short duration of the seismic survey, we do not expect vessel strikes or equipment entanglement of ESA-listed species to occur.

Conclusion

NSF identified three federally-listed species that could occur in or near the proposed survey areas. The Pacific Coast population of the western snowy plover relies on coastal habitats for its feeding and breeding needs. It is unlikely to be encountered in the project area, and its critical habitat will not be affected by offshore seismic surveys. The marbled murrelet relies on forested areas for breeding and nesting. It is an open ocean feeder, but foraging is largely restricted to the near shore habitat generally within three miles of the coast. It is unlikely to be encountered in the project area. Small numbers of short-tailed albatross may occur in the project area. However, given the short duration of the project and the limited number of expected birds in the area, it is unlikely to be encountered during the proposed surveys. The short-tailed albatross is a pelagic seabird that forages at the ocean surface, mainly at night. In the unlikely event that a foraging short-tailed albatross is encountered, surface feeding is expected to minimize the likelihood of any exposure to underwater acoustic stressors associated with the project. Additionally, if short-tailed albatross, or other ESA-listed species, are observed during the survey, the mitigation measures in place will reduce the likelihood that individuals will be exposed to acoustic stressors to such an extent as to result in "take" as defined by the ESA.

Based upon our review of the proposed seismic survey and the mitigation measures in place to avoid and minimize impacts to the three federally listed species that may be encountered during the proposed action, we have concluded that "take" associated with the activities covered under the NSF's proposed Marine Geophysical Survey is so unlikely to occur as to be considered discountable. Therefore, we concur that NSF's proposed Marine Geophysical Surveys "may affect" but "are not likely to adversely affect" ESA-listed species under the jurisdiction of the Service. Critical habitat designations for the western snowy plover and marbled murrelet do not include offshore components. Therfore, we concur that NSF's proposed Marine Geophysical Surveys are not likely to adversely affect critical habitat for the western snowy plover and marbled murrelet. Coordination with National Marine Fisheries Service on listed species under their jurisdiction is recommended.

We appreciate the collaboration your staff has provided. If you have any questions please contact Cheryl Amrani at (703) 358-2161.

Sincerely,

Ben Thatcher

Benjamin S. Thatcher, Ph.D.
Chief, Branch of Environmental Review
Ecological Services Program

APPENDIX F: COASTAL ZONE MANAGEMENT USFWS COMPLIANCE – OREGON AND WASHINGTON

From: Ruther, Elizabeth [mailto:elizabeth.j.ruther@state.or.us]
Sent: May-08-17 1:31 PM
To: Smith, Holly E.; Snow, Patty
Subject: RE: NSF Proposed Marine Geophysical Surveys off the Coast of Oregon and Washington

Hi Holly-

Thanks for your negative determination. The OCMP agrees with your determination. No further action or information is required.

Thanks--

Elizabeth Ruther | Coastal State-Federal Relations Coordinator
Oregon Coastal Management Program
Oregon Dept. of Land Conservation and Development
635 Capitol Street NE, Suite 150 | Salem, OR 97301-2540
Direct: (503) 934-0029 | Cell: (503) 239-9460 | Main: (503) 373-0050
elizabeth.j.ruther@state.or.us | www.oregon.gov/LCD

From: Smith, Holly E. [mailto:hesmith@nsf.gov]
Sent: Monday, May 08, 2017 11:55 AM
To: Snow, Patty <psnow@dlcd.state.or.us>
Cc: Ruther, Elizabeth <eruther@dlcd.state.or.us>; Smith, Holly E. <hesmith@nsf.gov>
Subject: NSF Proposed Marine Geophysical Surveys off the Coast of Oregon and Washington

Dear Ms. Snow – Attached please find a determination pursuant to Subpart C of the Coastal Zone Management Act (CZMA) (16 USC §1451, *et seq*.) for proposed marine geophysical surveys off the coast of Oregon and Washington by the National Science Foundation. If you have any questions about the proposed surveys or determination, please do not hesitate to contact me (703-292-7713; hesmith@nsf.gov), I would be happy to provide any clarifications.

