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

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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.

[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).

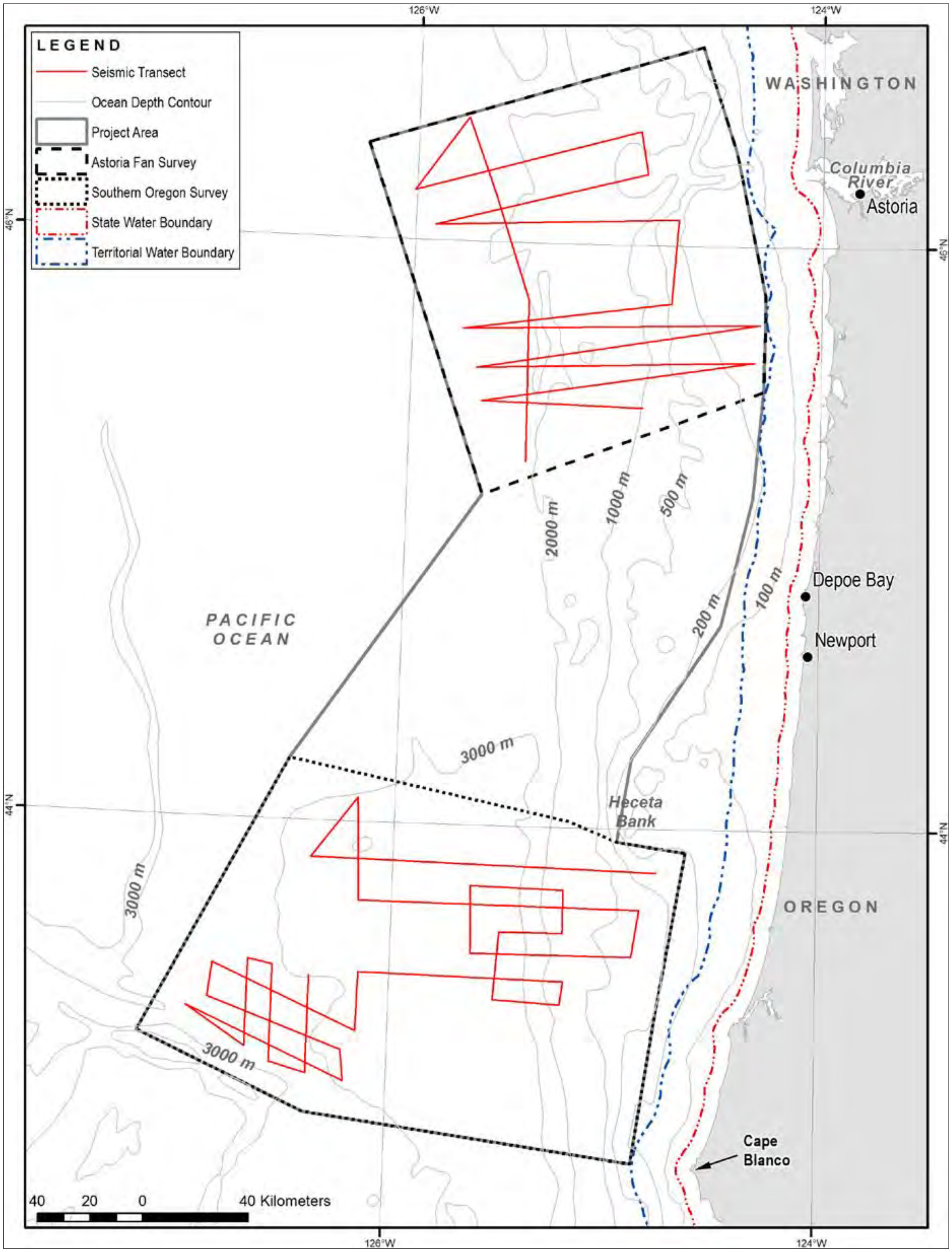

Figure 1: Planned potential track lines for low-energy seismic survey proposed by Scripps Institution of Oceanography conducted aboard the R/V *Revelle*.

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 ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	4.9	7.9
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	0.9	0

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

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