Regards,
Holly Smith
Environmental Compliance Officer

National Science Foundation
4201 Wilson Blvd., Room 725
Arlington, VA 22230
703-292-7713 (direct line)
hesmith@nsf.gov

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

May 8, 2017

Patty Snow
Oregon Coastal Management Program
Department of Land Conservation & Development
635 Capitol St. NE, Suite 150
Salem, OR 97301-2540

Re: Marine Geophysical Surveys by the R/V *Revelle* in the Northeastern Pacific Ocean

Dear Ms. Snow:

Attached please find a determination pursuant to Subpart C of the Coastal Zone Management Act (CZMA) (16 USC §1451, *et seq.*) for the above referenced Proposed Action by the National Science Foundation. If you have any questions about the Proposed Action or determination, please do not hesitate to contact me (703-292-7713; hesmith@nsf.gov).

Sincerely,

Holly Smith
Environmental Compliance Officer

cc: Ms. Elizabeth (Liz) Ruther, Oregon State Federal Consistency Contact

Attachment: Coastal Zone Management Act (CZMA) Negative Determination for the Marine Geophysical Surveys by the R/V *Revelle* in the Northeastern Pacific Ocean

Coastal Zone Management Act (CZMA)

Negative Determination
for the
Marine Geophysical Surveys by the R/V *Revelle* in the Northeastern Pacific Ocean

The National Science Foundation (NSF) has proposed to conduct low-energy marine geophysical surveys in support of training and research activities, in September 2017, in the Northeast Pacific Ocean, off the coast of Oregon and Washington (Proposed Action). The Proposed Action would be funded by NSF and led by Principal Investigators (PIs) Drs. M. Tominaga (Texas A& M University), Drs. A. Trehu and M. Lyle (Oregon State University), and G. Mountain (Rutgers University). The proposed seismic surveys would be conducted on the federally-owned research vessel (R/V) *Roger Revelle (Revelle)*, which is operated by Scripps Institution of Oceanography (SIO). The seismic surveys would be part of an Early Career Seismic Chief Scientist Training Cruise which would aim to increase the understanding of the sediment and crustal structure within the Cascadia continental margin and train scientists to effectively plan seismic surveys, acquire data, and manage activities at sea. The survey region is on the active continental margin of the west coast of the United States (U.S.) (Attachment 1, Figure 1), where a variety of sedimentary and tectonic settings are available, which would provide many easily accessible targets of geologic interest to a wide range of research cruise participants (Attachment 1, page 4).

During the cruise, high-resolution multi-channel seismic profiles would be collected. A pair of low-energy Generator-Injector airguns with a total discharge volume of approximately 90 cubic inches (in^3) for approximately 5 days would be used during the seismic surveys (total vessel operations would last approximately 8 days including transit, equipment maintenance, etc.). The seismic surveys would take place in water depths 130–2600 meters (m), within the U.S. Exclusive Economic Zone (EEZ), but outside of state and territorial waters. The surveys would occur approximately 18-223 kilometers (km) [approximately 10-120 nautical miles (nmi)] from the state water boundary (Attachment 1, Figure 1). The receiving system for the returning acoustic signals would be a towed hydrophone streamer, approximately 800 m in length. No equipment would be placed on the seafloor during the Proposed Action.

A Draft Environmental Assessment (Draft EA) pursuant to the National Environmental Policy Act (42 U.S.C. 4321 *et seq*.) was prepared on behalf of NSF by LGL Limited environmental research associates (LGL), entitled, "Environmental Assessment of a Low-Energy Marine Geophysical Survey by the R/V *Roger Revelle* in the Northeastern Pacific Ocean, September 2017" (Report FA0114) (Attachment 1). The Draft EA tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (2011) and Record of Decision (2012; PEIS). The conclusions from the Draft EA and PEIS were used to inform the NSF Division of Ocean Sciences (OCE) management of potential environmental impacts of the cruise.

Because of the complexities of the Proposed Action which involve a federal entity (NSF), a vessel operator (SIO), and PIs and students from multiple academic institutions, NSF considered this activity under Subpart C of the Coastal Zone Management Act (CZMA) (16 USC §1451, *et seq*.). In accordance with CZMA Subpart C, NSF reviewed Oregon Coastal Management Program

Federal Consistency Listings and determined that the proposed activity was unlisted. NSF also considered whether the Proposed Action would have any effect on coastal uses or resources of the state of Oregon.

Potential impacts of the seismic surveys on the environment, if any, would be short term, primarily a result of the operation of the airgun array, and would occur within close proximity of the vessel. The potential resources impacted are described in detail in Chapters III and IV of the Draft EA. The increased underwater noise may result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. Because of the characteristics of the Proposed Action and proposed monitoring and mitigation measures (described further below), in addition to the general avoidance by marine mammals of loud sounds, any injury to marine mammals is considered highly unlikely. Therefore, no long-term or significant effects are anticipated on individual marine mammals, sea turtles, seabirds, the populations to which they belong, or their habitats as a result of this proposed action. In decades of seismic surveys carried out by SIO and other vessels in the U.S. academic research fleet, Protected Species Observers (PSOs) and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality.

Mitigation of potential impacts from the proposed activities was taken into consideration during the scientific planning phase of the Proposed Action, including identifying the lowest energy source needed to meet the scientific objectives and calculating operational mitigation zones (Attachment 1, pages 6-12). To reduce potential risks to marine species during survey operations, monitoring and mitigation measures proposed for the surveys would include ramp-ups of the airguns (to allow any animals to leave the area if disturbed); typically two, but a minimum of one PSO maintaining a visual watch during all daytime airgun operations; two PSOs monitoring 30 minutes before and during ramp-ups during the day; no start-ups during poor visibility or at night unless at least one airgun has been operating; shut-downs when marine mammals or sea turtles are detected in or about to enter designated exclusion zones; and (although unlikely to be encountered) concentrations of large whales would be avoided (Attachment 1, pages 10-12; 71).

Human activities in the survey area would be limited to fishing activities, other vessel traffic, and possibly whale watching (Attachment 1, pages 15, 82-85). No significant impacts on these activities would be anticipated from the Proposed Action, including fishing, particularly because of the short duration of the proposed activities (approximately 1 week), the low-energy directional source used, involvement of only one vessel, and the distance between the survey area and the coastal zone (as noted previously, the surveys would occur approximately 18-223 km [approximately 10-120 nmi] from the state water boundary). In addition, these human activities that could occur within the survey area, including commercial and recreational fisheries activities, would not be precluded from entering or being in the area during the surveys. While a safe distance would need to be maintained from the R/V *Revelle* during operations to avoid entanglement with towed seismic equipment, the length of the streamers used would be relatively short (800 m). SIO would use vessel based radio broadcasts to alert mariners of ongoing activities and would issue a Notice to Mariners informing them of the activity. Thus, space-use conflicts would be highly unlikely and could be avoided. In addition, the R/V *Revelle* would avoid fishing gear to prevent entanglement with the towed seismic equipment. Therefore, the proposed surveys would not interfere with commercial or recreational fisheries activities, or other human activities, within or adjacent to Oregon's coastal zone.

NSF has initiated formal consultation with the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service under Section 7 of the Endangered Species Act (ESA), and an Incidental Harassment Authorization is being sought under the Marine Mammal Protection Act for the surveys. NSF will also consult with the U.S. Fish and Wildlife Service pursuant to Section 7 of the ESA and the NOAA Essential Fish Habitat West Coast Region Office pursuant to the Magnuson-Stevens Act.

Oregon's Geographic Location Description (GLD) for federal waters is within the area defined in Oregon Statewide Planning Goal 19 Ocean Resources as the Oregon Ocean Stewardship Area. The GLD starts from the seaward limit of Oregon state jurisdiction at 3 nmi from the shoreline, and extends seaward to a boundary line along the outer continental shelf which approximates the 500 fathom bathymetric contour. The GLD, however, only applies to the following types of activities: any offshore wind or wave power generation facilities or structures(s), of a permanent nature, regardless of size or number; underwater cables to service power generating facilities; and research and monitoring devices such as LIDAR, Met towers or wave energy measurement instruments with a deployment window of 5 years or greater. The Proposed Action does not include these activities, therefore, the GLD does not apply to the Proposed Action. Although not applicable to the Proposed Action, only a very small portion of the Proposed Action could occur within the GLD, as most activities are proposed to occur in waters greater than 500 m.

As noted in the Draft EA (Attachment 1, page 83), NSF has funded seismic surveys in this region in the recent past. High energy seismic surveys using a 36-airgun array (6600 in^3 total discharge volume) were conducted off the coast of Oregon and Washington by the R/V *Langseth* during June–July 2012. Under the CZMA, NSF came to a no effects determination for the 2012 surveys. NSF informed the Oregon Coastal Program Manager regarding the no effects conclusion in a letter dated February 17, 2012; on June 4, 2012, NSF received an email response concurring with our findings of no effects. During September 2007 and July 2009, SIO conducted low-energy seismic surveys for approximately 6–7 days off the coast of Oregon. During July 2008, University of Texas Institute for Geophysics conducted a low-energy seismic survey for approximately 6 days off the coast of Oregon. No impacts to coastal uses or resources were reported as a result of these surveys.

After review and consideration, NSF anticipates that the Proposed Action, which would be operated well beyond state waters, would not affect the state of Oregon's coastal uses or resources. In particular, NSF has considered the enforceable policies associated with Oregon's Territorial Sea Plan contained within the Statewide Planning Goals (Goal 19 Ocean Resources), and concludes there would be no effect from the Proposed Action; therefore, the Proposed Action would be consistent with the enforceable policies.

Attachment 1: Draft Environmental Assessment for a Marine Geophysical Survey by the R/V *Roger Revelle* in the Northeastern Pacific Ocean, September 2017

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

May 8, 2017

Mr. Brian Lynn, Manager
Shorelands & Environmental. Assistance Program
Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Re: Marine Geophysical Surveys by the R/V *Revelle* in the Northeastern Pacific Ocean

Dear Mr. Lynne:

Attached please find a determination pursuant to Subpart C of the Coastal Zone Management Act (CZMA) (16 USC §1451, *et seq.*) for the above referenced Proposed Action by the National Science Foundation. If you have any questions about the Proposed Action or determination, please do not hesitate to contact me (703-292-7713; hesmith@nsf.gov).

Sincerely,

Holly S

Holly Smith
Environmental Compliance Officer

cc: Ms. Loree Randall, Washington State Federal Consistency Contact

Attachment: Coastal Zone Management Act (CZMA) Negative Determination for the Marine Geophysical Surveys by the R/V *Revelle* in the Northeastern Pacific Ocean

Coastal Zone Management Act (CZMA)

Negative Determination
for the
Marine Geophysical Surveys by the R/V *Revelle* in the Northeastern Pacific Ocean

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During the cruise, high-resolution multi-channel seismic profiles would be collected. A pair of low-energy Generator-Injector airguns with a total discharge volume of approximately 90 cubic inches (in^3) for approximately 5 days would be used during the seismic surveys (total vessel operations would last approximately 8 days including transit, equipment maintenance, etc.). The seismic surveys would take place in water depths 130–2600 meters (m), within the U.S. Exclusive Economic Zone (EEZ), but outside of state and territorial waters. The surveys would occur approximately 18-166 kilometers (km) [approximately 10-90 nautical miles (nmi)] from the Washington state water boundary (Attachment 1, Figure 1). The receiving system for the returning acoustic signals would be a towed hydrophone streamer, approximately 800 m in length. No equipment would be placed on the seafloor during the Proposed Action.

A Draft Environmental Assessment (Draft EA) pursuant to the National Environmental Policy Act (42 U.S.C. 4321 *et seq*.) was prepared on behalf of NSF by LGL Limited environmental research associates (LGL), entitled, "Environmental Assessment of a Low-Energy Marine Geophysical Survey by the R/V *Roger Revelle* in the Northeastern Pacific Ocean, September 2017" (Report FA0114) (Attachment 1). The Draft EA tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (2011) and Record of Decision (2012; PEIS). The conclusions from the Draft EA and PEIS were used to inform the NSF Division of Ocean Sciences (OCE) management of potential environmental impacts of the cruise.

Because of the complexities of the Proposed Action which involve a federal entity (NSF), a vessel operator (SIO), and PIs and students from multiple academic institutions, NSF considered this activity under Subpart C of the Coastal Zone Management Act (CZMA) (16 USC §1451, *et seq*.). In accordance with CZMA Subpart C, NSF reviewed Washington Coastal Management Program's

Federal Consistency Listings and determined that the proposed activity was unlisted. NSF also considered whether the Proposed Action would have any effect on coastal uses or resources of the state of Washington.

Potential impacts of the seismic surveys on the environment, if any, would be short term, primarily a result of the operation of the airgun array, and would occur within close proximity of the vessel. The potential resources impacted are described in detail in Chapters III and IV of the Draft EA. The increased underwater noise may result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. Because of the characteristics of the Proposed Action and proposed monitoring and mitigation measures (described further below), in addition to the general avoidance by marine mammals of loud sounds, any injury to marine mammals is considered highly unlikely. Therefore, no long-term or significant effects are anticipated on individual marine mammals, sea turtles, seabirds, the populations to which they belong, or their habitats as a result of this proposed action. In decades of seismic surveys carried out by SIO and other vessels in the U.S. academic research fleet, Protected Species Observers (PSOs) and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality.

Mitigation of potential impacts from the proposed activities was taken into consideration during the scientific planning phase of the Proposed Action, including identifying the lowest energy source needed to meet the scientific objectives and calculating operational mitigation zones (Attachment 1, pages 6-12). To reduce potential risks to marine species during survey operations, monitoring and mitigation measures proposed for the surveys would include ramp-ups of the airguns (to allow any animals to leave the area if disturbed); typically two, but a minimum of one PSO maintaining a visual watch during all daytime airgun operations; two PSOs monitoring 30 minutes before and during ramp-ups during the day; no start-ups during poor visibility or at night unless at least one airgun has been operating; shut-downs when marine mammals or sea turtles are detected in or about to enter designated exclusion zones; and (although unlikely to be encountered) concentrations of large whales would be avoided (Attachment 1, pages 10-12; 71).

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NSF has initiated formal consultation with the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service under Section 7 of the Endangered Species Act (ESA), and an Incidental Harassment Authorization is being sought under the Marine Mammal Protection Act for the surveys. NSF will also consult with the U.S. Fish and Wildlife Service pursuant to Section 7 of the ESA and the NOAA Essential Fish Habitat West Coast Region Office pursuant to the Magnuson-Stevens Act.

As noted in the Draft EA (Attachment 1, page 83), NSF has funded seismic surveys in this region in the recent past. High energy seismic surveys using a 36-airgun array (6600 in^3 total discharge volume) were conducted off the coast of Oregon and Washington by the R/V *Langseth* during June–July 2012. Under the CZMA, NSF came to a no effects determination for the 2012 surveys. NSF informed the Washington Coastal Program Manager regarding the no effects conclusion in a letter dated February 17, 2012; on June 5, 2012, NSF received a letter concurring with our findings. During September 2007 and July 2009, SIO conducted low-energy seismic surveys for approximately 6–7 days off the coast of Oregon. During July 2008, University of Texas Institute for Geophysics conducted a low-energy seismic survey for approximately 6 days off the coast of Oregon. No impacts to coastal uses or resources were reported as a result of these surveys.

After review and consideration, NSF anticipates that the Proposed Action, which would be operated well beyond state waters, would not affect the state of Washington's coastal uses or resources.

Attachment 1: Draft Environmental Assessment for a Marine Geophysical Survey by the R/V *Roger Revelle* in the Northeastern Pacific Ocean, September 2017